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AN ASSOCIATIONAL STUDY OF ILLINOIS SAND PRAIRIE

BY

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ARTICLE I.—*An Associational Study of Illinois Sand Prairie.* BY ARTHUR G. VESTAL, A.M.

INTRODUCTION

Three reports on the biology of the sand areas of Illinois have appeared in earlier numbers of this Bulletin. The report of Hart and Gleason ('07) is a discussion of the plants and animals in the particular region in which the present studies were made; that of Gleason ('10) gives an account of the plant associations of the inland sand areas of the state; and that of Gates ('12) discusses the plant associations of the sand area of the Lake Michigan shore near the northern boundary of Illinois. The present study is restricted to the *grassland* associations of sand in the Illinois River valley, and the emphasis is placed upon the animals of the region. The unit of study is here the association, or community of organisms: the social aggregate of plants and animals, which, living in a common environment, come into various relations one with another. In the sand prairie of the river valley several types of areas may be distinguished, each characterized by a definite set of physical conditions, by a particular association of plants, and by a particular assemblage of animals. In this report the plant and animal assemblages are considered together, and inquiry is made into the relations which obtain between them, and between them and the physical environment.

The field work was done at Havana, Mason county, Illinois, on the Illinois River, during the summer of 1910, and during short periods in early fall in 1910 and early spring in 1911,—nearly all in an area of almost pure sand east of Havana, locally known as the Devil's Hole, somewhat less than two miles distant from the river. Several excursions were made to the Devil's Neck, a similar but much larger sand area north of Topeka, and to various other points in the valley. More attention was given to the insects than to any other group of animals, this partiality being justified by the fact that they are the most numerous and the most conspicuous forms in the animal life of the sand prairie.

ACKNOWLEDGMENTS

The preparation of this report would not have been possible without the aid of many persons. Dr. C. C. Adams, under whose direction the work was done, has been of very great assistance in many ways.

To Dr. H. A. Gleason I am under deep obligation for guidance in the field, for various information, for reading the manuscript, and for help of other kinds. I am grateful to Mr. C. A. Hart, who has helped me in many ways. Dr. F. C. Gates has allowed the use of some of his field records. Dr. M. M. Ellis has read part of the manuscript Mr. G. C. McFadden, of Havana, has furnished information concerning the topography of the valley. Professor T. E. Savage has furnished maps of the regions studied. Mr. F. E. Wood has given information concerning the mammals. Mr. Herman Douthitt has contributed toward the collections. To each of these gentlemen I desire to express my thanks.

The determination of the animal species has involved the labor of many persons. The bulk of the insect determinations are divided about equally between Mr. Hart, of the State Laboratory of Natural History, and the writer. The large insect collection of this Laboratory, containing, as it does, many previous collections by Mr. Hart from the sand regions, has been of most material assistance. The other determinations have been made by the following gentlemen: Professor T. D. A. Cockerell, University of Colorado; Mr. James H. Emerton, Boston, Mass.; Professor J. W. Folsom, University of Illinois; Mr. A. A. Girault, Brisbane, Australia; Mr. J. D. Hood, U. S. Biological Survey; Dr. George W. Peckham, Milwaukee, Wis.; Professor Charles Robertson, Carlinville, Ill.; Mr. S. A. Rohwer, U. S. National Museum; Dr. Henry Skinner, Academy of Natural Sciences of Philadelphia; Dr. Maurice C. Tanquary, now on the scientific staff of the Crocker Land Expedition; Mr. A. B. Wolcott, Field Museum of Natural History; and Mr. James Zetek, entomologist to the Sanitary Commission of the Panama Canal Zone. These determinations are credited separately in the annotated list.

General Relations of the Illinois Sand Regions

General description of the locality

The locality studied is in central Illinois, in Mason county, in the valley of the Illinois River. There are two vegetation types in Illinois, prairie and forest. In the northern parts of the state the forests are found in belts along the streams, the large rivers having the broadest forest belts. The sand areas of the Illinois River, though located in a wide forest belt, are characterized chiefly by a prairie vegetation, due to a local difference in soil. As will be shown later, the sand prairie differs in many respects from the richer black-soil prairie of

Illinois, and these differences are the combined effects of physical and historical factors.

These sand areas are extensive deposits made by the ancient Illinois River, which was once many times its present size, and by certain of its tributaries. The old Illinois was the outlet of Lake Chicago, of which Lake Michigan is the present-day successor, and it also carried away an immense volume of water from the melting Wisconsin ice-sheet, the terminal moraine of which crosses the river in the vicinity of Peoria. Below the moraine the valley suddenly widens, and the entire left bank of the glacial flood-plain is buried beneath many feet of sand and gravel. The surface of these sand deposits consists of several low, broad ridges of almost pure sand, separated by extensive sandy loam flats. The sand-plain reaches its maximum width, about 14 miles, in Mason county; toward the south it gradually becomes narrower, ending near Meredosia, in Morgan county. It is about 75 miles in length. The total area of sand deposits is about 179,200 acres (Hart and Gleason, '07: 145).

The original vegetation was of three types. The first was the prairie or meadow of the level flats, merging into swamps and bogs in the poorly drained areas; these are now drained, and all of the level country is under cultivation. The second was the sand prairie, which occupied the pure sand of the ridges and dunes. The sand prairie is of two formations: the prairie or bunch-grass formation, in which vegetational reaction upon the environment results in a dominating tendency toward stabilization of the sand, and the establishment of more mesophytic conditions; and the blowsand formation, in which the wind is the controlling factor, resulting in a dominating tendency toward continual shifting of the sand, and the establishment of desert conditions. The third type, the forest, is of comparatively recent development in the sand region, and is confined to the pure sand of the ridges, having replaced the sand prairie over a large part of the dune country. The early stage of the forest is very xerophytic, being composed of black-jack oak, black oak, and hickory. The black oak soon becomes the dominant tree, and a more mesophytic forest is developed—best seen in the dunes along the river (see Pl. V)—composed of black oak, hickory, walnut, hackberry, and a few other trees. Most of the forest area is uncleared.

The original fauna has been greatly modified. Most of the prairie-swamp animals, such as marsh birds, muskrats, frogs, and invertebrates, have disappeared, while the animals favored by cultivation have taken their place. In the sand prairie, the small mammals, the birds, and the insects, have undergone little change. The animals of the

forest are modified considerably. The larger mammals and a number of the birds can no longer be found, and their places are filled by other species which have become more numerous.

GENERAL HISTORY OF THE SAND PRAIRIE VEGETATION

Certain plant ecologists believe that after the close of the Illinois glaciation, and again after the retreat of the Wisconsin ice-sheet, the climate of the interior was extremely arid; that the conifers of the ice margin were succeeded directly by prairie plants of intensely xerophytic nature; and that there was consequently a great eastern extension of the prairie. The mesophytic prairie-grass of the eastern prairie region had not then reached its present development. There was subsequently an increase of moisture in the eastern states and in the Mississippi valley. This resulted in the east, in an advance of the deciduous forest from the southeast, and in the Mississippi valley, in the development of the mesophytic prairie formation. West of this region little or no change from the former arid conditions took place; the xerophytic prairie formation of the sand-hills therefore was changed little if at all. This partial history of the eastern prairies is supported by a mass of evidence which does not properly belong in this account. The evidence is taken from the distribution of relic colonies of western and northern plants, from the present successional tendencies of our vegetation, and from our knowledge of glacial and climatic history.

If we accept this explanation of vegetational changes in the past, we see at once that after and during the Wisconsin glaciation, the xerophytic grassland, which was then at its maximum development, must have covered most of Illinois south and west of the conifer margin, which never extended far beyond the terminal moraine. But it was at about the same time that the sand deposits of the Illinois River, and similar deposits of the Rock River and the Mississippi, were left uncovered by the diminishing streams. The xerophytic prairie was therefore the original vegetation of the sand deposits, for it was the only vegetation near enough at hand for invasion. This prairie was continuous in distribution from its present location in the sand-hills of the West to central Illinois and much farther east. It has persisted in the West because the arid climate has remained unchanged. It has persisted in the sand deposits of Illinois because physical conditions of the soil, evaporation, and exposure have been such as to keep out invaders not adapted to these conditions. The kinship between the sand prairie of Illinois and the sand prairie of the West is shown in the plants and in the animals. Many animals reach the eastern limit of

their range in the Illinois sand areas. Others are not continuous in distribution, but occur in the sand areas and also in the West. Others may have been isolated in the Illinois area, and have become distinct geographic varieties. Enough has been said to show that the sand areas of the Illinois River and similar sand deposits in other parts of the state are in reality local eastern extensions of the sand-hills of the middle region of the prairie province, or, what is nearer the true state of affairs, relic colonies of sand prairie, surrounded by the typical prairie-grass and forest formations of Illinois.

In addition to the xerophytic relic colonies in Illinois, other regions characterized by severe physical conditions point toward the former presence of the eastern extension of the arid prairie. The western element gradually fades out toward the east, and is best developed in the most barren habitats. This element is well represented in the flora and fauna of the sandy shores of the Great Lakes. Jennings ('08 and '09) records from the sand-plain of Cedar Point and Presque Isle, two sand spits in Lake Erie, such western plants as *Opuntia rafinesquii, Andropogon* spp., *Artemisia caudata,* and *Panicum virgatum* and *scribnerianum.* A larger number of western plants, and a very considerable number of western animals, are found at the lower end of Lake Michigan. Several sand regions occur in Indiana, the most extensive being the Kankakee River valley sand area. The principal sand areas in Illinois, aside from the Havana and Lake Michigan regions, are the Kankakee area, along the Kankakee and Iroquois rivers in eastern Illinois; the Amboy area, on the Green River, in Lee county, in which very little sand prairie is left; the Dixon area, in Lee county; the Winnebago county area, now mostly forested; and the Oquawka area and the Hanover area along the Mississippi, in which very extensive tracts of sand prairie are found.

Western relics are found on the xerophytic sandstone outcrops in La Salle county along the Illinois River, and in Ogle county along the Rock River. The outcrop of Sioux quartzite in northern Iowa furnishes xerophytic conditions of plant growth, and in a report on its flora, Shimek ('97) records *Opuntia, Buchloe, Chrysopsis, Bouteloua, Sporobolus,* and other plants of western derivation. All these colonies of plants and animals, a large number of which are derived from the sand prairie, indicate the former presence of arid conditions.

The Physical Environment

TOPOGRAPHY OF THE SAND REGION

Over most of the sand region the topography indicates that other agencies than wind have been at work. The ridges extend in a direction roughly parallel with the river, often being more than two miles across. They rise gradually from the plain, the highest points, near the middle, being usually about fifty or sixty feet above the general level. The surface of the ridges has been modified by the wind into dunes and blowouts, and aside from the general ridge-like form presents the appearance of a typical dune-complex. One line of sand-hills, starting from the marginal sand ridge of the river, a mile or two south of Havana, and extending in a northeasterly direction for four or five miles, presents some slight evidence of pure wind origin. The long axes of these hills lie in the same direction as the whole range, and the hills are usually about forty feet high and a quarter-mile long. The sand composing them is quite pure. The Devil's Hole is one very sandy part of these dunes. Some of the fields in this region having been plowed up, the blowing immediately became so serious that agriculture had to be abandoned, and now the sand that is not blowing is reverting to bunch-grass. The bunch-grass is usually pastured.

The large island between the Illinois and the old channel of the Mackinaw, now occupied by Quiver Creek (see Pl. I) presents the surface configuration of a stabilized dune-complex. On this former island, three miles north of Topeka, is the blowsand region known as the Devil's Neck. This is almost entirely under the control of the wind, and has an area of about 80 acres. A triangulation station of the Illinois River Survey of 1905 (Pl. III, Fig. 2) is situated on one of the highest dunes on the island, about a mile north and east of the Devil's Neck. The top of this dune is seventy feet higher than the trough of a depression not far away, and from the summit an uninterrupted view for miles may be had.

The drainage line of Crane Creek, extending from the Mackinaw valley through the re-entrant northeast corner of Mason county in a southwest direction to the Sangamon River, marks another of the great channels of the ancient stream. The Black-jack Ditch occupies a third broad flat, extending northward from the Sangamon bottomland nearly to Havana. Its northern end is drained by White Oak Run, which flows west into Matanzas Lake. The flats of Crane Creek Ditch and the Black-jack Ditch are covered with the sandy loam soil, and until they were used for agriculture were partly swamp, certain spots having been under water almost the year round. The subsoil is

usually a very porous gravel, and it is thought by some that a hard-pan layer must have been formed near the surface to prevent the water from sinking in. The flats are now drained by dredged ditches, and the area is devoted to agriculture. The map shows the relation of the level areas and the islands or sand areas, and the general appearance suggests the manner in which the floods from the melting glacier spread the alluvial material over the broadened valley. The Mackinaw River has had a share in the work of deposition; its drainage channel may at one time have proceeded by way of Crane Creek into the Sangamon.

The island between Crane Creek on one side and Quiver Creek and the Black-jack Ditch on the other, is not so clearly defined as the one on the other side of Quiver Creek, nor has its northern end been studied. The writer has been through most of its southern half, and the boundaries given on the map for it are fairly accurate. The other large island, lying between Black-jack Ditch and the river, is very sandy, especially near Saidora. The other parts of the same region have not been studied.

PHYSICAL FACTORS OF THE SAND PRAIRIE ENVIRONMENT

The physical factors of a land environment have been classified by Schimper ('03: 159-161) into two groups—climatic (geographic) factors, which operate over very broad areas, and edaphic (local) factors, which effect local modifications of the plant life (and the animal life as well) within any such broad region. The ecological type of the vegetation (whether forest, grassland, or desert) is primarily dependent upon the climatic factors—temperature, rainfall, and humidity of the air. The ecological type of the animal life is also dependent upon these factors directly, and indirectly through adaptation to the ecological type of vegetation; we may, therefore, speak of forest or grassland animals just as we speak of forest or grassland plants. The climate of Illinois favors the growth of the deciduous forest (Gleason, '10: 117; Schimper, '03: 162-175; Transeau, '05). The sand prairie has been able to persist because of the presence of local conditions of aridity.

The local factors to be considered in any regional study are heat, light, water and humidity, wind, soil, and topography. These factors make up what may be called a local environmental complex; they are so closely interrelated that they can not readily be analyzed and classified. It might be well to include them all under the term "physiography", for local environmental conditions are primarily matters of

physiography. The most important physiographical feature of the region studied is the soil. Sand has peculiar physical and chemical properties, which greatly influence the other edaphic factors. These factors may now be discussed in detail.

Temperature variations in sand during day and night and from the surface to the subsoil are great. When the association is open, as it usually is, the insolation is heightened by reflection; heat and light are thus both intense (Gleason, '10:34).

The moisture relations of sandy soils are peculiar. Coarse-grained soils hold relatively small amounts of water; but, on the other hand, more of this water is available to plants than in fine-grained soils. Coarse loose soils dry very readily at the surface; but there is a compensating tendency here, too, as the dry surface-layer forms a mulch which retards further evaporation, so that (in Illinois) there is always considerable moisture in the sand a few inches below the surface. The amount of evaporation therefore depends more upon the degree of openness of the association than upon the kind of soil. It depends upon the temperature of the evaporating surface, the relative humidity of the air, and the velocity of the wind (T. Russell, '88). Quantitative evaporation experiments in plant associations have been carried on by means of porous cup vaporimeters at the Desert Laboratory at Tucson, Arizona, by Livingston ('06) and on Long Island by Transeau ('08). Transeau's work shows that in a given locality the evaporation (at ground level) is greatest in open associations. Dr. F. C. Gates, during the summer of 1910, carried on a number of evaporation tests in the different associations in the Havana locality, and has kindly permitted the use of his results. The figures in the table below express relative amounts of evaporation. These readings extended over most of the month of July.

Relative Evaporation in Associations near Havana, July, 1910

Standard evaporimeter, in sandy flat near marginal dune	1.000
River beach, on dry sand	.933
Bottomland forest across the river (*Salix-Acer*)	.560
Bottomland forest composed purely of *Salix*	.443
Bunch-grass, *Leptoloma* consocies	1.178
Bunch-grass, *Eragrostis* consocies	1.040
Blowout, large bare area	1.270
Black-oak forest	.660
Black-oak forest, beginning of mesophytic stage	.550
Mixed forest, near the center	.293
Mixed forest, near the margin	.356

The standard evaporimeter represents nearly the proportion of evaporation in the sandy loam fields. The surface was sprinkled with a little loose sand which had drifted from the steep lee slope of the near-by river dune. The bottomland stations were flooded during the first part of the experiment; but this probably did not materially affect the reading. The sand-prairie associations tested were at the Devil's Hole, and the forest stations were in the woodland strip just east of there. The mixed forest at this point had not nearly reached the advanced stage of the mixed forest of the marginal dune. An evaporimeter placed there would doubtless show a very low coefficient. The coefficients in the above table vary directly as the openness of the association. The evaporation in one of Transeau's most open associations, a gravel slide, was a little more than three times the evaporation in the mesophytic forest of Long Island. The evaporation in the Havana blowout is more than four times that of the mesophytic forest at Havana. The blowout is probably more exposed than the Long Island gravel slide.* The moisture relations in the Illinois sand areas may be summarized in the statement that the water supply is ample, and that the evaporation depends not so much upon the soil as upon the plant-covering.

The dry surface layer of the sand, in addition to its property of retarding evaporation, has another and more direct effect upon plant and animal life. This layer is practically sterile; seeds can not germinate in it, and must be buried. Certain plant seeds (as those of *Cenchrus*) are armed with hooks or spines, perhaps to hold their position in the sand and keep from blowing about on the surface. These may later be buried by blowing sand and germinate. Other seeds (*Aristida tuberculosa* and *Stipa spartea*) are able to bury themselves, and round seeds have some chance of settling beneath the surface (Gleason, '10: 93). Roots of plants do not branch out until they get below the layer of dry sand. Burrowing animals usually stay beneath the surface layer, which in other soils usually teems with life. To prevent their burrows from caving in, insects and spiders usually line the mouths with silk.

Wind in the sand regions is one of the most important factors. Its carrying power is selective in its action, sorting the sands according to the size of its particles. The blowing of the sand results in continual change of the surface topography, and plants which live under these conditions must be able to resist burying or undermining.

*The writer knows of no evaporation experiments in which readings in forests have been taken *above* the tree canopy. Comparisons between open and forest associations will not be complete until this has been done.

Most of the physical properties of sand are discussed in connection with the other edaphic factors. The chemical properties are also important. Organic matter and mineral substances in solution occur in sand in very small proportions, consequently it is very deficient in plant food. The soil is usually slightly acid, and this tends to keep it poor in nitrogen, as the nitrifying bacteria do not thrive in acid soils. The low content of lime keeps out animals with calcareous shells, such as land snails.

Rain sinks readily into the porous soil, and surface drainage is very poorly developed. No streams at all are found on the sandy islands, and those of the loamy flats are merely sluggish ditches, usually dredged. The map (Pl. I) gives one an idea of the comparative development of streams in sand and in clay. The ground water issues from the sand all along the river bank. The rapid drainage takes away the soluble content of the soil almost as soon as it is formed, and this continual leaching keeps the soil poor, greatly retarding the development of the vegetation.

On the whole, physical conditions are severe in sand prairie, resulting in more or less open associations.

The Plant Environment

local history of the vegetation

In the general account of the sand region, it was shown that the uplands on both sides of the river were covered by a growth of xerophytic prairie, and that this prairie was the first vegetation to invade the sand-bars and islands of the overloaded river. It is probable that a subsequent decrease in the volume of water left many of the shallow-stream valleys mere broad, poorly drained flats. These were soon invaded by the swamp and bog associations, now found in the north, which must have been abundant along the bottoms and bayous of the rivers. Certain relic colonies of the bog associations still persist at the head of Matanzas Lake (Gates, '11b) and along the north shore of Quiver Lake. They are characterized by northern plants, as *Berula erecta, Peltandra virginica,* the fern *Onoclea,* the lizard's tail, *Saururus cernuus,* and others. The old bottom of the Mackinaw River is filled with peat, and the broad level areas were partly grown over with swamp vegetation. The dry parts of the level areas probably developed a xerophytic prairie growth somewhat less open than the bunch-grass of the loose sand ridges.

The arid climate which accompanied the retreat of the glaciers was at about this time gradually changed, the rainfall was materially in-

creased, and the temperature probably became somewhat cooler. It is an unpublished opinion of Professor Gleason that the eastern, or prairie-grass formation, had not developed before the change in climate, and that this gradual change favored the evolution of a mesophytic type of prairie over the whole eastern extent of the province. The uplands on both sides of the river, surrounding the sand-plain, were soon covered with this black-soil prairie, to the exclusion of the older xerophytic type, which was, however, preserved with little or no change on the sand ridges. At the same time, or a little later, hydrophytic members of the present swamp-prairie association appeared on the sandy loam flats and began to compete with the northern bog plants, which gradually gave way to their western rivals, except in a few localities unfavorable to the invaders.

Another far reaching effect of the increase of rainfall and humidity was the spread westward and northward of the deciduous forest, which during the arid period was developed only a short distance north of the Ohio River. The northern migration in the eastern states (Adams, '05) was aided materially by a northward moving wave of temperature increase, which followed the retreat of the ice-sheet. This extension of the forest to the north and west is evidently still in progress, though it is obscured by the clearing of land for agriculture. In the Havana region the forest probably first came in from the southwest by means of the Mississippi and Illinois rivers. The bottomland association was the first forest type in the up-stream migration, willow and poplar being the pioneer species; and this forest type came to occupy a narrow strip along the margin of the sand-plain, and probably the whole new flood-plain of the western edge of the valley. The semi-xerophytic and mesophytic oak forests followed the bottomland type up the Illinois, and spread laterally from the river, replacing to a large extent the black-soil prairie of the uplands. The forest could not at first invade the sand region: the level areas were covered with xerophytic prairie and swamp prairie; the sand ridges in their open condition were distinctly unfavorable to forest growth. In time, however, the xerophytic black-jack and black oak were able to establish themselves on the sand ridges. The succession from bunch-grass to forest is probably still going on very rapidly in the Illinois River valley region. This fact and the records of early explorers lead us to think that the forest invasion is very recent (see Gleason, '10: 120). The manner in which the succession from bunch-grass to forest takes place is not known. Once the forest is well established, the vegetation assumes complete control of the environment, and save for the factor of leaching, the peculiar unfavorable qualities

of sand are no longer operative. The climatic factors of temperature and rainfall since the time of the amelioration of the climate, have made the forest the dominant plant formation of the region. The forest has developed, in certain places on the sand, to a transitional mesophytic stage, which Gleason has called the mixed forest. This is best developed along the marginal ridge, probably indicating that the forest was established along the river first (Pl. V). The forest on both sides of the Black-jack Ditch flat (see Pl. I) has not, over most of its area, developed beyond the black-jack stage. The forests near Manito and Forest City are largely black oak. The climax association toward which the forest development is tending is not known, but it is thought from comparison with the forested dunes at the lower end of Lake Michigan, which have reached the climax beech-maple-red oak stage, that the mixed forest will ultimately develop into the red oak-hard maple forest. The red oak is present now in small numbers, and the herbaceous plants forming the ground cover are more or less indicative of advancing mesophytism.

The development of the sand prairie in its gradually firmer control of the environment may be measured by the increasing amount of humus in the soil, and by the decreasing degree of openness of the vegetation. There are all gradations, from the bare, almost pure, sand of the blowout associations to the dense sod-like structure of the black-soil transition stage (p. 80) with its dark brown soil which approaches a sandy loam. When the bunch-grass approaches its optimum development, the soil has become dark with humus, the dense tufts of grass have crowded together, eliminating almost entirely the spaces of bare sand between them, and the cactus has been almost entirely superseded by grasses. The earlier stages of this successional series take a very long time to complete, and there is constantly the danger of accident resulting in wind control. Over many parts of the sand region the bunch-grass has passed the danger of blowing, and such areas are usually under cultivation at the present time. Much of the country in the neighborhood of the Devil's Neck, among other places, is cultivated, though here and there spots of sand are found which are still subject to wind action. There are a great many hedges in the sand region. These stop the drifting of the sand temporarily, but it soon piles up against the barrier, sometimes even reaching the height of the hedge, burying it and the field beyond. In any event, it does little good to encourage dune formation, as sand is much more easily stabilized when level. Agricultural methods should rather favor a gradual modification of the soil by plowing in the straw (only the head of the grain being removed in harvesting) and by top-dressing

with clay and straw wherever the danger of blowing is greatest. These methods are merely an amplification and a hastening of the natural process of stabilization.

RELATION OF ANIMALS TO PLANTS

The writer's training had led him to the hypothesis that animals and plants in a given terrestrial environment are very intimately related; that plant and animal associations are coextensive and to a large extent interdependent, the animals being entirely dependent upon the plants, speaking broadly, and the plants being partly dependent upon the animals. If this be true, the boundaries of an animal association are those of the plant association; in fact both may be spoken of as a single *biotic* association, composed of plant and animal *assemblages*. Once this relation were established, certain of the problems of animal ecology would be greatly simplified; for although the animal assemblage is at first very obscure, the plant assemblage is evident, giving the characteristic appearance to the area. This physiognomy, lent by the plants, would thus serve as an index to the animals of the association, as regards ecological type, distribution, etc. Then, too, many of the methods of plant ecology, now an organized science, might be used in studying the animals of the association.

This study of the animals of the sand prairie was made with this hypothesis in mind, and the evidence, though very incomplete, is in accord with the theory.* It has seemed justifiable to treat the plant and animal associations together. The associations have already been named by the botanist, usually with reference to the dominant feature, be it physical or vegetational. By the "bunch-grass association" or the "black oak association," wherever the terms occur in the following pages, is not meant the plants alone, but the entire association of plants and animals.

ANNOTATED LIST OF ANIMAL SPECIES†

In this section it has seemed desirable to bring together, as far as possible, such ecological data—on habits, food, life-history, associated forms, etc.—as are significant for each species reported, and accordingly many published sources of information have been freely drawn upon to supplement the observations in the field. Specific ref-

*An analysis of these relations between plants and animals, based on material of this study, has been prepared, and is to be published separately.

†The plants of the sand prairie of the Illinois River valley are included in Gleason's annotated list of plant-species ('10:145-170).

erence to these sources of information is seldom made, since most of the literature is so well known as to make this unnecessary.

In the following list of species, frequent reference is made to the common environments of sand-prairie animals, such as bunch-grass, blowsand, blowout basin, etc. These environments are described with the associations of the same names in the section dealing with the associations of the sand prairie.

GASTROPODA

The acidity of the soil in the sand regions, its low content of calcium carbonate, and other adverse conditions, exclude practically all snail life from the sand prairie. No snails at all were seen during the summer, and in the spring only three empty and worn shells were found. Two of these were aquatic species, and the third was an inhabitant of deep forest, all being utterly foreign to sand prairie. The species were as follows: *Planorbis trivolvis* Say, from a sandy lane at the Devil's Hole; *Campeloma integrum* De Kay, from a sandy roadside east of Havana; and *Pyramidula solitaris* Say, from a blowout at the Devil's Neck. (Determined by J. Zetek.)

Order OLIGOCHAETA

Diplocardia sp. (indeterminable). April 4.

One specimen taken under a board with *Lithobius* and *Lacon rectangularis,* in bunch-grass; and another, probably of the same species, found in a similar situation on another dune. Earthworms, besides eating small living organisms, feed on the organic part of the soil; and as sand has a very small humus content, earthworms are very rare in it. The humus present may be due largely to the decay of boards or logs.

Order CHILOPODA

Lithobius sp. (indeterminable). April 4, 5.

One specimen taken under a large board near a dune summit. The soil had quite a little humus, indicating rather an advanced stage of bunch-grass. Another, taken from under a log at the edge of a field. Centipedes are very rare in the sand prairie, the soil conditions being unfavorable. The genus is predaceous.

Order DIPLOPODA

Parajulus sp. (indeterminable). April 6.

Several specimens in a non-typical part of the Devil's Hole bunch-grass. Considerable humus was in the soil. The scarcity of organic

material in the sand normally keeps millepeds out of the sand region. *Parajulus* is probably a scavenger.

Order PHALANGINA

Phalangiinae, sp. (indeterminable). April 1.

One immature "harvestman," taken in a mullein plant. Mature specimens were seen in 1910, but none were collected. Hart found *Liobunum vittatum* Say common on mullein in the Havana region.

Order ARANEINA

Xysticus gulosus Keyserl.; Emerton, det. April 1, 4.

A common brown crab-spider, taken hibernating in mullein along the border of a field, and also under a board in bunch-grass southeast of Havana. A widely distributed species, usually found under cover. Other *Thomisidae,* unlike *Xysticus,* are usually found in flowers, where they lie in wait for insect prey. The common genus *Misumena* is probably represented in sand prairie, in flowers.*

Drassus sp. (indeterminable). April 4.

The *Drassidae* are common spiders which roam about in search of insect prey. They do not spin webs and are inclined to be of nocturnal habit. One immature specimen, from under a board in bunch-grass.

Steatoda corollata Em.; Emerton, det. April 1, 4.

A common and widely distributed species of the family *Theridiidae.* These are usually small spiders which build irregular webs. Found hibernating under boards in bunch-grass, and along the border of a field. The specimens taken were all quite young.

Euryopis funebris Em.; Emerton, det. April 1.

A common and widely distributed species. Immature specimen, taken in a sheltered place at the border of a cultivated field.

Epeira stellata Walck.; Emerton, det. October 8.

A small specimen, taken in the blowsand of the Devil's Hole. The orb-weavers, or *Epeiridae,* build large spiral webs in herbaceous growth, and entrap insect prey by this means.

Lycosa missouriensis Banks; Emerton, det. June 28, October 8, April 8.

This large lycosid is found in several associations of the sand prairie. A female was dug from a burrow in June, a male was taken

*An immature specimen of *Misumena* has since been taken at the Devil's Hole (August 22, 1913) in flowers of *Cassia.*

at the edge of a blowout in October, and a number of females were dug from burrows in April. The males are found only in fall or late summer. All of these were from the Devil's Hole. They hibernate in their burrows and eggs are laid in spring. The egg-case is carried about attached to the female. The burrows are vertical, about half an inch in diameter, and are usually capped by a small turret, particularly when located in bunch-grass. About half-way down, the burrow enlarges into a fusiform chamber. Some of the burrows reached a depth of twenty inches. Beetle remains were sometimes found in the chambers. This spider is a dominant bunch-grass species. It is abundant in the sand-dune region of the Great Lakes. It is reported also from New Jersey, Texas, and Utah. This species has been confused with *L. arenicola* and *L. domifex*. Emerton determined the specimens as *L. missouriensis;* this in Chamberlin's revision of the genus is synonymous with *L. fatifera*. It is quite abundant in the Devil's Hole and is one of the dominant species. It is known from Alabama, Georgia, Texas, Missouri, Kansas, Illinois (also in the Lake Michigan region), and Utah.

Lycosa erratica Hentz; Emerton, det. April 8, 9.

A common and widely distributed species. It is conspicuously marked with gray and black. Found running about in bunch-grass. It is of a roving habit; one specimen, however, was found in the burrow of another lycosid, probably to molt, as a recently cast skin was found near the top of the burrow.

Lycosa wrightii Em.; Emerton, det. April 7.

One specimen, dug from burrows in bunch-grass dune north of Devil's Neck. This species has only recently been described (Psyche, 19:25-36, April, 1912), although it has long been known. It is also recorded from the sandy shores of Lake Michigan and Lake Erie.

Lycosa (*Geolycosa*) sp. (indeterminable). April 7.

One specimen, resembling *Lycosa fatifera,* dug from burrow in bunch-grass dune north of the Devil's Hole.

Attidae, sp. (indeterminable). October 8.

Taken on plants at the Devil's Hole. The jumping spiders run jerkily and jump to and fro on the stems and leaves of plants, in search of insect food. One *Phidippus* taken along the roadside was eating a fly, perhaps *Lucilia caesar*. They are very common spiders.

Phidippus insolens? Hentz; Peckham, det. April 4.

One specimen, found dead inside a silken case under a cactus lobe, on a bunch-grass dune near Havana. Hart records the species

as very common in blowsand and on dune summits. Resembles female mutillids.

Phidippus audax Hentz; Peckham, det. April 4.

A black species with orange spots; quite common hibernating under cactus lobes on a dune summit.

Phidippus ardens Peckham; Peckham, det. June 28.

A male jumping spider, taken running about on the bare sand in the bunch-grass association.

Phidippus mc-cookii Peckham; Peckham, det. October 8.

A jumping spider with red abdomen, taken in a blowout, close to the *Cassia* growth. The specimen is a male.

Order ACARINA

Microtrombidium locustarum Riley. July 19.

This small red mite is a very common parasite of insects, particularly grasshoppers. Several specimens were taken on grasshoppers from blowsand at the Devil's Hole. Observed also on *Asilidae, Tachinidae,* and other insects of the sand prairie.

Order COLLEMBOLA

Entomobrya sp.; J. W. Folsom, det. April 1.

Found under logs in sand with considerable humus content. Another collembolan was found in pure or almost pure sand, but no specimens were captured.

Order PLATYPTERA

Termes flavipes Kollar. July 25, April 1, 4.

The termites are very abundant in sand regions, where they are found under boards. They eat wood tissue, and logs in the woods are often found with most of the interior eaten out. Several colonies containing workers, soldiers, and winged forms were found in April. They are common in the Lake Michigan sand region and on the dry soils of southern Illinois. Widely distributed.

Order EPHEMERIDA

Hexagenia bilineata Say. July 6.

A dark-colored May-fly of large size; wings clouded and dark in color. This is the most abundant May-fly in the river. The residents

call them "willow-bugs", as the full-grown nymph crawls up on the trunks of the willows of the flooded bottoms to cast off the pupa skin and emerge as adult. The tree trunks are often covered with these exuviæ. The adults fly actively about at night, and their numbers are so great that the heaps of dead willow-bugs accumulated under the arc lights have had to be hauled away in wagon-loads. Several species of *Ephemerida* are very numerous in early summer at the Devil's Hole; they probably form an appreciable element in the food supply of predaceous insects.

Hexagenia variabilis Say. June 25.

A rather large May-fly with yellow wings. Very common throughout the sand region in the breeding season. The larvæ are very numerous in the river. The adults are found as far as three miles from the river.

Order NEUROPTERA

Chrysopa oculata Say. August.

The "lace-winged fly", a common and widely distributed species. The larvæ are known as "aphis-lions", and roam about on plants in search of plant-lice, from which the juices are extracted by means of the mandibles. The eggs are laid on long stalks. No specimens were taken, though several were seen. Hart took it at the Devil's Hole.

Cryptoleon signatum Hag. June to August.

This species was seen, but no specimens were captured. Hart found it very common in different parts of the sand regions. No other Illinois records.

The larvæ of the *Myrmeleonidae* dig pits in loose soil and lie in wait at the bottom for insects to fall into the trap. These pits are common in sand, wherever there is protection from wind.

Two other myrmeleonids taken by Hart were not formerly recorded from Illinois. These are *Brachynemurus irregularis* Currie and *Myrmeleon immaculatus occidentalis* Currie. The family reaches its highest development in the southwest.

Order ODONATA

Ischnura verticalis Say. July 8.

One specimen, taken at the Devil's Neck in bunch-grass. Dragonflies are very abundant in the bunch-grass areas, even as far as several miles from the river, which, with its lowlands, is their principal breeding-place. They form a derived element in the bunch-grass.

Being predaceous, they exert a considerable influence upon the insect life of the sand prairie.

Erythemis simplicicollis Say. July, August.

This dragon-fly is the most abundant species of early summer in the river district. It is very commonly seen at the Devil's Hole, and is an important predaceous species of the bunch-grass.

Sympetrum rubicundulum Say. July 3.

This dragon-fly is infrequent in sand prairie. One specimen was taken in the bunch-grass pasture at the Devil's Hole.

Perithemis domitia Drury. June 28.

Rather a common species, taken in bunch-grass at the Devil's Hole.

Order ORTHOPTERA

Ischnoptera sp. (indeterminable). April 4.

In decaying log at the edge of the bunch-grass association. Probably *inaequalis* Sauss.-Zehnt. All were nymphs. This is a forest species; none of the *Blattidae* are typical sand-prairie forms.

Family *Acrididae*

The *Acrididae,* or locusts, are the dominant group of the *Orthoptera.* They usually hatch in spring and mature in summer, reaching their maximum development late in summer. The food is almost entirely vegetable, principally grasses. Some of the locusts are migratory. Those living in open plains usually have better powers of flight than the locusts of thickets or forests. The *Acrididae* are diurnal, non-social, and short-lived. They do not build nests or dig holes; they have not a high order of insect intelligence. They are active only in the most favorable season. We may say that their habits are very simple; they have taken the simplest means to solve the problem of existence. The locusts are best developed in warm climates. In North America they are commonest in the southern and southwestern parts, and in the prairie region. They are very sensitive to local environmental differences, so that the species are good indices in local distribution studies.* Terricolous species (those which are found usually on the ground, not on the plants) are more suited to dry treeless areas, in which the bare soil is considerably exposed. The *Acrididae* have very many enemies—mites, predaceous beetles, flies and wasps, birds, reptiles, and mammals. They are one of the important sources of animal food supply.

*The agreement in local distribution of grasshoppers and plant-communities is the subject of a recent paper by the writer (Vestal, '13).

Tettix ornatus Say. April 8.

A member of the subfamily *Tettiginae* or grouse locusts. The food is mainly vegetable. Most of the grouse locusts are of northerly distribution. Found at the bottom of a hollow in the bunch-grass. Terricolous. The peculiar life history of the grouse locusts (they hibernate as adults) may possibly be an adaptation to conditions in the north, where the growing season is shorter. It may also remove them from competition with the more dominant locusts, which are most active later in the season. This species is not typical of bunch-grass.

Tettix hancocki Morse. April 4, 8.

Found in the bunch-grass, and with the preceding species. Much more abundant in the sand prairie, though still not a typical species. Of northerly distribution.

Mermiria bivittata Serv. July 6, 19, October 8.

Like the other members of the subfamily *Tryxalinae*, this species is herbicolous (living much of the time upon plants) and flies strongly. Found in the Devil's Hole, usually in the longest and driest grass. It is probably never found in bare sand. A typical bunch-grass species, of western distribution.

Mermiria neomexicana Thom. July 29.

Habits and local distribution similar to those of the preceding species. It is more restricted to the western regions, is smaller, and not so commonly found in the Illinois sand regions. Hart's record is the first for Illinois.

Syrbula admirabilis Uhl.

This species, quite common in the drier parts of Illinois, was not taken at Havana, probably for the reason that it is abundant at a time of year when no collecting was done. Mr. Hart found it in the sand regions in the middle of August.

Eritettix sp. (undescribed). April 1, 8.

Thought by Mr. Hart to be a new species. (Cf. Hart and Gleason, '07: 231, 259.) Nymphs common in bunch-grass at the Devil's Hole in spring. The eggs probably hatch very early in the season, as the specimens found were too small to have wintered as nymphs.

Ageneotettix deorum Scudder. July 19, October 8.

Taken as early as July 6. The habits are more like those of the *Acridiinae*, as it depends less upon its wings and more upon its power of leaping. It has also a terricolous tendency. It is a western spe-

cies, occurring east only as far as the Lake Michigan sand region. It is a common bunch-grass species.

Amphitornus bicolor Thom. July 8.

Taken at the Devil's Neck on a high grassy dune. A very active species. This is one of the most typical plains species, and has formerly been recorded only from the western states, Montana to Texas.

Arphia sulphurea Fab. June 6, 7, 9, 23.

One of the *Oedipodinae,* which are terricolous. A common and widely distributed species, rare in sand prairie, however. The winter is passed in the nymph stage. The adult state is reached as early as May 1 according to Blatchley, and the species remains active till about the middle of July, when it is replaced by *Arphia xanthoptera.*

Arphia xanthoptera Burm. July 25, October 8.

Taken at border of forest at Matanzas Lake, and at the Devil's Hole in bunch-grass. This species is similar to *A. sulphurea,* its close relative, in habits and distribution. It is, however, larger and of stronger flight. The chief difference is in time of appearance, and there seems to be a mutual adaptation in this respect. *Sulphurea* winters in the nymph stage; *xanthoptera* does not become adult till the other species is nearly gone. There is therefore no competition between the two species, which otherwise might probably be keen rivals. Certain other species show very similar seasonal distribution, and it is thought that this may be explained in terms of removal from competition. Neither of the two species is typical of bunch-grass or sand prairie. One specimen of *xanthoptera* had evidently run into a plant of *Opuntia,* for a number of the spines and thorns were stuck into the joints of the legs and in the neck joint.

Chortophaga viridifasciata De Geer. April 1.

The winter is passed by this species in the nymph stage. The locust is mature from April 15 till November 1, according to Blatchley. It is the first locust to reach maturity in the spring. It is an unusual species, very widely distributed geographically, and thrives in a great variety of habitats. It has no close relative. Two nymphs were taken in the bunch-grass, but it is not typical of sand prairie.

Hippiscus phoenicopterus Germ. July 5, 19.

Common in bunch-grass. Winters in the nymph stage. It matures probably late in May. There is a time adjustment with species of *Hippiscus,* much as in *Arphia. H. tuberculatus* is the earliest, followed by *phoenicopterus* and *haldemanii,* which in turn give place

to *rugosus*. The data are too scanty, however, to allow important conclusions, and these would be of no particular significance in this discussion, as *tuberculatus* is only accidental in the regions, and *rugosus* is by no means common. *Phoenicopterus* is a dry grassland species of southern distribution; it is not a distinctive sand species.

Hippiscus haldemanii Scudder. July 19.

This species winters in the nymph stage. The seasonal relations to other species have been discussed under *H. phoenicopterus*. The species is probably restricted largely to sand. It is found in the bunch-grass, and not in blowsand. Not nearly so common as *phoenicopterus*. It is a Great Plains species, found in the states east of the Rockies.

Hippiscus rugosus Scudder. August.

This species winters in the egg stage, appearing later in the season than the two preceding. It ranges east of the Rocky Mountains, and is probably more abundant in the eastern part of its range. Taken at the Devil's Hole in bunch-grass, by Mr. Hart. Like many other species, *rugosus* is found in many kinds of dry habitats in the South, but in the northern part of its range, it is confined to isolated areas of sand.

Dissosteira carolina Linn. August.

A common species of roads, but is not found in bunch-grass or bare sand areas in the Havana region. This is rather surprising, for at Grand Tower, Illinois, it was regularly found on the sand-plain of the river beach. Those found on sand were conspicuously lighter in color than others, found on black soil.

Spharagemon wyomingianum Thom.

A very common terricolous species of the bunch-grass. Probably the dominant member of its subfamily. It winters in the egg stage, and is mature from the middle of June probably until frost. A very widespread species, showing great geographic variation. In the northern and eastern part of its range the species is confined to sandy localities. It is not found in blowsand or blowouts. In the eastern part of its range it probably is more important than in the plains region, because in the east it is free from the competition of other species adapted to arid conditions.

Mestobregma thomasi Caud. July 19.

A common terricolous bunch-grass species. It is a rather active species, of western distribution. A late summer form. It is common

on the dry soils of southern Illinois, but toward the north becomes restricted to sand.

Psinidia fenestralis Serv. July 6, 19.

This species is restricted to sandy areas; it is an eastern species, not common west of the Mississippi. In the bunch-grass no species of the *Oedipodinae* but *Spharagemon* outnumbers it. It occurs at times in blowsand. In the Havana region it is much more abundant than it would be in similar associations farther west.

Trimerotropis citrina Scudder. July 8.

This species is most commonly found on the sandy shores of large rivers, and on the shores of the South Atlantic and Gulf States. It occurs also in the interior in sandy or sparsely vegetated arid places. One specimen, from the Devil's Neck, in bunch-grass; Hart took one at the Devil's Hole. Not a typical bunch-grass species.

Schistocerca alutacea Harris. July 19, October 8.

This large locust is mature from late July till frost. It occurs east of the Sierra Nevadas, and is of scattered distribution, being more common in the southern part of its range. Restricted to sand northward. In the Devil's Hole it is seldom seen far from blowsand, being abundant in bunch-grass apparently only in the more sparsely vegetated areas. It is terricolous.

Campylacantha olivacea Scudder. July 19, October 7, 8.

The species is herbicolous and short-winged. In southern Illinois it is abundant on *Ambrosia bidentata,* but in the Havana area it does not seem to be confined to any one plant. A typical western species, found towards the north and the east in sand. In the Havana area it is confined to bunch-grass.

Melanoplus flavidus Scudder. July 19, October 8.

Mature from July till frost. It is found from Illinois and Montana to Texas and Arizona (Scudder). Widespread geographically, but restricted locally to sand that is almost bare—blowsand and the bare basins of blowouts. In this region it is the most characteristic locust of the bare sand. It is a terricolous species. *Flavidus* was very scarce in 1910, though Hart found it abundant in former years.

Melanoplus atlanis Riley.

Not found in true bunch-grass or blowsand. Not rare, however, in other parts of the sand region. In southern Illinois it is the dominant locust of the lower Illinoian glaciation. All summer.

Melanoplus scudderi Uhl. April 4.

One dead specimen, from under log along fence bordering bunch-grass. A late autumn locust, mature from August 5 to November 22. It is thus able to withstand quite severe frosts. As it is short-winged it is probably sedentary in habit. It is found in borders of open woods, fence-rows, and dry grassy situations. Not a typical bunch-grass species. Its range is "United States east of Great Plains" (Scudder).

Melanoplus femur-rubrum De Geer. July 23, April 4.

Common along roadsides and in cultivated fields. Totally wanting in bunch-grass or blowsand. Found only where a certain amount of humus and clay occurs in the soil. All summer. This is the commonest *Melanoplus* in northern Illinois prairies. In the sand prairie it is replaced by *M. angustipennis.*

Melanoplus angustipennis Dodge. July 19, October 8.

This is the most abundant and most characteristic locust in the bunch-grass. Common throughout the sand region, from July until frost. *Angustipennis* is a western species, and was formerly quite rare, but of late years has been increasing in numbers in the West. Its range is from Indiana to Montana and south through the plains region to Texas. This insect is the chief plant-eater in the Illinois sand prairie, and is probably of greater importance in the association than any other species. It is one of the very destructive species of the genus. It is also found on blowsand and in the margin of blow-outs.

Melanoplus differentialis Uhl. July 25.

Common in sandy loam flats and along roadsides. Coextensive with cultivation, but very rare in the native blowsand or bunch-grass areas. Two were found in the Devil's Hole region just east of the walnut grove.

Melanoplus bivittatus femoratus Burm. July 25.

Taken in two places where conditions indicated the presence of an advanced stage of sand prairie. The first place was a pasture near Matanzas Lake; the second, a small area east of the black-oak woods near Quiver Station.

Scudderia texensis Sauss.-Pict. July 12, July 19.

The eggs of this katydid are inserted at the edge of leaves. The adults are active from mid July or earlier till frost. Most of the katydids are arboreal, but this species is not to any great extent. At the Devil's Hole they are found in the bunch-grass quite a distance

from any trees. Herbicolous. It has been taken in blowsand, but is more typical of bunch-grass, where it is fairly common.

Ceuthophilus sp. (indeterminable). April 1.

This genus comprises wingless underground or cave crickets. The species are probably omnivorous, and are nocturnal in habit, hiding by day in the ground or under logs. A number of species are found in the plains region; others extend over the eastern states. The one specimen taken is a nymph; others were seen during the previous summer upon digging up the burrows of mammals. The *Ceuthophili* are an isolated group of peculiar habits, thus occupying an unusual place in the association. They are seldom abundant.

Conocephalus robustus Scudder. July 19.

This genus is more or less campestrian. The eggs are laid in grass leaves, and the adults, when resting head downward on a grass stem, closely resemble a grass leaf (Hart). The stridulation is very loud and shrill, usually occurring at twilight. The species is found in the northern states east of the Rocky Mountains (Scudder). Blatchley says that it occurs only along the Atlantic coast and the shores of the Great Lakes. Lugger found it near the shores of Lake Minnetonka and White Bear Lake. The species is probably typical of dry or sandy habitats, and is not restricted to bunch-grass.

Gryllus abbreviatus Serv. April 4.

Dead specimens taken under logs in bunch-grass. This field cricket is nocturnal and omnivorous in habit, even cannibalistic, according to Blatchley. Found in open fields usually under shelter of some kind. Much more common in other regions than in the sand prairie.

Oecanthus confluens Hart MS. July 6.

The eggs of the tree-crickets are inserted into the stems of tall herbaceous plants, usually composites. The eggs hatch in May or June; the insects are mature usually in July. The young œcanthids feed upon aphids or plant-lice. The insects usually stay upon the plants which they frequent. They are to a large extent nocturnal.

Order THYSANOPTERA

Anthothrips verbasci Osborn. April 1.

The common mullein thrips. It occurs regularly on *Verbascum* along roadsides. Not typical of sand prairie.

Order HEMIPTERA

Tettigia hieroglyphica Say. July 3, 8, 12.

This small cicada was quite common in bunch-grass at the Devil's Hole and the Devil's Neck. In former years it has been much less abundant. A large robber-fly *Proctacanthus rufus,* was taken at the Devil's Neck with a cicada in its grasp. The *Cicadidae* are normally forest insects, but this species is probably one of open plains. It ranges from the foot-hills and plains of the southwestern states as far east as New Jersey, where it is found in sandy pine-barren regions. It has not been taken in Illinois except in sand.

Enchenopa binotata Say. June 25, July 25.

A common species, usually found on the hop-tree, *Ptelea trifoliata.* Taken on Osage orange near the Devil's Hole, and on the hop-tree near Matanzas Lake.

Scolops grossus Uhl. October 8.

Taken at the Devil's Hole by sweeping in bunch-grass. A common and generally distributed species of grassland, ranging from the western states to the Atlantic border. It is not abundant in the eastern part of its range.

Ormenis pruinosa Say. July 8.

Taken on Osage-orange hedge beside a sandy road east of the Devil's Neck. A common and generally distributed species.

Agallia sanguinolenta Prov. April 4.

Abundant under logs in bunch-grass pasture southeast of Havana. Common in the western states, ranging east to the Atlantic border.

Typhlocyba comes Say. April 1.

This common jassid is known as the grape leaf-hopper. In the Urbana region it is found in early spring under logs in the woodlands. Near the Devil's Hole it was found under logs at the border of a cultivated field.

Fitchia aptera Stål (*nigrovittata* Stål). April 9.

Taken on southern slope in very open bunch-grass at the Devil's Hole. A single wingless specimen. A typical plains species, ranging east to the Atlantic states. The only record from the Illinois sand region.

Sinea diadema Fab. June 20, July 19, October 6, 7.

A large and powerful reduviid, which preys upon a variety of insects. It is usually found on plants or flowers. Taken at the Devil's

Hole in bunch-grass and in blowsand. They have been taken on *Kuhnia,* and on *Cassia* one was seen eating a ladybird beetle, *Coccinella 9-notata.* A very widely distributed species, from the plains to the Atlantic border. Common in many habitats.

Reduviolus ferus Linn. April 8.

Probably our commonest nabid. The species feeds upon small insects, usually immature stages. Common in herbaceous growth; it is often found taking shelter under logs. A Devil's Hole specimen was taken on the sand in bunch-grass. The species occurs over practically the entire United States; it is also widely distributed in Europe.

Adelphocoris rapidus Say (*Calocoris* Fieber). October 8.

Found in bunch-grass sweepings with the following species, which it resembles closely in habits. Very common in black-soil prairie and in cultivated fields, but rare in sand prairie. Widely distributed.

Lygus pratensis Linn. October 6, 8, April 1.

A very common and widely distributed capsid. These insects are plant feeders exclusively. Taken at the Devil's Hole on *Kuhnia* and in bunch-grass sweepings. The species is very much less common in sand prairie than in cultivated fields and in black-soil prairie.

Poecilocapsus lineatus Fab. June 20.

Taken in a cultivated field on plants. Habits similar to those of *Adelphocoris* and *Lygus;* the species is not so common, however.

Phymata fasciata Gray (*wolffi* Stål). July 23, 29.

The common "ambush bug"; frequently found in flowers, lying in wait for insect prey, which is seized and held by the powerfully developed front legs. An insect primarily of open places and forest margins. Taken on *Pycnanthemum* at the edge of woods near Matanzas Lake. One specimen from the Devil's Hole, on *Cacalia.* Rare in sand prairie. This species is of eastern distribution; other species in the western states are more typical of prairie.

Piesma cinerea Say. June 24.

A small tingitid species, quite common and widely distributed; taken in herbaceous growth along a sandy roadside.

Lygaeus bicrucis Say (*Melanocoryphus* Stål). July 29.

A widely distributed species, occurring on *Cacalia atriplicifolia,* on which it is very abundant at the Devil's Hole, and throughout the sand prairie. All the *Lygacidae* are plant feeders. More common in dry or sandy localities.

Lygaeus kalmii Stål. July 12, April 4, 5.

Found quite commonly on *Apocynum* with *Chrysochus auratus*, in an abandoned field at the Devil's Hole. Taken in spring under a cactus lobe in bunch-grass, and under a log at the edge of a cultivated field. One of the commonest members of its family, ranging from the plains and the southwestern states to the Atlantic coast. It is commonest in the eastern states.

Oncopeltus fasciatus Dallas. July 23.

Taken on *Asclepias syriaca* at Matanzas Lake, and also in herbaceous growth on the forested marginal dune south of Havana. Ranges from the southwest to the Atlantic states, and is almost always associated with the milkweed.

Ligyrocoris diffusus Uhler (*sylvestris* Stål). October 8.

One specimen, swept from bunch-grass. A widely distributed species, usually found in grassy situations. Not characteristic of sand.

Geocoris bullatus Say. April 1, 7, 9.

Species of *Geocoris* are often found crawling about on sand in sparse vegetation. Taken in bunch-grass at the Devil's Hole, and in blowsand at the Devil's Neck. Common along the Atlantic coast, and found as far west as Colorado. A typical species of sand.

Microtoma atrata Goeze. April 5.

This black lygæid is the single representative of its genus, and is of wide distribution. One specimen, taken under a board at the edge of a field.

Corizus sp. (undetermined). April 1.

Taken under a log at border of cultivated field. The *Coreidae* eat both animal and vegetable matter, particular species doubtless inclining in one of the two directions. This species is probably predaceous in large part.

Alydus sp. (undetermined). July 5.

Coreids of this genus have while immature a remarkable superficial resemblance to ants. The specimens taken were all immature. They were found in the *Cassia* belt of blowsand and in a small blowout, and in bunch-grass. Hart records three species of *Alydus: pilosulus* H.-Schf., *conspersus* Mont., and *eurinus* Say. The genus is found usually on dry or sandy ground, in sparse vegetation, and ranges from the plains to the Atlantic region. *A. pluto* and *A. setosus* are confined to the western states. Probably a predaceous species.

Stachyocnemis apicalis Dallas. July 5, October 6, 8.

Common in the basin of small blowouts and in the *Cassia* growth in blowsand; all summer. One of the few characteristic basin animals. It is probably always found in sand, and has a very wide range,—California to Florida, and from the Great Plains to the northern Atlantic states. The only species of the genus in North America at least. Its wide range is probably due to freedom from competition. No other species is closely related to it either taxonomically or in habits, and in its open habitat there are few other species to compete with it. There is no direct evidence as regards the nature of its food, but the species is probably predaceous.

Charicsterus antennator Fab. August 12, 15.

Taken by Hart quite abundantly, usually on *Euphorbia corollata*. Occurs from the southwestern states and the plains region to the Atlantic border.

Cosmopepla carnifex Fab. June 24.

The food of the *Pentatomidae* is both animal and vegetable. *Cosmopepla* is probably a plant feeder. On *Scrophularia* in the blackjack woods and on other plants along roadsides. Near Urbana a number of the insects were taken on *Linaria canadensis* (toad-flax), a ruderal plant. A common and generally distributed species.

Euschistus variolarius Beauv. October 8, April.

One of the commonest and most generally distributed pentatomids. Found in bunch-grass on *Kuhnia* in the fall; under boards in spring. Devil's Hole and Devil's Neck. It is a plant feeder.

Hymenarcys nervosa Say. April 4.

Taken in bunch-grass on a dune southeast of Havana, under a board. Probably a predaceous species. Ranges from the plains region to the Atlantic border. A species of open areas and forest margins.

Pentatoma persimilis Horvath (*juniperina* Van Duzee). October 8, April 1, 4, 9.

This is the characteristic pentatomid of the sands in Illinois. Its distribution is principally northern, and in the Lake Michigan sand regions it is associated with the dwarf cedar (*Juniperus sabina*), a northern plant. It has been recorded from two localities in Colorado, however, and other species of the same genus are found in the West and Southwest, so that the genus is typically of western distribution. It is a plant feeder, and is associated most closely with *Opuntia rafinesquii*. Hart says it punctures the tip of the fruit. It

is also found on *Chrysopsis, Kuhnia, Ambrosia psilostachya, Lespedeza capitata,* and grasses. The winter is passed in sheltered places. In April it has been taken crawling about on sand, and also under cactus lobes and boards. It is a typical bunch-grass species.

Peribalus limbolarius Stål. October 7, April 1, 4.

One of our commonest and most generally distributed pentatomids. It is a plant eater. Found on *Kuhnia* in the bunch-grass, and under logs and cactus lobes in April. Much less common in the sand than in open areas of different soil type.

Perillus circumcinctus Stål. July 8.

This pentatomid is found in the sand regions on *Rhus canadensis illinoensis.* Hart found it very abundant in former years, but in 1910 only one specimen was seen. John B. Smith reports it as being predaceous upon beetle larvæ. The members of this subfamily feed upon chrysomelid larvæ. *Blepharida rhois,* a chrysomelid, usually abundant on *Rhus* also, has a larva which feeds on the leaves. It is therefore quite probable that *Perillus* preys upon the larvæ of *Blepharida.* The fact that *Blepharida* was also rare in 1910 (none being seen) would seem to confirm this inference. *Perillus* has a very wide range—Nebraska, Missouri, Canada, Dakota, New England, Panama, and the island of Trinidad (Uhler). Other species of the genus are found in the Southwest and in Mexico.

Cydnus obliquus Uhl. April 8.

This insect and others of the same family are commonly found in sand or mud banks. The legs are formed for digging. The species ranges from the Rocky Mountains to the Atlantic coast. Two specimens taken crawling on the sand in open bunch-grass at the Devil's Hole. Hart took one specimen at the Devil's Neck.

Sehirus cinctus Beauv. April 8.

This genus is represented by a single widely distributed species. One specimen was taken crawling about on the sand. Hart took one specimen at the Devil's Hole on *Monarda punctata.* The cydnids hibernate as adults, probably burrowing in the sand.

Thyreocoris ciliata Uhler (*Corimelaena* White). June 25, October 8.

A western "negro bug." Very abundant on *Cassia* in blowsand, and about the roots of blowsand plants. Found on interstitial plants in the bunch-grass. At times they were fairly swarming on the *Cassia.* One of the distinctive blowsand animals. Not found in Illinois except in sand regions.

Thyreocoris nigra Dallas. April 8.

This larger species is rare in the sand region, being more typical in black-soil prairie and cultivated fields, where, however, it is not so common as *T. pulicaria.* Only one specimen was found, in addition to a nymph taken the July before, which was of doubtful determination. Found crawling about on sand in the bunch-grass. *Corimelaenidae* pass the winter in the adult stage. The range of this species is northern.

Order COLEOPTERA

Family *Cicindelidae*

Tiger-beetles

The family *Cicindelidae,* the first family, taxonomically, in the *Coleoptera,* consists of a large number of predatory beetles which are surprisingly quick in their movements, both in running and flying. By far the greater number of them belong to the genus *Cicindela.* These are really beautiful beetles, with metallic colors and variable elytral patterns. Aside from size and color, the Cicindelas vary hardly at all in general appearance. The mandibles are large and powerful.

The eggs are laid in small vertical holes in the soil. The females of each species select definite types of soil, with regard to slope, moisture, amount of humus, etc. The larvæ, which generally do not leave the spot where the egg was laid, enlarge their burrows as they grow. They pass through three stages, hibernating in the last, become active again the following spring, pupate in summer; the adults emerge in the fall, hibernate and come out the second spring, become sexually mature late in spring or early in summer, lay eggs and die (Shelford, '08). The life history varies to some extent with the different species, but for most, two years is required for the complete cycle. One or two species require only a year. *Cicindela purpurea* lays about 50 eggs.

The food of the larvæ consists of myriapods, spiders, insects (adult or larvæ) of all kinds, or any other small animals that come within reach. The larvæ can live without food for over two weeks. They lie in wait for their prey, with head concealing the mouth of the burrow. They catch insects that are very large in proportion to their own size, the dorsal hook helping to prevent their being dragged from the burrow. When conditions are unfavorable as to moisture relations or temperature the larvæ of several species migrate; but the greater number merely dig their burrows deeper. If matters do

not improve they die. The majority never get beyond the larval stage.

The adults run and fly swiftly, being able to catch the swiftest insects. When disturbed, they run rapidly away, stopping suddenly. If pressed, they take wing, flying low and stopping suddenly as before. It takes a trained eye to follow their movements. The adults of most of the species are terricolous, always being found on bare ground. They take shelter during the night in holes dug in the sand, under bark, stones, etc.

The western and southwestern parts of North America present optimum conditions for the development of the *Cicindelidae,* and there they are most abundant and varied, though many species are widely distributed. The tiger-beetles are also well represented on other continents.

The peculiar preference of the females for certain kinds of soil for egg-laying results in rigid habitat restrictions. The most common habitats are sandy roads and fields; shores of rivers, lakes, and the ocean; mud flats; and bare rock or clay exposures. The beetles are found in habitats usually occurring only locally; hence their geographic distribution, though extensive, is discontinuous.

Bombyliid flies parasitize the larvæ of certain species; a few birds may be rapid enough to capture the beetles; and the lizard *Cnemidophorus sexlineatus* is reported to catch and eat them. The larvæ, being sedentary, are much more subject to attack, and many kinds of predaceous animals doubtless eat them. It is probable that physical conditions are the greatest natural check, rather than predaceous or parasitic animals.

The *Cicindelidae* are dominant forms among insects. They are characteristic of open formations, usually where the ecological influence of vegetation is subordinate to physical conditions of the environment. In the sand prairie three species represent the group, four others being occasionally present. Physical conditions of sand prairie are nearly the optimum for the development of tiger-beetles; they are therefore much more characteristic of this formation and form a more important part of it, than of more luxuriant formations, as the black-soil prairie or the deciduous forest. In the sand prairie the *Cicindelidae* are probably more important than the *Carabidae,* by which they are overwhelmingly subordinated in black-soil prairie.

Cicindela formosa generosa Dej. June 25, July 12, 16, 22, October 6.

This large species lays eggs in May and June. A generation lives two years, as described in the generic discussion. The burrow,

vertical for most of its length, opens obliquely at the top into the side of a pit, which serves to keep the drifting sand out of the burrow proper, and also as a pitfall for small animals. It is admirably adapted to the looseness of the material. The mouth of the burrow is kept open by cementing its wall with saliva. Similar adaptations must be present in the burrows of other small sand animals; at any rate they do not often cave in, though perfectly dry at the opening. The species has been reported from Kansas, Texas, Colorado, Illinois, and Indiana. Locally it is found in almost pure dry sand in which sparse vegetation grows. In the Devil's Hole it is perhaps equally common in bunch-grass and blowsand. In the bunch-grass it is an "interstitial" animal. It is a dominant species, one of the most powerful insects in bunch-grass and blowsand, and the commonest species of its genus in the Havana region. A typical member of the bunch-grass and blowsand associations.

Cicindela 12-guttata Dej. April 9.

One specimen was taken from a small blowout at the Devil's Hole. Hart took one specimen in a blowout at Moline. Larval burrows usually occur in humus or clay, so that the presence of this species in the sand is more or less unusual. It probably ranges over all of the United States east of the Rocky Mountains.

Cicindela 12-guttata repanda Dej. June 27, July 11.

This form is found along sandy shores of rivers and lakes. Taken at the Quiver Lake beach above Havana and at Matanzas Lake. The larval burrows are found in moist depressions in sand with a small humus content. The adults are found in dry sand, however; Hart took one specimen at Moline, in a blowout on a sand hill, and Knaus records the species from the Arkansas River dunes. It occurs in Canada and in the United States as far west as Kansas and Colorado, and northwest as far as Manitoba.

Cicindela tranquebarica Hbst. August 30, September 8.

A large species, with much narrower elytral markings than *C. formosa generosa*. Three species were taken by Hart at Moline and Meredosia, in the sand. Knaus records *C. tranquebarica* (*C. vulgaris* Say) from the sand dunes of the Arkansas River in Kansas. It probably occurs occasionally in the sand dunes of the Havana area. The larval burrows occur in moist sand which has a little humus intermixed. The species ranges over practically all of the United States and southern Canada.

Cicindela scutellaris lecontei Hald. June 28, October 6, April 9.

The food, habits, and life history of this species are similar to those of other species of the genus. The geographic range is West-

ern Canada (Hamilton), Indiana, Illinois, Wisconsin, Iowa, Kansas, Nebraska (Leng). The species is usually found in sandy soil which has a little more humus than is necessary for *C. formosa generosa*. Most of the soil in the sand dunes of the Illinois River region has only a very small humus content; *generosa* is thus the commonest tiger-beetle of the region. In the Lake Michigan sand area more humus is present, consequently *scutellaris lecontei* is the most abundant species. It may be said to be an index of a rather advanced stage of the bunch-grass association.

Cicindela cuprascens Lec. July 11.

An elongate green-bronzed species, taken only on the wet sandy margins of rivers and lakes. Taken at Matanzas Lake, at Grand Tower, Waukegan, and in the Indiana lake sand regions. It occurs in Kentucky, Kansas, Missouri, Arkansas, Texas, Nebraska, and Dakota, on the banks of rivers and on sand-bars.

Cicindela sexguttata Fab. July 9.

One specimen was taken in the mixed forest of the marginal river dune. The species is found only in a rather advanced stage in the ordinary development of the deciduous forest, marked by an accumulation of leaf mold, in which the eggs are laid. Advanced stages of the forest are very poorly represented in the sand region; thus the present species is to be regarded as a recent member of the forest association. Its geographic distribution closely parallels that of the deciduous forest province. It occurs in eastern United States and Canada, and west of the Mississippi River in local forested areas, being reported from Iowa, Dakota, and Texas (Leng).

Cicindela punctulata Oliv. July 12, 29.

The larvæ of this species are restricted to more or less loamy soil; but the adults are often seen on dirt roads and paths, and quite frequently on concrete walks in towns. It sometimes gets into sandy localities and has been taken in the sandy lane near the Devil's Hole. Wickham has found it on dry sand in Iowa, with *scutellaris lecontei* and *formosa generosa*. Hart has taken it at the Devil's Hole and Devil's Neck, showing that it is an occasional member of the bunch-grass association. Leng gives its distribution as "Canada west to Manitoba, Maine to Florida, Louisiana, Texas, Colorado, New Mexico, Arizona, Ohio, Iowa, Wisconsin, and Illinois." It is a typical plains species.

Cicindela lepida Lec. July 5.

In the Havana region; also in Nebraska sand hills, where, according to Professor Bruner, it is confined to the bare bottoms of blow-

outs. Found also at Grand Tower and in the Lake Michigan area. It is very wary and flies strongly. Perhaps the most distinctive species of blowout basins. Leng gives the following distribution: "Atlantic coast in New York and New Jersey; plains of Kansas, Nebraska; New Mexico, Manitoba, Illinois, Iowa."

Family *Carabidae*

Ground-beetles

The *Carabidae* are predaceous forms which invade a variety of habitats, and, generally speaking, are the dominant members of the order *Coleoptera*. While they are an essentially carnivorous group, many species eat mostly vegetable food. Almost all the larvæ live under ground, and are also predaceous.

Pasimachus elongatus Lec. June 28, April 4.

This is a subterranean species and is occasionally found under logs, stones, and rubbish, in open woods and along the borders of cultivated fields, particularly in sandy places. The elytra are grown together at the suture, indicating a complete adoption of the underground habit. In the bunch-grass one specimen was found in digging up burrows of mammals, being there, perhaps, in search of larvæ of scavenger insects. The elytra of one specimen was found under a log near the summit of a bunch-grass-covered dune southeast of Havana.

Pterostichus lucublandus Say. April 4.

This species hibernates in the adult state. Studies by Dr. Forbes indicate plant and animal food, partly fungi, seeds, etc., and 43 per cent. caterpillars and other insects. It is found usually under logs, stones, and leaves. In the bunch-grass association, it was taken under a log along a fence.

Amara cupreolata Putz. April 7.

This small metallic beetle is one of those *Carabidae* which feed largely upon vegetable matter—usually the seeds of grasses and other plants. It is generally found under logs or stones, and occurs in a wide range of habitats. One specimen was picked up on blowsand at the Devil's Neck.

Calathus opaculus Lec. April 5.

Common in sandy soils. One damaged specimen taken near a fence, in sandy loam. This is the only record from the Illinois River sand regions. Two thirds of the food is animal, the rest consists of the pollen of grasses.

Geopinus incrassatus Dej. July 8, April 1, 4.

Specimens taken on April 1 had the fresh appearance of newly emerged beetles. In July these beetles were sometimes found dead on the surface of the blowsand. Like most *Carabidae, Geopinus* is probably predaceous, feeding upon the insects taking shelter under the boards covering the burrows. The species lives under ground, burrowing deeply in damp sandy localities. The burrows frequently open under boards; and when these are turned over the insect retreats downward within the burrow. In summer the insect is generally a few inches under ground most of the time, where the soil is damp. Restricted to sand which is quite pure, it is not found in the sandy loam of the flats in the Havana region. It is an important index species of sandy regions. It seems to be independent of the vegetation, except indirectly, as it is found under boards in large tracts of blowsand, or in the middle of blowouts.

Crotacanthus dubius Beauv. July 29.

A brown convex carabid of moderate size, which is very common in the eastern United States. Taken under a board in blowsand. Apparently not restricted to any particular habitat.

Nothopus zabroides Lec. June 7, July 25, August 14, 18, 22, Sept. 16.

This species is very characteristic of blowsand and blowouts, but was not taken during the present studies. In 1903 and 1905 it was quite common in the Devil's Neck, Devil's Hole, and other parts of the sand region, as shown by Hart's records. Knaus records it from the Arkansas River sand dunes in Kansas; Wickham records it from the northern parts of New Mexico and Arizona (Bull. Lab. Nat. Hist., Univ. of Iowa, 1896: 157). Blatchley records one specimen (*Nothopus grossus* Say) from Pine, Indiana, in the lake dune region, taken by Wolcott. It is a typical Upper Sonoran species, and is characteristic of sandy habitats. It is rather peculiar that this species was not seen in 1910 and 1911 in the sand region studied, as it was common there before that time.

Agonoderus pallipes Fab. April 1.

One of our most common carabids, but apparently scarce in the sand, only one having been taken (under a board). Not a sand species.

Harpalus caliginosus Fab. June 28, April 8.

The food of this species is largely vegetable, seeds of ragweed seeming to be in favor. It roams about in grass and stubble, taking shelter at times under boards. It seems not to be greatly restricted in

habitat, having been taken in the walnut grove, under a board, in the blue-grass, under cow-chips, and being common all over the state. It is not a typical sand species.

Harpalus testaceus Lec. August 22, September 8.

Hart records this species from under boards in blowouts at the Devil's Neck and at Moline. It is a western species, rare in the Illinois sand region, but confined to sandy territory. *Nothopus zabroides* Lec., *Harpalus erraticus* Say, and the undescribed harpaline carabid are in the same category, finding their eastern limit at or near the Illinois sand region.

Selenophorus pedicularius Dej.; Wolcott, det. April 1.

The carabids of this genus are small shining beetles, occurring for the most part in sandy or dry localities. They are never abundant. One specimen, crawling on bare sand between tufts of bunch-grass.

Selenophorus ellipticus Dej.; Wolcott, det. April 4.

One specimen, taken under log with *Anisodactylus rusticus* and *Lacon rectangularis,* in sandy pasture.

Anisodactylus rusticus Say. June 28, April 1, 4, 5.

A dull piceous carabid, variable in size and general appearance. This may well be called the most abundant carabid of the sandy regions, being most commonly found in spring, under boards in blow-sand and bunch-grass. It hibernates in the adult state. The food is largely vegetable, about 79 per cent. of it according to Professor Forbes. It is common in dry habitats throughout the state, but is particularly abundant in sand.

Anisodactylus discoideus Dej. Devil's Hole, April 1.

Widely distributed, but favoring sandy localities; a typical sand species. Found usually under boards, particularly in damp places. It is very abundant along moist sandy river shores. Common on the Illinois River shores at Havana and Pekin. Abundant on the sandy shores of Lake Michigan.

Anisodactylus baltimorensis Say. April 4.

A common carabid, apparently no more characteristic of sandy habitats than of others. Taken under boards in bunch-grass near the Devil's Hole.

Harpalini, sp. (gen. and sp. undescribed). April 4, 7, 8.

About the size of *Harpalus testaceus,* but even paler. Thorax very similar to that of *Harpalus herbivagus.* A partial description is given in Hart and Gleason's joint article on the biology of the

sand areas of Illinois ('07:264), from a single female taken at Moline, September 8, 1905. Its systematic place is still uncertain. Hart has found the species very abundant in late fall at the Devil's neck, since his partial description of it was published, and during the present studies it was found under boards and on blowsand in different parts of the sand region. Most of the specimens were dead. Others were found alive in October. The beetle probably emerges late in summer, hibernating in sheltered places and resuming activity in the spring. Those found in April were, however, dead.

Necrophorus marginatus Fab. July 5.

A member of the family *Silphidae*. Taken with *Saprinus* and *Trox* on the carcass of a field-mouse caught in a trap two or three days previous, in the bunch-grass at the Devil's Hole. A common and generally distributed species.

Silpha inaequalis Fab. April 6.

Taken on a bone in bunch-grass at the Devil's Hole, with some decaying material still attached. A common and generally distributed species; gregarious; hibernates in different stages. Members of this genus are commonly found on decaying fungi.

Tachyporus sp. (undetermined). Havana, April 1.

A very small, broad, convex species with abruptly tapering abdomen, hibernating in the adult stage under mullein leaves or in other sheltered places. Other *Staphylinidae* of small size were taken under boards in the sand, being more often found in forest margins or near cultivated fields. Hart records only three staphylinid species, none of them from typical sand prairie. It is quite probable that some of the large carrion-feeding beetles of this family are to be found in bunch-grass, but as a group the staphylinids are a very inconspicuous element in the sand-prairie fauna.

Eustilbus apicalis Melsh.; Hood, det. July 23.

A very small brown oval, convex beetle, belonging to the family *Phalacridae*, or shining flower-beetles. They live principally on flowers, the larvæ living in the heads of flowers, especially those of *Compositae*. The winter is probably passed in the adult stage. Taken in the herbage near border of woods at Matanzas Lake.

Eustilbus nitidus Melsh.; Hood, det. April 1.

Very similar to the preceding species, but smaller. A common and generally distributed species. Taken under a log at the border between two fields.

Megilla maculata De G. Havana, April 1, 7.

The common red coccinellid beetle, with black spots. It hibernates in the adult form, often being found in large numbers in sheltered spots. Very scarce in the bunch-grass in summer, and not many specimens were found hibernating. Next to *Coccinella 9-notata* it is probably the most common species of the family in the east-central states. The food of the *Coccinellidae* consists chiefly of plant- and bark-lice, and in summer the beetles are found exploring every stem of the plants.

Hippodamia parenthesis Say. July 19, April 1.

One of our most abundant ladybird beetles, being very commonly found with *Coccinella 9-notata.* These species, with *Megilla maculata,* are the three that take most readily to cultivated crops. They are more abundant in the cultural and ruderal situations of the sandy loam flats and the roadsides than in the native bunch-grass. In the summer the species was not infrequent in the growth of *Cassia* in the blowsand of the lee slope of blowouts.

Hippodamia glacialis Fab. April 1.

Very much less frequent than the other species. It is probable that the species is to some extent typical of dry or sandy localities.

Coccinella novem-notata Herbst. July 19, April 1, 4, 5, 7.

Commonest species of the family, especially in cultivated areas. It is usually found with *Hippodamia parenthesis.* In the bunch-grass it was common on the *Cassia* growth on lee slopes of blowouts. One was being eaten by a reduviid, *Zelus socius.* Much more abundantly found in spring, hibernating under boards or between lobes of cactus.

Adalia bipunctata Linn. July 26.

Taken in street of Havana; one specimen. The species has only recently become abundant in this state, having been introduced by commerce.

Chilocorus bivulnerus Muls. June 25.

Hibernates in the adult stage. Not an abundant species. Taken on grass plant at the Devil's Hole.

Languria bicolor Fab. June 28, July 29.

An elongate shining beetle of the family *Erotylidae.* Occurs on the stems and leaves of *Cacalia atriplicifolia* L., in the stems of which the larvæ live.

Dermestes caninus Germ. April 4.

A species of the family *Dermestidae*. Like all the members of its family, this beetle is a scavenger. The one specimen found was under a log, hibernating in the bunch-grass.

Dermestes vulpinus Fab. April 5.

Very similar in size and appearance to the preceding species. Taken under log, hibernating. Only one record.

Hister biplagiatus Lec. June 28, April 1, 4, 7, 8.

The adults hibernate during the winter in sheltered places, or under ground. *Histeridae*, owing to the surroundings in which they were commonly found, were formerly thought to be scavengers; they are now recognized as predaceous insects. In distribution, this species is limited to sandy soil. Blatchley records an Indiana specimen which was dug from a sand bank. In New Jersey, Smith usually found it on the beach. It is never abundant.

Saprinus pennsylvanicus Payk. July 5.

Common in sandy regions, especially on beaches and shores; found in numbers on carrion. Those from the Devil's Hole were taken with *Trox* and *Necrophorus* on the body of a field mouse, trapped two or three days previous.

Saprinus illinoensis Wolcott, type unique. July 19.

A black species of moderate size, taken under a board at the Devil's Hole. Closely related to *S. lakensis* Blatchley. For description, see Wolcott ('12).

Histeridae, especially those of this genus, are very characteristic of sandy shores, where they are often found in remarkable abundance. A number of species are found on the banks of the Illinois River, and the Lake Michigan sand beach also shows an unusual development. About half the species listed by Blatchley for Indiana have been taken in the Lake Michigan region; many of the others being taken from sandy localities in the interior of the state.

Melanophthalma distinguenda Com. April 5.

A small scavenger beetle of the family *Lathridiidae*. Common under bark and logs; hibernates in the adult state. In summer the beetles are taken in flowers, particularly those of the black haw, *Viburnum prunifolium*. Taken under a log southeast of Havana, near border of black-jack woods.

Lacon rectangularis Say. June 25, April 1, 4, 5.

This broad, dark-colored elaterid is one of the most characteristic sand insects, being restricted to sandy soil. Found abundantly

under boards and in sheltered places in all parts of the sand-dune regions. They hibernate in the adult stage.

Cardiophorus cardisce Say. April 7.

A sand insect, being commonly found under boards or other shelter. One specimen, from the Lake Michigan sand region (April 14, 1910). One specimen was taken from under a board at the Devil's Neck, and another was found under a piece of tin. On turning the tin over, an ant-nest was disclosed, but as the beetle ran out at once it was impossible to tell whether there were any direct relations between the elaterid and the ants (*Pheidole vinelandica*).

Cardiophorus cardisce, var. April 7.

Similar to the preceding, but without the four yellowish spots. Taken under a board at the Devil's Neck.

Drasterius elegans Fab. Havana, April 1, 4.

The species is not typical of sand; it has become of economic importance, being very injurious to sprouting corn and wheat. Usually found along the borders of cultivated fields, hibernating in the adult stage. Taken under a board at the edge of a cultivated field near the Devil's Hole, and in a similar situation southeast of Havana.

Limonius quercinus Say. June 20, 24.

A small slender elaterid, commonly found on leaves of oak and hazelnut. A common forest species, not restricted to sand. Taken on herbaceous plants on the road to the Devil's Hole.

Acmaeodera pulchella Hbst. July 5.

A prettily marked buprestid, belonging to a large genus representative of the southwestern and Pacific states. This genus is a departure from typical buprestids, which are normally borers in forest trees. Found on flowers of *Chrysopsis* along railroad track. Occurs on many flowers, especially those of *Ceanothus americanus.* Probably in this region a typical, though infrequent, member of the bunch-grass association.

Acmaeodera tubulus Fab. June 23.

Hart found adults of this species in flowers of *Opuntia* and *Chrysopsis.* It is recorded from other parts of Illinois, and Blatchley mentions it as common throughout Indiana. A species of dry prairie regions.

Calopteron reticulatum Fab. October 6, April 4.

The elytra of this lampyrid are broadly banded with black and yellow, and are soft and broadened out, so that the insect has a certain superficial resemblance to a moth. The fireflies of the whole

subfamily to which this species belongs are diurnal, and are found usually on leaves and flowers of herbaceous plants in search of insect prey. This species is also commonly found dead in spring under logs, indicating that the adults die at the approach of winter. They become adult probably about June 1. One was picked up in the blowsand beside a large area of bare sand. Others were taken under logs in bunch-grass and in blowsand.

Chauliognathus pennsylvanicus De G.

The larvæ hatch in late summer, pass the winter in a nearly full-grown stage, feed ravenously in spring, pupate, and become adult in summer. The larvæ are predaceous, eating all kinds of soft-bodied insects; the adults feed upon the honey and pollen of various flowers. *Chauliognathus* is rare in the sand region, while very abundant in black-soil prairie regions of other parts of Illinois. It is usually found on flowers, in company with the black blister-beetle, *Epicauta pennsylvanica.*

Podabrus tomentosus Say. June 24.

Very common in other parts of the state, but rare in the sand. One specimen, taken in flowers along a sandy roadside.

Trichodes nuttalli Kirby. August 13.

Specimens of this clerid were taken on *Eupatorium perfoliatum* in the sandy region of the lake shore at Waukegan, Illinois. Blatchley records it from Porter, Kosciusko, Elkhart, and Crawford counties in Indiana; the first three counties are largely sandy. As the Porter county specimens were taken in flowers of *Opuntia,* in an association similar to the Illinois River bunch-grass, it seems probable that the species is also to be found in the latter region.

Lucanus placidus Say. June 28, July 1.

A large brown "pinching-bug," so called from the large mandibles. The eggs are laid in crevices in the lower bark of trees, and the larvæ feed upon wood in various stages of decay. They mature very slowly. The adult beetles remain in or beneath decaying trees or stumps by day, and emerge and fly about at night. The breeding season is June. Occasionally found dead at the base of trees, usually in the mixed forest. *Placidus* is more frequently found in sandy regions; its close relative, *L. dama,* is commoner in other parts of Illinois. *Lucanus* is essentially a forest insect and is not a typical member of the bunch-grass association.

Canthon nigricornis Say. June 28, July 1.

A member of the scavenger division (subfamily *Laparosticti*) of the *Scarabaeidae.* Smaller than others of the genus; length, 6

to 9 mm. The larger members of this genus are quite commonly seen in pastures and along roads, rolling a ball of dung, which is to serve as the food of the larva. When a proper place is reached, the ball is buried in the ground and the female deposits an egg in one side of it. Comstock interprets the rolling habit as affording protection to the larva, which would otherwise be in danger from the predaceous insects normally present in the masses of dung from which the balls are removed. *Nigricornis* is never abundant. It may be restricted to sand. Blatchley records only two specimens,—from Starke County, Indiana. One specimen from the Devil's Hole was taken in the burrow of a field-mouse in the bunch-grass; another was taken in a bottle trap.

Canthon laevis Drury. April 1.

This is the very common tumble-bug which is common over the eastern United States. It is probably not found in habitats where the soil is pure sand. One dead specimen was taken along the lane leading to the bunch-grass pasture, in sandy loam soil, under a log.

Canthon vigilans Lec. July 3.

This species, which is larger than *C. laevis,* is found from Pennsylvania and Ohio westward. It is much less common than *C. laevis.* Found in a mole tunnel in the Devil's Hole pasture.

Copris carolina Linn. July 3.

Species of the genus *Copris* do not transport balls of dung to any considerable distance, but bury them on or near the spot where they are found. The writer has dug them from burrows made in the hard clay of a street corner, under electric lights in towns. It is a very common species in pastures or along roadsides. The one dead specimen found, was in the middle of an extensive bare area of blowsand at the Devil's Hole.

Onthophagus pennsylvanicus Harold. April 7.

A common and generally distributed scarabaeid, found in carrion and excrement. Resembles a small *Canthon* superficially. *O. hecate* is the common species in other parts of Illinois; but in the sand *O. pennsylvanicus* apparently dominates. One specimen was found crawling about on blowsand at the Devil's Neck; a second was taken under cow-chips.

Aphodius fimetarius Linn. April 1.

This species was originally introduced from Europe, and is now widely distributed. Found commonly in or beneath half-dry cow-dung. Two specimens under cow-chips in sandy lane near Devil's Hole.

Aphodius inquinatus Hbst. April 1, 7.

Smaller than *fimetarius*. Introduced from Europe, and found in the same situations as *A. fimetarius*. Sandy lane near Devil's Hole; in spring flight and quite common at the Devil's Neck April 7.

Aphodius terminalis Say. April 4.

Quite small; scarce; perhaps typical of sandy localities. Hibernates beneath cow dung and partly buried logs. Taken under boards in blowsand with *Anisodactylus rusticus* and *Opatrinus notus*.

Geotrupes opacus Hald. April 8.

Restricted to sandy localities, occurring under cow dung in pastures, often burrowing into the ground beneath. Found dead with *Harpalus caliginosus* under cow-chips, in bunch-grass pasture at the Devil's Hole.

Trox scabrosus Beauv.; Hood, det. July 5.

Occurs on carrion or bones in sandy localities. Scarce in Illinois. Taken with *Saprinus pennsylvanicus* and *Necrophorus* on the carcass of a field-mouse.

Serica sericea Ill. June 23.

Occurs beneath shelter of various kinds; hibernates in pupal stage beneath partly buried logs. Found in the stomach of a toad, *Bufo lentiginosus americanus*. A number of these toads were taken in the mixed forest of the river dunes. Four stomachs contained the remains of numbers of two species of ants, several elaterids, scarabæids, and a weevil, *Phytonomus punctatus*, with a few cutworms. *Serica* is a forest-inhabiting species.

Lachnosterna prunina Lec.; Hood, det. April 8.

One of the common May-beetles. Scarce. Blatchley found it only in Lake and Vigo counties (sandy regions). Taken along the beach of Lake Michigan. Ranges from Ohio and Michigan to Kansas and Texas. The larvæ live under ground, eating the roots of grasses and other plants; the adults probably eat leaves of trees; they are nocturnal feeders. In digging up the burrow of a spider, in the bunch-grass at the Devil's Hole, quite an excavation was made; the *Lachnosterna* was seen crawling out of the old pupal cell into this excavation, at a depth of nine or ten inches.

Lachnosterna micans Knoch.; Hood, det. July 3, 29.

A common species of early summer. Four dead specimens found on two different occasions on bare blowsand, where no doubt they had been blown after death. In April, 1910, large numbers of dead insects were collected in hollows on the sandy beach of Lake Michi-

gan in much the same way, these, too, having been blown about by the wind.

Lachnosterna implicita Horn; Hood, det. June 25.

A common species, one of the first to emerge in early summer. Found dead, with *Lacon rectangularis,* in sandy lane leading to the Devil's Hole.

Polyphylla hammondi Lec. August 12, 15, 17.

Hart found one specimen lying dead on bare blowsand in the marginal sand ridge just north of Havana, August 17, 1903. Mr. J. D. Hood took six specimens at the Devil's Hole, August 12, 1907. They were taken at dusk, flying rapidly about four feet above ground. Three days later, Hood took seventeen males flying in the same manner, and one female was found at rest. These are the only records for Illinois. The species is of far-western distribution, and is probably a typical member of the bunch-grass association of the Great Plains.

Anomala binotata Gyll. April 1.

A member of the subfamily *Pleurosticti,* which are leaf-feeders. Common from late spring to early summer. Not distinctive of sandy regions, and more or less an insect of cultivated fields. Remains of a dead specimen, taken under a log at the border of a field.

Anomala lucicola Fab. June 24, July 23.

A common species of early summer. Occurs most commonly on the leaves of wild grape and Virginia creeper. Taken on flowers along roadside, with *Strigoderma arboricola* (probably breeding at that time); also on the leaves of a bog plant at Matanzas Lake.

Strigoderma arboricola Fab. June 15, 24, July 3, 6, 11.

Common on flowers. Notes taken June 24: "The first *Strigoderma* was noticed a few days ago floating down the river. They are now excessively abundant on cactus, wild rose, red clover, timothy, elderberry, dewberry, dog fennel, *Verbena stricta,* wild parsnip, *Monarda punctata, Plantago, Saponaria, Tephrosia, Erigeron.* They are most abundant on prairie plants, being quite common in the bunch-grass association and along roadsides, very few being found in the forest." July 3: "*Strigoderma* is still fairly abundant on different flowers." On July 6 a robber-fly, *Proctacanthus brevipennis,* was caught with a *Strigoderma* in its grasp, which it was in the act of eating.

Catalpa lanigera Linn. June 28, July 28, April 4.

A widely distributed species; never abundant, however. An injured specimen was taken on the river dune north of Havana. Re-

mains of dead beetles taken under logs July 28, on the river dune south of Havana; April 4, at the border of a bunch-grass field, on a dune east of Havana.

Ligyrus gibbosus De G. July 23, April 4.

A common and widely distributed species often attracted to electric lights. Taken in stomach of a toad with *Serica sericea* and other insects. The toad was taken in the mixed forest of the river dune, indicating the same habitat for the beetle. A fresh-looking specimen, perhaps recently emerged, was taken under a log in the bunch-grass.

Euphoria sepulchralis Fab. August 14, 16, 18, 30.

Common in southern Illinois; found in prairie flowers, especially *Solidago*. Hart took specimens at the Devil's Hole, Matanzas Lake, and other places.

Euphoria inda Linn. April 9.

Worn specimens taken at the Devil's Hole, flying about. In April, 1910, these beetles were flying about in the same way in the sand dunes of Lake Michigan, north of Waukegan, Illinois. The larvæ feed upon manure or rich soil containing a large amount of humus.

Trichius piger Fab. July 11.

Found in early summer in flowers. One specimen, taken in a flower of wild rose, along sandy roadside south of the Devil's Neck. A fairly common species of general distribution.

Batyle suturalis Say. July 25.

The *Cerambycidae* are generally adapted to forest life. They are timber-boring insects. A number of forms are somewhat aberrant, and this group is represented in prairie associations. This species is occasionally found in flowers of *Ceanothus, Cornus,* and other plants. Taken on *Chrysopsis villosa,* near border of black-oak forest, three miles east of Havana. A common and generally distributed species, but never very abundant.

Strangalia luteicornis Fab. July 5.

Occasionally found on flowers; early summer. Two specimens, taken on *Chrysopsis villosa* along a railroad track.

Plectrodera scalator Fab. July 8, August 13.

Associated with species of willow and poplar in sand regions. Found at the lower end of Lake Michigan; at Grand Tower, Illinois, in the Mississippi sand deposits; at Waukegan, Illinois; and at the Devil's Neck, in *Populus*. The larvæ bore in the trees.

Dectes spinosus Say. June 28.

Frequently found in dry or sandy regions. Associated with species of ragweed (*Ambrosia*), on which they breed. The larvæ burrow in the stems. The species ranges from New England to New Mexico and Colorado. A prairie species. Taken at the Devil's Hole.

Mecas pergrata Say. June 25, July 5.

Scarce; found also in the dry soils of southern Illinois and Indiana. This, like many other insects of dry regions of the South, finds its northern limits in sandy localities. (Cf. Hart, '07:203.) Found in low herbage of open areas. A prairie species. Devil's Hole, in mat of *Chrysopsis*.

Tetraopes tetraophthalmus Forst. June 6, 8, 24, July 1.

A common and widely distributed species, found on species of *Asclepias*. A prairie form, but rare in the bunch-grass. The milkweeds begin to bloom in June; the adult beetles are first seen at this time, continuing abundant throughout the early part of the summer.

Tetraopes femoratus Lec. July 25, 29, August 15, 16, September 8.

Closely resembling the preceding species, but with antennæ ringed with gray at the joints. It is common in late summer, as indicated by the dates, part of which are from Hart's records, while *T. tetraophthalmus* is an early-summer species. This is apparently an example of time adjustment, by means of which closely related species are removed from competition.

Typophorus canellus aterrimus Oliv. April 4.

This is the first species, taxonomically, in the list of sand region *Chrysomelidae*. This group of beetles is exclusively leaf-eating. They are represented in practically all associations, and reach their maximum development in tropical and subtropical regions. A very common species, often found on foliage of wild grape. Taken from under a log in bunch-grass bordering a cultivated field.

Chrysochus auratus Fab. June 25, July 5, 12, 25.

Common and widely distributed. It lives upon the foliage of *Apocynum* and *Asclepias*. Quite common in the bunch-grass. Taken on *Asclepias syriaca, Asclepias phytolaccoides*, and a species of *Apocynum*. In an abandoned field near the Devil's Hole, which was reverting to bunch-grass, the *Apocynum* was very abundant over a large area, and four or five *Chrysochus* beetles were seen on each plant.

Graphops nebulosus Lec. April 9.

Known from Ohio, Wisconsin, Illinois, and Kansas. Taken on the sand at the Devil's Hole, while moving about.

Metachroma angustulum Crotch. June 28.

A western species, found in this part of the country in the driest habitats, usually sand. Very abundant in the Illinois sand regions on poplar, willow, and *Oenothera*. One specimen from the Devil's Hole.

Metachroma parallelum Horn.

Found in abundance with the preceding species by Hart, early in June, in practically all parts of the sand region.

Calligrapha similis Rogers. April 4.

Common; more frequent in sandy localities. Hibernates under logs and rubbish. One specimen, taken under a log in bunch-grass near the Devil's Hole.

Chrysomela auripennis Say.

Hart found this species at the Devil's Neck and gives records of it from northern Illinois. Kwiat records it from sand-dunes of northwestern Indiana, and Blatchley mentions it as found about the prickly pear cactus in the same region. Linell gives its range as Texas to Nebraska.

Lina interrupta Fab. June 24.

Common on willow and cottonwood. Taken along sandy roadside east of Havana.

Lina scripta Fab. April 7, 1911.

Elytra usually with longitudinal black spots, sometimes wholly black. Associated with species of *Populus* and *Salix*. Taken on the ground in a poplar growth at the Devil's Neck.

Galerucella notulata Fab. July 23.

Frequent in southern Illinois; common northward in sandy localities. On herbaceous plants near forest border, Matanzas Lake.

Diabrotica 12-punctata Fab. October 6.

Normally an insect of grassland, the larvæ feeding on the roots, but now largely ruderal, occurring in numbers on cultivated plants. Much less frequent in the bunch-grass than in the cultivated regions adjoining.

Diabrotica vittata Fab. October 7.

Habits much the same as for others of the genus. Quite rare in the bunch-grass.

Diabrotica longicornis Say. October 6, 7.

Rare in the bunch-grass, except in fall, when it was numerous in flowers.

Blepharida rhois Forst.

Commonly found on species of sumac, upon which the larva is often seen feeding. The adult has greatly enlarged hind femora. Occurs in early summer. Very scarce in 1910.

Oedionychis gibbitarsa Say. April 4.

Commonly found hibernating in sheltered places. Occurs in summer on various flowers. Under log in bunch-grass near Devil's Hole.

Disonycha pennsylvanica Ill. April 4.

Common in moist meadows or swamp borders, hibernating under cover. In sandy regions it is associated with willow. Throughout Illinois, more frequent toward the north. Under log in bunch-grass near Devil's Hole.

Disonycha 5-vittata Say.

Associated with willow; taken at the Devil's Neck, Waukegan, Grand Tower, and in the sand-dunes of northwestern Indiana. All summer.

Disonycha triangularis Say. June 28, April 1, 4, 8.

Probably the commonest flea-beetle in the sand regions, and in other habitats throughout the state. Hibernates, being found under logs in spring. Said to be associated with *Chenopodium* and *Amaranthus*. Found under logs on the border of a cultivated field, and in the bunch-grass.

Haltica fuscoaenea Melsh. June 6, 8, July 22, August 12.

Not very abundant; usually found in dry or sandy regions, associated with *Oenothera biennis*, its food plant. Hart took it on this plant at the Devil's Hole, and at other places in the neighborhood of Havana.

Bruchus cruentatus Horn. July 16.

On *Cassia chamaecrista*, probably breeding in the seeds. An insect of the blowsand association. Recorded from New Jersey, Georgia, Illinois, and Texas. This species is a member of the family *Bruchidae*, which constitutes a small group of beetles related to the *Chrysomelidae* on one hand and to the *Rhynchophora* on the other. They eat out the inside of seeds, especially those of *Leguminosae*, and are known as pea-weevils.

Bruchus arenarius Wolcott, type unique. April 9.

Found on the sand between tufts of bunch-grass at the Devil's Hole. (For description, see Wolcott, '12.)

Epitragus acutus Lec. July 22, 30, August 3, 12, 14, 18, 19, 20, 22.

Found by Hart in various parts of the sand region, on flowers of *Cacalia atriplicifolia.* No other Illinois record. This is a species of western distribution. Not seen in 1910, although it has been common in other years. The *Tenebrionidae* reach their highest development in the arid Southwest, where they are more abundant than any other beetle family. They usually feed upon fungi, dead wood, or other vegetable substances, and may be considered as plant-eaters or scavengers for the most part.

Xylopinus saperdioides Oliv. June 25, July 25.

A common woodland species. Occurs especially under oak bark. Found under logs at the Devil's Hole and the Devil's Neck; and under bark of black-oak log in the forest about three miles east of Havana.

Opatrinus notus Say. April 4, 7.

Not infrequent in dry or sandy localities, under boards or other cover. A typical blowsand species, found more commonly in bare sand than in bunch-grass. Usually associated with *Lacon rectangularis.*

Blapstinus interruptus Say. April 7.

Found occasionally in sandy localities under rubbish. One specimen picked up on blowsand at the Devil's Neck.

Mordella marginata Fab.; Wolcott, det. July 23.

The *Mordellidae* are small active beetles, found on flowers or dead trees. The larvæ live in old wood or inside the stems of plants, and are thought to be predaceous upon the phytophagous larvæ of *Lepidoptera* and *Diptera* which they find there. *M. marginata* is a common and generally distributed species, occurring on *Cornus, Ceanothus,* and other plants. A species of clearings and forest margins. On *Pycnanthemum,* near Matanzas Lake.

Notoxus bifasciatus Lec. June 25, 28.

The *Anthicidae* are small flower-beetles which resemble ants in general appearance. This species is rather common at forest margins, usually found in flowers. Frequent in dry sand under a small clump of walnut and coffee-trees. A number of lepidopterous pupæ, apparently *Noctuidae* in large part, were found in the same place.

Anthicus cervinus Laf. April 1.

Commonly found under rubbish in sandy places. Hibernates as an imago. Taken under logs in sandy lane bordering cultivated field.

Amblyderus pallens Lec. April 7.

Found under rubbish or boards. One specimen, from the Devil's Neck, picked up on the blowsand.

Epicauta pennsylvanica De G.

This species, which is a member of the family *Meloidae* or blister-beetles, is found upon prairie plants along roadsides in the sandy loam flats, but is seldom found in bunch-grass or blowsand. The larvæ prey upon the eggs of grasshoppers. The adults emerge in late summer and are found upon flowers; their food is chiefly nectar and pollen. They are usually found with the soldier-beetles, *Chauliognathus*. The whole family is best represented in the West and Southwest.

Rhipiphorus octomaculatus Gerst.; Wolcott, det. July 23.

The adult *Rhipiphoridae* occur on flowers but are comparatively uncommon. The larvæ are usually parasitic; some in the nests of wasps, and others on cockroaches.

This species is occasional in flowers of herbaceous plants of forest margins. I have found *Rhipiphoridae* very abundant in flowers of *Eupatorium perfoliatum*. One specimen, from Matanzas Lake, on a mint (*Pycnanthemum*).

Phacephölis sp. June 28.

The *Rhynchophora*, or snout-beetles, form a suborder of the *Coleoptera*. They are characteristically plant feeders. This species was taken in the bunch-grass on a stem of *Lithospermum gmelini*. This plant has hard white seeds (nutlets); and the weevil resembles the seeds so much, in appearance and position, that ordinarily it would not be distinguished from them. This species, according to Chittenden, is undescribed.

Phytonomus punctatus Fab. June 23, April 1.

The "clover-leaf weevil," as this species is called, is a brown snout-beetle, quite common and of wide distribution, its spread being doubtless hastened by cultivation. One specimen from the stomach of a toad, with *Scrica* and *Ligyrus*. This one was doubtless a resident of the mixed forest, where the toad was captured. Another specimen was taken under a log near a cultivated field, having apparently hibernated.

Lixus concavus Say. April 4.

The adults breed in early summer on stalks of *Rumex* (dock) and other plants. The larvæ probably live inside the stems. A common and generally distributed species, not restricted to sand. The adults hibernate in sheltered places. Taken under a board at the summit of a bunch-grass dune southeast of Havana.

Lixus musculus Say. April 1.

Not a common species. Taken under a log in a sandy lane near the Devil's Hole.

Chalcodermus collaris Horn. April 9.

Commonly found on *Oenothera* in sandy places. Picked up on the sand between tufts of bunch-grass, Devil's Hole.

Centrinus picumnus Hbst.; Hood, det. July 23, October 5.

Of general distribution; commonly found on flowers. Taken on *Euphorbia corollata* flowers in black-oak woods near Matanzas Lake, and, in the fall, on flowers of a white aster along a roadside near Havana.

Barilepton filiforme Lec. April 4.

A very small black weevil, taken under a log in bunch-grass south of the Devil's Hole.

Sphenophorus scoparius Horn. April 7, 1911.

Members of this genus are known as "bill-bugs," and are often injurious to cultivated plants. One specimen was found dead on blowsand at the Devil's Neck.

Gymnetron teter Fab.; Hood, det. June 24.

The common and widely distributed weevil so commonly found on mullein. Found on this plant along every roadside in the sand region.

Order LEPIDOPTERA

The *Lepidoptera* were, unfortunately, rather slighted in the field work, and the records are accordingly very scanty. The larvæ of insects of this order eat great quantities of vegetable tissue and are among the important plant-eating groups in an association. Many of the *Lepidoptera* recorded by Mr. Hart were taken on roadsides, and are generally distributed. Quite a few species, however, are typical of the sand prairie, some being found nowhere else in the state.

Danais plexippus Linn. July 5.

The milkweed butterfly was seen several times flying about in

a large blowsand area. It is more or less accidental in the sand prairie associations.

Pyramcis cardui Linn. April 7.

Several of these butterflies were seen at the Devil's Neck, flying about over the blowsand. They are very abundant forms, are two-brooded, and visit a number of different food-plants. Hardly typical in sand prairie.

Callosamia promethea Dru. July 11.

A common large saturniid moth. Cocoons abundant on sand-bar willow (*Salix longifolia*) on the sandy shore of Matanzas Lake. Not typical of sand prairie, however.

Apantesis sp. (larvæ). April 4.

The larvæ of an *Apantesis* were taken under a log in the bunch-grass. These larvæ are very active, usually feeding upon plants of low growth. Another arctiid, *Eubaphe aurantiaca brevicornis* Walk., was found by Mr. Hart quite frequently on sand-dunes.

Diacrisia virginica. Fab. April 1.

Two pupæ were taken at the edge of bunch-grass, in a hollow log. The moths emerged later; one about April 20, and the other about May 15. The larvæ belong to the type of caterpillars known as "woolly bears." The species is generally distributed, and is very destructive in certain localities.

Noctua c-nigrum Linn. April 1.

Taken in fence-row, under boards, in the larval state. The noctuid caterpillars are known as cutworms, from their underground habit of cutting off stems. They are very characteristic of grass-land and cultivated crops. A number of cutworms occur regularly in the bunch-grass associations. Whether these species are the same as those which were present before the cultivation of the region, is a difficult question. The adult noctuids were frequently seen flying about in the bunch-grass, though they are very much more active at night.

Feltia subgothica Haw. April 1, 4.

This is the commonest species of the genus, and the most abundant cutworm of the bunch-grass. Quite generally distributed.

Mamestra meditata Gr. April 1.

Found with other cutworms in fence-row under boards. A common species of economic importance.

Leucania phragmitidicola Guen. April 1, 8.

Under boards with other noctuid larvæ, and under boards in the Devil's Hole, in bunch-grass. A common and generally distributed species.

Crambus sp. (indeterminable). April 1.

The larva of a crambid moth was taken under a log in a fence-row, with other insects. The crambids are characteristic grassland species, the larvæ living in grass roots. Hart found a number of individuals of *Crambus hayticllus* Zinck., in the neighborhood of blowouts. The species is described from Hayti, and listed from Texas. Mr. Hart was unable to find other records.

Pyraustidae, sp. (indeterminable). April 7.

Two larvæ of this family found on bare sand, at the base of a clump of sumac, *Rhus canadensis illinoensis,* from the foliage of which they had apparently been blown (the day being windy). No others were found on the leaves. The larvæ were kept from blowing about on the sand by means of silk threads.

Order DIPTERA

Helobia punctipennis Meig. April 1.

This small tipulid was very abundant along a roadside east of Havana. On April 1, not long before sundown, numbers of small *Tipulidae* were seen near the hedge flying up and down four or five feet above the ground, in the manner described as breeding swarms. They were in groups of from five to ten.

Chironomidae, sp. (undetermined). April 8.

The larvæ of the chironomid midges are aquatic, and are very abundant in the river. In the spring and summer, large numbers of the adult flies emerge, and are found at considerable distance from the river. Those which get into the Devil's Hole and other parts of the sand prairie must add an appreciable food-element to the association, like the *Ephemeridae* and other non-predaceous forms with aquatic larvæ.

Sciara sp. (undetermined). April 1.

Found under log in fence-row. This genus belongs to the family *Mycetophilidae,* or fungus-gnats, the larvæ of which live in fungi or decaying vegetable matter.

Tabanus costalis? Wied. June 28.

The horse-flies, as the *Tabanidae* are called, are swift-flying forms which attack horses and cattle, extracting the blood by means

of their powerful beaks. One specimen, referred to the above species, was taken in the bunch-grass. Other species were seen along the roadside. As much of the bunch-grass is pastured, a number of the *Tabanidae* would be expected in the association.

Chrysops callidus Osten-Sacken. June 20.

One of the "deer-flies." Taken along sandy roadside.

Anthrax sp. (undetermined). July 19, 29.

Members of this family, the *Bombyliidae,* are parasitic or partly predatory, according to John B. Smith. Some parasitize lepidopterous larvæ; others feed on the egg-pods of grasshoppers; and still others live in the nests of bees. Hart records five species of *Anthrax* from the sand regions. Flies of this genus have been seen flying about on bare sand or in blowouts, hovering especially over hoof-prints or other impressions in the sand.

Systoechus vulgaris Loew. August.

This species was not taken because of its scarcity early in the season. Mr. Hart found it quite commonly on flowers. This is the small bee-like form which is parasitic on grasshopper egg-pods. It is quite generally distributed. A very important member of the bunch-grass association, since it is an efficient check upon the number of locusts.

Proctacanthus brevipennis Wied. July 6.

One specimen of this robber-fly was taken at the Devil's Hole, eating a beetle, *Strigoderma arboricola.* The *Asilidae* are predaceous swift-flying forms, dominant among the *Diptera.* They are best developed in the open arid associations of the West and Southwest. They are characteristic members of the bunch-grass association. This species has not been recorded from any other Illinois locality.

Proctacanthus rufus Will. July 8, 12.

An extremely large and powerful asilid, taken eating *Tettigia hieroglyphica* on two occasions; once at the Devil's Neck, once at the Devil's Hole. Though characteristically a plains species it ranges east to New Jersey. Hart took *P. milbertii* Macq. from August 15 to 20. This is a western species also, and is reported to prey upon the Rocky Mountain locust. The *Asilidae* in the Illinois region no doubt prey upon its close relative, *Melanoplus angustipennis,* which is the most abundant bunch-grass insect. The range of dates for *P. brevipennis* is June 6 to July 6; for *P. rufus,* July 8-12 (it was seen later than this); and for *P. milbertii,* August 15-20. A seasonal relation seems to be clearly indicated.

Syrphus arcuatus Fall. October 7.

The brightly colored syrphid-flies feed in the adult stage upon pollen. The larval food habits vary greatly, but the larva of this species probably lives upon plant-stems, feeding upon plant-lice. The specimens in the Havana series were taken on flowers of aster, along a roadside. They are not restricted to sand regions.

Spalangia sp. (undetermined). October 6.

A gray tachinid taken on flowers of *Kuhnia,* with pentatomids. The tachinids are almost all parasitic, particularly upon caterpillars.

Gonia frontosa Say. April 8.

This tachinid was found at the bottom of a hollow between bunch-grass dunes. It had evidently just emerged from the pupa, for the wings and other parts had not hardened. The genus is parasitic upon cutworms, and probably other caterpillars.

Phorbia fusciceps Zett. April 4.

One specimen, from under a log, with a large number of other insects, in bunch-grass of advanced stage. Of the family *Anthomyiidae,* the larvæ of which include scavengers, parasites, leaf-miners, and root-maggots. This species is a general feeder in roots of common crops, according to Smith. In the natural state it probably feeds on grass-roots.

Scatophaga sp. (undetermined). April 1, 8.

Common at the Devil's Hole, flying about in the bunch-grass. The larvæ of the *Scatophagidae* are of various habits, a number occurring in stems of *Rumex.*

Order HYMENOPTERA

Urios vestali Girault, type unique. April 1.

A nearly wingless female, taken in the nest of the sand ant *Pheidole vinelandica* Forel, which it closely resembles. The nest was in the bunch-grass of the Devil's Hole. Family *Pteromalidae.* (For description see Girault '11.)

Apanteles theclae Riley; Girault, det. April 1.

Two bunches of cocoons were found; one under a board in a sandy lane, the other in a rosette of mullein. The adult parasites began hatching out April 17. Bunches of empty hymenopterous cocoons, probably of several different species, were seen in bunch-grass in 1910.

Formica pallide-fulva schaufussi Mayr; M. C. Tanquary, det. April 4, 8.

This large ant is very active. Found commonly in bunch-grass and under logs. One nest, in which a specimen of *Hister biplagiatus* was taken, was found in the roof of a mole tunnel.

Lasius niger americanus Linn.; Tanquary, det. April 1, 8.

Common in the sandy loam flats, but rare in pure sand and in the bunch-grass. Associated with cultivated crops, particularly corn. Apparently restricted to soil of considerable humus content.

Leptothorax sp. (indeterminable). April 8.

A single specimen, from pocket-gopher hill at the Devil's Hole.

Pheidole vinclandica Forel. April 1, 7, 8.

The determination was made by Mr. Tanquary and verified by Dr. Wheeler. The genus is characteristic of sand habitats. Common under boards in bunch-grass. There are two kinds of workers—major and minor. An elaterid, *Cardiophorus cardisce,* was taken from one nest. Other nests were taken in the hills of pocket-gophers. Not recorded from any other region of the state.

Monomorium minimum Buckley; Tanquary, det. April 1.

A rather common sand species. Taken under log near Devil's Hole.

Sphaerophthalma occidentalis Linn. July 21, 29.

Taken on bare sand of marginal dune and on blowsand at the Devil's Hole. A large, rather common, species. The *Mutillidae* are terricolous, running about on the bare sand.

Sphaerophthalma vesta Cresson; Henry Skinner, det. June 28.

From bare sand in sparse bunch-grass at the Devil's Hole. This species was taken by Hart near Havana August 20. No other Illinois records.

Sphaerophthalma ferrugata Fab. June 28, July 19.

Occurs regularly in blowsand and as an interstitial in bunch-grass. The mutillid females run about on the bare sand; the males fly to and fro a few inches from the ground. They are solitary in habit. The species dig burrows in the sand, some storing food for their larvæ, "while others seem to be parasitic or guests in the nests and cells of bees and wasps" (J. B. Smith). This species is rather common and widely distributed, but is restricted to very dry or sandy localities.

Sphaerophthalma chlamydata Mel. July 1, 8, 12, 29.

Bare sand of marginal dune, blowsand at Devil's Neck and Devil's Hole, in blowouts, and an interstitial species in the bunch-grass. The commonest species of the Illinois River sand region. It has not been taken elsewhere.

Mutilla dubitata Smith; Skinner, det. October 6.

Two females taken in a blowout, just at the tension line between the basin and the blowsand, at the margin of the *Cassia* growth.

Myzine interrupta Say. July 23, October 5.

Taken on flowers of a white aster along roadsides. The females were quite abundant. One male was taken at the border of the Matanzas Lake forest, on *Pycnanthemum*. Not characteristic of sand.

Hedychrum obsoletum Say. October 7.

One specimen taken on white aster. Hart took it at the Devil's Neck and the Devil's Hole, in August.

Odynerus fulvipes Sauss.; Robertson, det. October 5.

One specimen, from flowers of white aster growing along roadside. Hart took three other species of this genus near Havana.

Polistes pallipes St. Farg. October 5, 6.

On aster along roadsides; in the Devil's Hole, according to Hart, on *Cassia*. In the spring the nests of either *Polistes* or *Vespa* were seen in hollow logs along fences. This is one of the true social wasps, which build paper combs. The larvæ are fed continually by the adults, which are predaceous. Very common and generally distributed.

Anoplius tropicus Fab. July 23.

One specimen, from *Pycnanthemum* at the margin of the Matanzas Lake forest. Hart found it common in many other parts of the sand regions. He records ten species of *Anoplius*. The family, *Ceropalidae*, includes digging species which prey upon insects and spiders. Certain species are said to be guests in the nests of other diggers.

Anoplius marginatus Say.; Robertson, det. July 3.

One specimen from a blowout.

Sphex pictipennis Walsh; S. A. Rohwer, det. October 5.

Taken on aster flowers along a sandy roadside. The *Sphecidae* are powerful wasps which make underground cells, provisioning them with caterpillars, spiders, or grasshoppers, which serve as food for the larvæ.

Sphex violaceipennis Lepel.; Rohwer, det. October 6.

Found in a very sandy, abandoned field, in growth of *Cenchrus* (sand-bur). The wasp was observed closing its burrow in the sand. It faced away from the opening, throwing the sand into it with the hind pair of legs, then faced about and threw the sand forward, alternating these movements several times.

Priononyx bifoveolatus Tasch. October 5, 7.

On aster along roadsides, and at the Devil's Hole (Hart). The species probably burrows in the sand. It was quite common.

Priononyx atratus St. Farg. October 7.

Found on aster with the preceding species. One specimen.

Cerceris clypeata Dahl; Robertson, det. October 5.

One specimen from aster along roadside. Hart took two species of this genus at the Devil's Hole—*C. fumipennis* Say, and *C. venator* Cress. A member of the family *Philanthidae,* which burrow into the ground and store their cells with beetles or with small digger-bees.

Tachytes elongatus Cress.; Robertson, det. July 19.

One specimen taken flying about the *Cassia* growth in a blowout. A member of the family *Larridae,* which burrow in sand. Grasshoppers and crickets are used to provision the nests.

Tachytes mandibularis Patton; Robertson, det. July 3.

Three specimens taken in the basin of a blowout on *Acerates,* the green milkweed. Two were *in copula.* Hart took *Tachytes obscurus* at the Devil's Hole in August. A characteristic basin species, observed quite frequently on *Acerates,* and in basins about the inner margin of the *Cassia* growth. A species of *Tachytes* was seen in abundance on the beach sand-plain at Matanzas Lake, July 11.

Halictus pilosus Smith; Robertson, det. October 7.

On aster along roadside. One specimen. One of the most common and widely distributed green forms.

Augochlora humeralis Patton. June 28, July 8, October 5.

In flowers of wild rose and aster along roadside. Hart records the species from the Devil's Hole. One of the *Halictidae,* which are solitary bees. They burrow in the ground.

Agapostemon splendens Lep. October 7.

On aster flowers along roadsides. Quite abundant, both males and females. Hart records the species from the Devil's Neck and the Devil's Hole.

Sphecodogastra texana Cresson; Cockerell, det. October 7.

On aster along roadsides. Described from Texas. Taken in Pierce county, Wisconsin, by Graenicher.

Megachile mendica? Cresson. July 11.

Taken on sand-plain of Matanzas Lake beach. One specimen only. Hart took two other species of this genus in the sand region. The *Megachilidae* are known as the leaf-cutting bees. Their cells are constructed of parts of leaves. They are solitary in habit.

Triepeolus pectoralis Rob.; Robertson, det. October 5.

On aster flowers along roadsides. A member of the family *Nomadidae,* which are parasites, or guests, in the nests of other bees.

Melissodes sp. (undetermined). October 5.

On aster flowers along roadside. Hart took three other species of the genus in the sand regions. A member of the family *Euceridae,* which are long-tongued solitary bees, feeding upon honey and pollen.

Melissodes auriginia Cresson. October 5.

On aster flowers with the preceding species.

Bombus virginicus Oliv. October 5.

On flowers of aster particularly. A very common and generally distributed bumblebee. Social in habits. The nests are made in cavities in the ground. The fertilized female hibernates, starting a new colony in early summer. Hart took three other common species of this genus in the sand region.

Bombias auricomus Robertson. July 6.

One large specimen, taken from a burrow in bunch-grass. Hart does not record this species from the sand.

Apis mellifera Linn.

The honey-bee is of rather frequent occurrence in the sand prairie.

AMPHIBIA

Amblystoma tigrinum Green. April 4.

One specimen, taken under a log at the edge of a bunch-grass field, southeast of Havana. Only the fore part of the body was at first to be seen, the rest being sunk into the burrow. The soil was not pure sand, the roots of the grass and the decay of the log having made an approximation to sandy loam. A swampy depression about 100 feet away probably afforded a breeding place.

This salamander is widely distributed, but is very scarce in the sand region, principally because of the lack of permanent pools.

Bufo lentiginosus americanus Boul.

Bufo was found but sparingly in the sand prairie regions. It was several times seen along roadsides near the Devil's Hole; and a few times, in the black-oak forest, from one to two miles from the river. The absence of breeding places is the probable cause of its scarcity. In the mixed forest of the river dunes, and in fact all along the river, these toads are very abundant. They may be seen hopping about by day; and at night they are found on the beach in great numbers. (See also discussion of *Serica sericea* p. 44.) *Americanus* is the prairie variety of the toad. Sand prairie conditions, however, are such as to exclude the species. Frogs are practically absent from the sand prairie.

REPTILIA

Heterodon nasicus Bd. & Gir.* Ellis, det. June 29, July 8, 26.

Specimens were taken at the Devil's Hole, the Devil's Neck, the marginal dune north of Havana, and in a blowsand area southeast of town. H. Garman reports one specimen from Pekin, which is at the northern end of the sand regions. *Nasicus* is the western species of the blow-snake, and is typical of the prairie region. Following H. Garman, the species is listed by Hart under *H. simus*. The blow-snakes are confined to sandy or very dry places. The eggs are laid in summer in the sand. The food consists principally of toads and frogs. The names "blow-snake" and "puff adder" arise from the snake's habit of simulating ferocity by flattening the anterior part of the body and hissing. It also feigns death, lying on its back, reviving, however, long enough to turn over again on its back if placed in any other position. The blow-snake is a typical predaceous member of the sand-prairie associations.

Cnemidophorus sexlineatus Linn. June 25, 28.

These striped lizards were quite abundant in the bunch-grass in the Devil's Hole and other places. The genus is subtropical, all but *sexlineatus* being restricted to the Sonoran Province. The eggs are laid in a hollow in the sand, and are left to be hatched by the sun.

*A small specimen taken by James Zetek in the *sand prairie*, in 1911, has no subnasal plate; both prefrontals and postfrontals are separated from the azygous plate by a series of small plates, nine in number. Scale-rows are 23. Top of head is crossed by the typical white stripe in the region of the eyes. Other markings are almost identical with those of a specimen from Julesburg, Colorado.

A blow-snake taken in the *mixed forest* of the marginal dune, August 20, 1913, is plainly to be referred to the eastern species, *H. platirhinos* Latreille, having no small plates separating the azygous plate from the prefrontals and postfrontals.

The food consists of insects and spiders, which are only taken when moving, and other animal food, sometimes the eggs of small ground-nesting birds. The insects most commonly eaten are grasshoppers and beetles. Even active forms like the tiger-beetles are captured by these lizards. They are diurnal, solitary, and hide in burrows at night. They are found on the Atlantic coast as far north as Maryland and Delaware, and south and west into Mexico. In Indiana and Illinois they occur in the Lake Michigan sand area, and they are also found at Henry and Ottawa, in dry habitats along the Illinois River.

Terrapene ornata Ag. June 28, July 3, 6, October 6.

This is the prairie species of *Terrapene,* and is much commoner in the sand prairie than in other parts of the state. It is very long-lived, hibernating each winter in a deep burrow. It is practically omnivorous. It is known to eat vegetable food. One specimen when first caught had part of the tegmina of a grasshopper adhering to the lower mandible, and it ate grasshoppers later from the hand. The movements are usually sluggish. It feigns death when too roughly handled. The box-turtle is found usually in open bunch-grass or blowsand. Several burrows were found along a fence in sparse growths. The animal is more or less roving in habit. It is a typical sand prairie species, hardly characteristic of any one of the associations. Mr. Hart lists this species as *Terrapene carolina,* which is the forest species of the genus, and which has a distinctly carinate ridge along the median line of the carapace. The Havana species has not been taken in the woods, and seems to be perfectly at home in the sand prairie. It has hardly a trace of the dorsal ridge.

AVES

The bird records for the summer of 1910 are in large part records of the observations of Mr. F. C. Gates, who has kindly permitted their use. They include notes on other associations than those of sand prairie (Gates, '11a).

The bird life of the sand prairie is scanty in comparison with that of the black-soil prairie. There is an abundance of insect food, particularly grasshoppers, and it is thought that severity of nesting conditions is the chief factor in the exclusion of so many birds from the association. Species which nest in hedges and thickets are quite abundant, but the true prairie species, which nest on the ground, are very few.

Colinus virginianus virginianus Linn.

The quail, or bob-white, is of secondary importance in bunch-grass. It feeds in the sand prairie, much of its food being grasshoppers while these are abundant. Several flocks were seen in spring.

Zenaidura macroura carolinensis Linn.

The mourning dove is of secondary importance in the bunch-grass association. It does not nest in the sand prairie, and when found the birds are in groups of two or three. They feed upon seeds, and to some slight extent upon grasshoppers.

Buteo platypterus Vieill. July, April 5.

The broad-winged hawk was often seen soaring above the sand prairie. It was very frequent in spring. Probably a species to be reckoned with in the sand-prairie associations.

What appeared to be the red-tailed hawk was seen July 25 in the black-oak forest east of Havana, and in several places south of Havana, in April. The marsh hawk was also seen, at a distance from the river, in April.

Coccyzus erythrophthalmus Wils.

The black-billed cuckoo nests in thickets. It is very abundant in the sand region, and is occasionally seen in bunch-grass, on fences, or in shrubbery. At the Devil's Hole a number were seen in a small clump of coffee-trees. The food consists of insects, notably hairy caterpillars which other birds avoid.

Tyrannus tyrannus Linn.

The kingbird is often seen singly in the bunch-grass, darting from its perch on a fence or bush in pursuit of some insect. It is a thicket species primarily.

Otocoris alpestris praticola Hensh.

The prairie horned lark is not listed in Gates's summer records for the sand prairie. It was quite abundant in spring, and was seen once or twice in sand prairie, but more often in the cultivated fields. One would expect to find it a typical member of the bunch-grass association.

Corvus brachyrhynchos brachyrhynchos Brehm.

The common crow is seldom seen in the bunch-grass, and then generally singly. A secondary bird species.

Sturnella neglecta? Aud.

The western meadowlark is the dominant form in the bunch-grass, nesting on the ground in that association; while the eastern

meadowlark, *S. magna*, as Dr. Gates assures me, is accidental in the sand prairie, though it is fairly common in the flat areas of sandy loam. *Neglecta* is a characteristic plains species. (Cf. Gates, '11a.)

Passer domesticus Linn.

The English sparrow is sometimes found in flocks in bunch-grass pasture. Not a typical bunch-grass species.

Poocaetes gramineus gramineus Gmel.

The vesper sparrow is one of the dominant species, normally nesting in the bunch-grass, and frequently seen in flocks. Its food consists largely of grasshoppers. A western species is found in the same habitat of the plains region.

Chondestes grammacus grammacus Say.

The lark sparrow is another dominant sparrow of bunch-grass, nesting on the ground, and frequently found in small flocks. A typical prairie species. Grasshoppers and other insects constitute a considerable proportion of its food.

Spizella pusilla pusilla Wils. April 4, 5.

A number of field sparrows were seen in the bunch-grass southeast of Havana. During the first week in April they were common over all the open areas of the sand region.

Cardinalis cardinalis cardinalis Linn.

The redbird is one of the dominant species of thickets in the sand region; but in the bunch-grass it is hardly more than an accidental visitor.

Spiza americana Gmel.

Another dominant bunch-grass species, probably nesting on the ground. Seen in flocks or pairs quite frequently. The dickcissel is a characteristic species of the prairie. Its diet is partly grasshoppers.

Lanius ludovicianus ludovicianus Linn. July 25.

The shrike is rather scarce in the sand prairie, and perhaps more typical of the cultivated fields than of the bunch-grass. Seen in the Devil's Hole on fences. Eats numbers of locusts and other insects.

Mimus polyglottos polyglottos Linn.

The mocking-bird, though characteristic of thickets, is more often seen in the bunch-grass than is the brown thrasher. Much of its food consists of insects, largely grasshoppers.

Toxostoma rufum Linn.

Though primarily a bird of thickets, the brown thrasher is often seen on fences in the bunch-grass. A grasshopper-feeder to some extent.

Sialia sialis sialis Linn. July 15.

The bluebird is often seen on high perches in open places, and on telegraph wires near bunch-grass. Not a sand-prairie species. Commonly seen in spring.

MAMMALIA

Peromyscus maniculatus bairdii Hoy and Kenn. July 5, April 4.

The white-footed prairie mouse is very common in the bunch-grass, being the most abundant rodent of the sand prairie. The burrows have usually two or three openings, and are seen throughout the bunch-grass, though in pastures the holes are more frequent along the fences. The food is principally vegetable. Almost all rodents eat animal food on occasion, and no doubt this species eats a number of insects. The prairie white-foot is very prolific, there being three broods each year, with from four to nine in a litter. The species stores up food, remaining active all winter. *Peromyscus* is a very important animal of the bunch-grass. The nocturnal carnivores and owls, and probably the snakes of the region, feed principally on this species. Among the larger animals it occupies a similar position to that of *Melanoplus angustipennis* among the insects. It is a dominant form. It is very unlikely that *Peromyscus bairdii* is the only small rodent of the sand prairie. In thickets and near forest borders, the white-footed wood mouse, *P. leucopus noveboracensis,* will probably be found; and the prairie meadow-mouse, *Microtus austerus,* should be present in the open fields. One of the spermophiles, *Citellus franklini* or *C. tridecemlineatus* is no doubt present.*

Geomys bursarius Shaw. June 25, 28, October 7, 8.

The burrows of pocket-gophers, with the characteristic mounds of sand, are quite common in the bunch-grass, and in several places were seen in blowsand with sparse vegetation. Mr. F. E. Wood has taken the species at the Devil's Neck; and Mr. Herman Douthitt took a number of pocket-gophers in the marginal dunes north of Havana. The species is vegetarian, active during the winter, and stores up large quantities of roots and other vegetable matter. It is solitary and strictly subterranean, coming to the surface only in the breeding season. Active tunneling begins very early in spring. During the greater part of the April visit there were heavy rains, and as soon as these were over many fresh mounds were observed. Illinois

*A fox squirrel, *Sciurus niger rufiventer* Geoff., has since been seen (August 22, 1913) in the bunch-grass at the Devil's Hole, about 150 yards from a walnut grove. It is properly a forest animal, and may aid in extension of the forest into the prairie.

is near the eastern part of the range of the pocket-gopher. Coming through the Kankakee sand region in eastern Indiana, the writer has seen from the train, mounds which could hardly have been other than those of *Geomys*. The eastern limit of its range should be looked for in a sandy region.

Sylvilagus floridanus mearnsi Allen. June 28, October 6, April 4.

The cottontail, our commonest rabbit, is quite abundant in the sand region, being sometimes a true prairie form, but more often with the den in the forest border or a thicket. These rabbits are very prolific. Since their natural enemies, the larger carnivores, are now almost extinct, their numbers would be overwhelming were it not for the reduction made each year by hunters. The food is almost exclusively vegetable. The rabbit is one of the important plant-feeding species of the sand prairie. It is quite frequently seen in the blowsand, but is more prevalent in bunch-grass. It is most active at dusk.

Mephitis mesomelas avia Bangs. April 4, 5.

This subspecies of skunk is recorded by Mr. F. E. Wood from San Jose, Mason county. None of the animals were seen, but large burrows and suspicious odors encountered together on two occasions corroborated the statement of one of the farmers residing near the Devil's Hole, to the effect that skunks are common in the sand prairie. Their dens were seen; one northeast of the Devil's Hole, and the other south of Havana. The skunk is carnivorous, eating insects, frogs, mice and other small mammals, birds' eggs, and poultry. It is sluggish and not very shy. Though the skunk causes considerable change in the animal life of an association wherever it goes, it is never abundant, and probably, for this reason, has little influence upon the association in the long run.

Several other carnivorous mammals no doubt exist in the sand region, especially the weasel, *Putorius noveboracensis* Emmons.

Scalopus aquaticus machrinus Rafinesque. July 5.

One specimen of the common mole was taken from a non-typical part of the Devil's Hole, where the blue-grass had invaded, forming a sod. It must be quite frequent in the bunch-grass, where its tunnels are often seen. On one or two occasions the burrows were seen in almost pure sand.

Several other insect-eating mammals are likely to be present in the sand prairie. Of these, *Blarina brevicauda* Say and one or two bats are almost certain to be found.

THE ASSOCIATIONS OF THE SAND PRAIRIE

The classification of the associations and the description of the plants are based upon the work of Gleason ('10), with the exception of the discussion of the black-soil transition association and the blowsand complex. From the botanical view-point the associations are quite distinct from one another, and a study of the animals shows a definite demarcation of the different animal assemblages as well. The ability of the animals to move about, however, makes the conditions for study more complex.

The animals of the sand prairie are characteristically terrestrial, as surface water is almost absent from sand. The scarcity of humus excludes most animals lower in the taxonomic scale than spiders, and the most abundant animals are insects, both as regards species and individuals. Reptiles and birds are not abundant. The larger mammals are no longer present, owing to the encroachment of civilization.

The sand prairie is composed of two formations, the prairie formation, and the blowout formation.

Method of Analysis of the Animal Assemblages

The animals have been classified primarily according to kind of food; secondarily according to those behavior characters which effect distribution within the association. The major space-divisions within an association correspond to the horizontal strata in which animals live. (Cf. Shelford, '11b: 602.) In the sand prairie these are four: the air, the plant, the ground, and the underground layers. The animals which live in these strata have been called *acricolous, herbicolous, terricolous,* and *subterricolous.* In determining which stratum an animal belongs in, the one in which it obtains its food has usually been selected, though for other activities the animal more frequently seeks some other level. The tertiary division is based upon the flexibility or non-flexibility of habits, particularly food-habits. Animals of very restricted food-habits are found to be of much less importance than those which take different kinds of food.

Knowledge of the habits of many of the animals studied is very imperfect, and for this reason the different groups in the classification have not been subdivided to the same extent. In some cases the divisions can be made with considerable accuracy; in others the different ecological types can not at present be separated. In certain groups of only a few animals, minute subdivision would be cumbersome, and has not been attempted.

It is to be remembered that larva and adult of a particular species may be quite dissimilar ecologically, each having a different status in the association. The habits of many animals may vary widely; thus most of the sand-prairie birds eat both animal and vegetable material, and are accordingly listed with both phytophagous and predaceous animals.

Dominant animals are those of considerable importance in the association. In the lists of animals of the various associations, an asterisk denotes that the species is a dominant form.

The Prairie Formation

The important ecological feature of the prairie formation is the control of the physical environment by the vegetation. Though the formation is open, it is usually quite stable, and the processes at work tend toward the binding of the sand, the gradual enrichment of the soil through the accumulation of humus, and the ultimate establishment of a closed formation. The dominant plants are grasses; the dominant animals are largely grass-eaters, such as locusts and other phytophagous insects, rodents, etc., with a few of the animals which prey upon these. The associations in the prairie formation are three: the bunch-grass association, the *Panicum pseudopubescens* association, and a closed association which represents the culmination of the sand prairie, and may tentatively be called the *black-soil transition association.*

the bunch-grass association

The bunch-grass association, being better represented in the sand prairie than the other associations, has been more carefully studied.

The soil of the bunch-grass association is sand, mixed with a little humus. The association is open, usually about twenty or thirty per cent. of the surface being exposed. The patches of bare sand are dry at the surface, but are not greatly subject to wind action. The topography is usually undulating, the elevations having the aspect of stabilized dunes, which, in fact, they almost invariably are (Pl. II, Figs. 1, 2).

The dominant plants of this association are the bunch-grasses, which form dense tufts or bunches, in which the dead leaves of the year before remain. The bunches are separated by patches of bare sand. The general appearance of the association depends upon that of the species of bunch-grass which happen to be abundant. The important bunch-grass species are *Koeleria cristata* (Linn.), forming

large regular tufts, higher in the center; *Leptoloma cognatum* (Schultes) Chase, with large, compact, flat-topped tufts; *Stipa spartea* Trin., tall, loose, few-leaved; *Panicum pseudopubescens* Nash, with short, broad leaves, forming very flat bunches, often eighteen inches in diameter; *Bouteloua hirsuta* Lag., very depressed, grayish bunches, which are often subordinated by other grasses; one, possibly two, other species of *Bouteloua; Cyperus schweinitzii* Torr., a sedge forming sparse, open bunches; *Andropogon scoparius* Michx., and *Andropogon furcatus* Muhl., forming very large bunches.

The bunch-grasses permit the growth of the secondary plants only in the small areas of bare sand between the bunches. These secondary plants form three ecological groups, which may be called perennials, mats, and interstitials.

The perennials are usually deep-rooted, most of them growing in bunches like those of the grasses. These are usually able to withstand the encroachment of the grasses, but can not displace them. The typical perennials are *Aster linariifolius* Linn., *Lithospermum gmelini* Michx., *Aster sericeus* Vent., *Tephrosia virginiana* (Linn.) Pers., *Chrysopsis villosa* Nutt., *Petalostemon* (2 species), *Physalis virginiana* Mill., *Baptisia bracteata* (Muhl.) Ell. The shrubs of the association may be classed with this group. They are *Rhus canadensis* var. *illinoensis* (Greene) Fernald, which forms dense masses, often building up small dome-shaped dunes, and *Amorpha canescens* Pursh and *Ceanothus americanus* Linn., with large woody roots.

The second group, the mat plants, is a small one, including only *Opuntia rafinesquii* Engelm. (the common prickly pear) and a species of *Antennaria.*

The interstitial plants are usually annuals, and as the slender stems occupy very little space, they have no part in the binding of the sand. They are absolutely dependent upon the bunch-grasses. The commonest of the interstitials are: *Oenothera rhombipetala* Nutt., *Ambrosia psilostachya* DC., *Linaria canadensis* (Linn.) Dumont, *Cassia chamaechrista* Linn., *Monarda punctata* Linn., and *Croton glandulosus* Linn., var. *septentrionalis* Muell. Arg.

The animals of this association include most of the species characteristic of sand prairie.

PHYTOPHAGOUS ANIMALS OF THE BUNCH-GRASS

The plant-eaters are the basic group of the animal assemblage. They are represented in all the habitats of the association, but are most numerous in the plant stratum.

The Aericolous Stratum.—The air is an important animal habitat. It provides a medium for rapid locomotion and a temporary means of escape from enemies. A great many animals fly about in search of food, descending when it is located, and a number of predaceous forms take their food on the wing. The aerial stratum is used by phytophagous animals during many of their ordinary activities, but not in feeding, of course. In the present discussion, it has been found inexpedient to separate plant-eating animals which fly about much of the time, as *Danais plexippus,* from other plant-frequenting forms which are not such strong fliers, or which may not fly at all. All of these animals are placed in the herbicolous group, since, to avoid complication, the animals have been placed in the habitat in which they feed. It is to be remembered, however, that during other activities the plant-feeding animals are well represented in the aerial stratum.

Herbicolous Non-selective Plant-eaters.—Animals of this group eat herbage of almost any kind, not being restricted to particular plant species. They are thus preeminently eaters of grass.

Non-selective plant-feeders*

**Mermiria bivittata*
Mermiria neomexicana
Eritettix sp.
Amphitornus bicolor
Campylacantha olivacea
**Melanoplus angustipennis*
Scudderia texensis
Conocephalus robustus
**Tettigia hieroglyphica*
Scolops grossus
Agallia sanguinolenta
Typhlocyba comes
**Aphididae*
**Coccidae*
Adelphocoris rapidus
Lygus pratensis
Ligyrocoris diffusus
Lygaeus kalmii
Euschistus variolarius
**Pentatoma persimilis*
Peribalus limbolarius
**Lachnosterna prunina*
Lachnosterna micans
Lachnosterna implicita
Polyphylla hammondi
Anomala lucicola
Calligrapha similis
Diabrotica longicornis
Ocdionychis gibbitarsa
Disonycha triangularis
Rhynchophora
Apantesis sp., larvæ
Diacrisia virginica, larvæ
Noctua c-nigrum, larvæ
**Feltia subgothica,* larvæ
Leucania phragmitidicola, larvæ
Crambus sp., larvæ

*In the lists of animals of the various associations, an asterisk denotes that the species is a dominant form.

Certain of the above animals are probably more or less restricted in food, but until the food-plants are ascertained they may be considered as general feeders. All of these herbicolous animals are insects. The larger animals are referred to the ground habitat rather than to the plant layer, though some of the sparrows are frequently seen perching on the plants. In grassland associations the plants are too small to provide a well-defined habitat for the larger animals.

Herbicolous Selective Plant-eaters.—These animals are of two types: (1) those which select particular *parts* (usually the flower) of various plants, and (2) those which select particular *species* of plants.

(1) Animals associated with particular parts of plants

Acmaeodera pulchella	*Bombyliidae,* adults
Chauliognathus pennsylvanicus	*Lepidoptera,* adults
Strigoderma arboricola	*Augochlora humeralis*
Batyle suturalis	*Agapostemon splendens*
Strangalia luteicornis	*Sphecodogastra texana*
Dectes spinosus	*Megachile mendica*
Mecas pergrata	*Melissodes aurigenia*
Notoxus bifasciatus	*Bombus virginicus*
Epicauta pennsylvanica	*Bombias auriconus*
Syrphidae, adults	*Apis mellifera*

All of the above are associated with flowers and feed upon nectar and pollen. Many dipterous and lepidopterous and a few coleopterous larvæ live in *stems* of plants.

(2) Animals associated with particular species of plants

Animal species	Plant species
Lygaeus bicrucis, *Languria bicolor*, *Epitragus acutus*	*Cacalia atriplicifolia*
Haltica fuscoaenea, *Chalcodermus collaris*	*Oenothera rhombipetala*
Blepharida rhois, *Pyraustidae,* larvæ	*Rhus canadensis illinoensis*
Chariesterus antennator	*Euphorbia corollata*
Oncopeltus fasciatus, *Lygaeus kalmii*, *Tetraophthalmus* spp., *Danais plexippus*	*Asclepias* spp.

Chrysochus auratus — *Apocynum cannabinum*

Plectrodera scalator
Metachroma angustulum
Metachroma parallelum — *Populus* and *Salix* spp.
Lina interrupta
Lina scripta

Though *Populus* and *Salix* are not in reality plants of the bunch-grass association, they are frequently found in the sand area.

Of the herbicolous plant-feeders, the grasshoppers (*Acridiidae*) are by far the most abundant and the most conspicuous. It is probable that the quantity of plant material eaten by them would be at least one-fourth as great as that eaten by all the other animals in the association. The grasshoppers have numerous enemies, and constitute a large part of the food supply of the predaceous and parasitic members of the association. They are dominant animals.

Terricolous Plant-feeders.—The ground stratum consists in reality of two more or less well-defined divisions which may be called *surface* and *sub-surface*. The cotton-tail rabbit is a surface animal. The sub-surface group includes animals in surface burrows, as ant-lions, and animals found under cover of some kind, as leaves, boards, stones, or at the base of plants. *Xysticus gulosus, Termes, Lacon rectangularis,* and many other insects are typically found at the surface, under cover. It is seen that distribution of the animals varies horizontally as well as vertically, the various layers not being homogeneous throughout. Though in some associations the sub-surface habitat is continuous, as the habitat furnished by the leaf-mold of a forest floor, in the bunch-grass it is of limited extent and much scattered, boards and rocks being accidental in sand prairie. Plant-eaters, predaceous animals, parasites, and scavengers are all represented in the surface and sub-surface habitats, predaceous animals being perhaps most conspicuous. The surface phytophagous animals are probably not exclusively ground-feeders.

(1) Surface phytophagous animals

**Ageneotettix deorum*
**Hippiscus* spp.
**Spharagemon wyomingianum*
**Mestobregma thomasi*
Psinidia fenestralis
**Melanoplus angustipennis*
Colinus virginianus virginianus
Zenaidura macroura carolinensis
Otocoris alpestris praticola
**Sturnella neglecta*
**Poocoetes gramineus gramineus*
**Chondestes grammacus grammacus*

Geocoris bullatus
Cydnus obliquus
Sehirus cinctus
**Formica pallide-fulva schaufussi*
**Pheidole vinelandica*
Monomorium minutum
Terrapene ornata
**Spiza americana*
**Peromyscus maniculatus bairdii*
Microtus austerus?
Citellus sp.?
**Sylvilagus floridanus mearnsi*

(2) Sub-surface phytophagous animals

Pterostichus lucublandus
**Harpalus caliginosus*
**Harpalus* spp.
.Harpalini, sp. nov.
Amara cupreolata
**Anisodactylus rusticus*
**Lacon rectangularis*
Cardiophorus cardisce
Opatrinus notus
Blapstinus interruptus

Very little is known of the food habits of the last four species.

Subterricolous Animals.—Although many plant-eaters burrow in the ground, most of them obtain their food above the ground, so that the truly subterranean plant-eaters are not abundant. A short list follows:

Ceuthophilus sp.
Aphididae
Elateridae, larvæ
Scarabaeidæ, larvæ (except *Laparosticti*)
**Chrysomelidae,* larvæ
Phorbia fusciceps, larvæ
**Geomys bursarius*

PREDACEOUS ANIMALS OF THE BUNCH-GRASS

Predaceous animals, as well as plant-eaters, include forms which select their food within more or less narrow limits, and those which exercise very little preference. *Perillus circumcinctus* feeds upon the larvæ of *Blepharida rhois;* tiger-beetles eat any small moving animal. Our knowledge of the food of most of the animals is quite incomplete, and therefore a division of the predaceous animals according to food selection can not at present be made.

Aericolous Predaceous Animals.—The aericolous group of the predaceous animals has been restricted to those which obtain their food in the air. Certain strong fliers, *Macrochires, Odonata,* etc., are continuously on the wing. Quite frequently they fly at considerable altitudes, and are not influenced by the boundaries of local associations. They are thus seen scattered about, and can not be said

to be typical of any one association. (Cf. Gates, '11a: 22.) Their influence, however, is felt by all the associations which contribute to their food, and to that extent these animals which fly above the bunch-grass, catching flying insects on the wing, are members of the association. There is a second group of aericolous animals which are normally at rest, perhaps on a perch or other prominent station (sometimes on the bare sand), and which make occasional short flights after their prey. The following list includes members of both groups:

Ischnura verticalis
Epicordulia princeps
Sympetrum rubicundulum
**Erythemis simplicicollis*
Perithemis domitia
**Proctacanthus* spp.
Other *Asilidae*
Chordeiles virginianus virginianus
Chaetura pelagica
Tyrannus tyrannus
Hirundinidae?
Chiroptera?

Robber-flies and the kingbird wait for their prey while at rest. Not all the food of the robber-flies is taken in the air, and so they are not exclusively aericolous. The other animals fly about during most of their active period of the day. I have no record of the occurrence of swallows or bats, but they are to be expected in the bunch-grass association.

Herbicolous Predaceous Animals.—Most herbicolous predaceous animals have little or no direct relation to the plant. They are found on the plant because the animals on which they feed are there. In some associations rocks and stumps form as productive a hunting-ground, to certain animals, as do plants, and webs of *Drassidae* and *Theridiidae* are found there as well as on plants. In the sand prairie one is as likely to find jumping-spiders on fence-posts (or any other introduced objects) as on plants. The spiders feed on stray insects which are almost always present. In effect there is little difference between an elevated inanimate object and a plant, so far as most predaceous animals are concerned. The fact that both are in the same horizontal stratum makes them essentially similar as a habitat for predaceous animals.

Liobunum sp.
Thomisidae
Steatoda corollata
Euryopis funebris
Epeira stellata
Phymata fasciata
Hymenarcys nervosa
Perillus circumcinctus
Hippodamia parenthesis
Chilocorus bivulnerus

Phidippus spp.
Myrmeleonidae, adults
Chrysopa oculata
Oecanthus confluens
Sinea diadema
Reduviolus ferus
Triphleps insidiosus
Coccinellidae, larvæ
Calopteron reticulatum
Odynerus sp.
Polistes pallipes
Prionony x bifoveolatus
Prionony x atratus
Cerceris spp.

Terricolous Predaceous Animals.—The predaceous animals of the surface and sub-surface, though found with the phytophagous forms of those habitats, are apparently much more abundant than the latter.

(1) Surface predaceous animals

Drassus sp.
**Lycosa* spp.
Phidippus ardens
**Cicindela formosa generosa*
**Cicindela scutellaris lecontei*
Sphaerophthalma ferrugata
**Sphaerophthalma chlamydata*
Sphaerophthalma vesta
Anoplius spp.
Sphex pictipennis
**Heterodon nasicus*
**Cnemidophorus sexlineatus*
**Cistudo ornata*
Colinus virginianus virginianus
**Sturnella neglecta*
Poocoetes gramineus gramineus
Chondestes grammacus grammacus
**Spiza americana*
Mephitis mesomelas avia

(2) Sub-surface predaceous animals

Lithobius sp.
Xysticus gulosus
Myrmeleonidae, larvæ
Gryllus abbreviatus
Alydus sp.
**Cicindela* spp., larvæ
Pterostichus lucublandus
Calathus opaculus
Selenophorus spp.
Hister biplagiatus
Saprinus spp.
Telephorinae, larvæ

This habitat is more or less heterogeneous and of scattered horizontal distribution, and the animals in it have a great variety of habits. Many animals found under cover by day are roaming about through the association at night, and while under cover are merely resting. Others are known to feed in the sub-surface stratum.

Interstitial Animals.—The small animals, both phytophagous and predaceous, which live on the bare spaces between the bunch-grasses, are the characteristic forms of open associations. They gradually

disappear with the development of the bunch-grass into a closed association. They depend for space upon the tuft-like growth-form of the bunch-grasses, in the same manner as do the slender annual plants of the association, the interstitial plants. The animals of the bare sand spaces have accordingly been called *interstitial animals*. The tiger-beetles are very good examples of this group. The large animals are not influenced to any considerable extent by these extremely local differences between grass tufts and bare spaces, and so the interstitial group is composed only of the smaller animals, *Cnemidophorus* being the only vertebrate. This relation of the small animals to the plants is important, for it illustrates one of the ways in which the animals are influenced by the plants. The interstitial group serves further as a convenient index to the relations between the bunch-grass and other associations of the sand prairie.

Subterricolous Predaceous Animals.—Although a number of animals are burrowing forms, their principal activities are carried on at or above the surface, so that the number of strictly subterranean animals is greatly limited.

Pasimachus elongatus
Geopinus incrassatus
Carabidae, larvæ
Histeridae, larvæ
Meloidae, larvæ
**Scalopus aquaticus machrinus*
Blarina brevicaudis?

PARASITIC ANIMALS OF THE BUNCH-GRASS

The parasitic bunch-grass animals are very poorly represented in the collections, as appears from the following scanty list.

Parasite	Host
Trombidium locustarum	*Acridiidae*
Anthrax spp., larvæ	*Acridiidae; Lepidoptera,* larvæ
Systocchus vulgaris, larvæ	*Acridiidae,* eggs
Gonia frontosa, larvæ	*Lepidoptera,* larvæ
Spalanzania sp., larvæ	*Lepidoptera,* larvæ
Apanteles theclae	*Lepidoptera,* larvæ
Urios vestali	*Pheidole vinelandica*

None of the bunch-grass animals were examined for internal parasites. A search would probably have revealed the following forms: *Trichonympha gracilis* Leidy, a flagellate, very abundant in termites; *Hirmocystis rigida* Hall, a gregarine, occurring in from 15 to 90 per cent. of *Melanopli,* wherever examined; several genera

of small nematodes, often very abundant in grasshoppers and beetles; nematodes, trematodes, and cestodes in vertebrate animals. Common ectoparasites to be looked for are mites, *Mallophaga,* and fleas. Many parasitic insects other than those listed above are to be expected, particularly among the *Bombyliidae* and *Tachinidae* in *Diptera,* and the division *Parasitica* in *Hymenoptera.*

The free-living stages of parasites are represented in all the strata of the bunch-grass association.

There is often little distinction, from the ecological point of view, between parasites and such predaceous animals as are of more or less selective food-habits. It is sometimes difficult to decide whether an animal is parasitic or predaceous. The positions of the two groups in the association are essentially the same.

SCAVENGERS OF THE BUNCH-GRASS

The scavengers are of different types, according to the character of their food. Omnivorous animals are scavengers in part. Others may eat dead wood, decaying herbaceous material, carrion, animal excrement, or the organic matter in the soil. Certain animals depend on the presence of humus, though it is not known whether their food is dead organic material, or small living organisms of the soil. However, as humus is not abundant in the Illinois River sand, animals depending on its presence are accidental, and the question need not be entered upon here. Wood-feeders also are not typical members of prairie associations.

Omnivorous animals

Ceuthophilus sp.
Gryllus pennsylvanicus
Formica pallide-fulva schaufussi
Monomorium minutum

Humus-feeders

Diplocardia sp.
Parajulus sp.
Entomobrya sp.

Wood-feeders

Termes flavipes
Ischnoptera sp.

Carrion-feeders

Necrophorus marginatus
Silpha inaequalis
Staphylinidae
Dermestes caninus
Dermestes vulpinus
Trox scabrosus
Sarcophagidae

Excrement-feeders

Canthon nigricornis	*Onthophagus pennsylvanicus*
Canthon vigilans	*Aphodius* spp.
Canthon laevis	*Geotrupes opacus*
Copris carolina	*Euphoria inda,* larvæ

As the bunch-grass is very generally pastured, the presence of horses and cattle attracts large numbers of excrement-feeders. As the scavengers are commonly divided into plant scavengers and animal scavengers, according to the origin of the dead material on which they feed, it would be supposed that excrement-feeders should be placed unconditionally in the latter category. As a matter of fact, much of the plant food eaten by horses and cattle passes through the alimentary canal undigested, and the scavengers thus feed to some extent on vegetable material.

Scavengers belong mainly to the sub-surface and underground strata of the association. They include animals of both selective and non-selective food-habits. Strictly scavenger species are never dominant.

INVADERS FROM OTHER ASSOCIATIONS

The animals of the bunch-grass and those of surrounding associations always intermingle to some extent, and the invading animals assume a place in the association, and exert an influence in it, much as if they were typical members of it. Often the breeding activity of these animals is restricted to local environments not represented in the sand prairie, as in the case of insects with aquatic larvæ. The associations from which invaders are derived most frequently are forests and thickets, the cultivated fields, marshy and aquatic situations, and the blowsand association. Most of the species from the blowsand are also found in the bunch-grass itself, as interstitial animals, so that the invaders are not readily separated from the true bunch-grass animals.

(1) Invaders from forests and thickets

Diplocardia sp.	*Buteo platypterus*
Parajulus sp.	*Coccyzus erythrophthalmus*
Termes flavipes	*Tyrannus tyrannus*
Ischnoptera sp.	*Corvus brachyrhynchos brachyrhynchos*
Limonius quercinus	*Cardinalis cardinalis cardinalis*
Serica sericea	*Lanius ludovicianus migrans*
Batyle suturalis	*Mimus polyglottos*
Xylopinus saperdioides	

(2) Invaders from cultivated fields and ruderal associations

Acanthothrips verbasci	*Diabrotica* spp.
Adelphocoris rapidus	*Phytonomus punctatus*
Lygus pratensis	*Gymnetron teter*
Megilla maculata	*Lasius niger americanus*
Coccinella novemnotata	*Apis mellifera*
Drasterius elegans	*Passer domesticus*
Leptinotarsa 10-lineata	

Certain of the above may originally have been true members of the bunch-grass association, but they are now, at least, more abundant in cultivated fields, and spread from them. The horses and cattle of the pastured areas are really important bunch-grass animals, and might well be added to the above list.

(3) Invaders from marshy and aquatic situations

Ephemerida	*Chironomidae*
Trichoptera	*Bufo americanus*
Odonata	*Amblystoma tigrinum*

The nearness of the Illinois River makes the aquatic element important.

The bunch-grass association covers most of the sand prairie in the Illinois River valley. It contains a larger number of plant and animal species than any of the other associations, and presents a greater variety of interrelations. It may be said to be the association most representative of sand prairie.

THE PANICUM PSEUDOPUBESCENS ASSOCIATION

The dominating factor in the *Panicum pseudopubescens* association is the wind, which has gained control over the plants, and is now destroying the vegetation. This association is the transition stage in the succession from bunch-grass to blowsand, and is marked by a large proportional area of bare sand, which is constantly being removed by wind. The association is very commonly found on dune summits, where wind exposure is pronounced.

Panicum pseudopubescens is the last bunch-grass species to be killed by the removal of sand from its roots. It seems to thrive better under conditions of sand removal than in more stable sand, in competition with the other bunch-grasses. It thus becomes the domi-

nant plant of the association. A few other bunch-forming species may persist in this association as relics from the bunch-grass; some of these are *Panicum perlongum, Andropogon scoparius, Koeleria cristata,* and *Cyperus schweinitzii.* The secondary species are perennials, which persist as relics, and interstitials, which are very well developed in this more open association. The species are nearly all the same as those of the bunch-grass.

The animals do not differ greatly from those of the bunch-grass. The herbicolous species which live in the bunches are not so well represented, but the interstitial species and those more characteristic of the blowsand are very much more abundant than in the bunch-grass. On the whole, the animals may be said to form a group which is transitional between the animals of bunch-grass and those of blowsand. The tiger-beetles, mutillids, sand-wasps, and terricolous grasshoppers are more numerous than in the bunch-grass. The structure of the animal assemblage is thus seen to be parallel with that of the plant assemblage.

THE BLACK-SOIL TRANSITION ASSOCIATION

This association is not well represented in Illinois, for the reason that in it, or even before its development, the soil has reached such a stage of fertility and stability that it is suitable for agriculture, and only the more open associations have been allowed to remain in a natural state. This stage is a relative or temporary climax in that it marks the end of the sand series. It probably connects the sand prairie to the prairie-grass or black-soil prairie formation of the eastern part of the province, and doubtless many relics of an association very much like it may be found in the tension zone between the sand-hills and the prairie-grass regions. The normal tendency is for the most advanced stage of the sand prairie to develop slowly into a stage of the black-soil prairie. Under natural conditions this development would rarely occur in the Havana region, for invasion by the forest would be much too rapid for the succession between the two prairie formations to be completed. Thus in the Havana region we find much of the area forested, but no development of mesophytic black-soil prairie. The bunch-grass has reached its most advanced stage in places near the Devil's Neck, in places east of several forested dune areas, and particularly in the eastern border of the sand-plain. It is probable that some such vegetation covered the drier parts of the sandy loam flats. Part of the growth is dominated by *Andropogon furcatus* Muhl. *Panicum perlongum* Nash marks meso-

phytic stations. *Euphorbia corollata* Linn. is more abundant than in open bunch-grass; its white flowers are in late summer the most conspicuous feature of the vegetation. Animal species typical of rather less sandy situations are the sub-surface millipeds, earthworms, etc., of soils containing humus; *Bacunculus blatchleyi* Caud. (see Pl. XVII in Hart and Gleason '07,) *Schistocerca americana* Drury, *Melanoplus femur-rubrum* De G., *M. differentialis* Uhl., *M. bivittatus femoratus* Burm.; *Cyanospiza cyanea* Linn. (indigo bunting), and *Astragalinus tristis* Linn. (goldfinch). Even the most advanced stage of sand prairie is much less mesophytic than is the typical black-soil prairie as seen in northeastern Illinois, and many characteristic species of the latter growth are absent.

During a recent visit to the sand prairie (August, 1913) indications were found of development of black-soil prairie from the swamp prairie of wet parts of the sandy loam flats. The peculiar umbellifer *Eryngium yuccifolium* Michx., which grows in moist soils with humus, was found in a station eight miles south of Havana, in what was the border between swamp and sand prairie. Other prairie mesophytes, as *Pycnanthemum pilosum* Nutt., indicate prairie development from wet habitats in the sand region.

The black-soil transition association in the Havana region is the continuation and culmination of the processes resulting from the dominance of the vegetation over the physical environment: (1) the elimination of the interstices between the bunches of grass, and with these the interstitial plants and animals, thus changing the loose tuft growth into a dense sod, (2) the gradual accumulation of humus, (3) the increasing capacity of the soil for water storage, and (4) the increase of atmospheric humidity. With the closing of the association most of the perennials, including the cactus, would be eliminated as well as the interstitials. There is then the tendency towards the dominance of a few species of plants and animals, rather than of numerous species. Without forest invasion we should expect the successional series of the sand prairie of the sand ridges and the successional series of the swamp prairie of the sandy loam flats to converge ultimately in an advanced mesophytic stage common to both series. The processes of stabilization and accumulation of humus which characterize the bunch-grass do not culminate in that association; there is a natural and gradual succession between the sand-prairie formation and the prairie-grass formation typical of the eastern part of the prairie province.

The Blowout Formation

The distinguishing feature of the blowout formation is the dominance of the physical factors of the environment. The wind exercises complete or almost complete control of the vegetation. The formation is so open that its general appearance and color is that of almost bare sand. The associations, being subordinated by the physical conditions, are distinguished from each other by differences in physical environment; the difference in plant and animal species is an effect rather than a cause. Changes in the life are determined by changes in the physiography. In the prairie formation the normal changes in the physical conditions are largely the work of the plants. In the blowout formation, even the names of the associations have been taken from physical features. The prevailing tendencies are continual shifting of the sand, which is thus kept in a sterile condition, the formation of blowouts and dunes in places where the vegetation is or has been of influence in modifying the action of wind (Pl. III, Figs. 1, 2), and the formation of large, nearly level sandy wastes, wherever the wind has long been the controlling factor (Pl. IV, Figs. 1, 2, 3). This latter "blowsand" (see p. 88) conformation is due largely to the confluence of a number of blowouts, but is very characteristic, and covers in the Havana region many times the area of the isolated blowouts. Gleason's discussion of the formation of the blowouts is without doubt the best we have ('10: 84-90).

The blowout itself is a wind-formed excavation, normally originating in the *Panicum pseudopubescens* association by gradual ascendency of the influence of wind, resulting in increasing openness of the association. Blowouts sometimes start in the bunch-grass, usually by accident. Figure 2, Plate II, shows the beginning of a blowout on the slope of the dune to the left. A small bare expanse from which the wind is gradually removing the sand is the first stage of the blowout. It gradually deepens, the sand from the basin of the depression being deposited above the general level on the lee side. The deepening continues, the sides of the depression become steeper, except the lee slope, up which the sand is drifted and deposited as a low dune formation. The windward slope reaches the critical angle, and from then on the removal of the sand from this side of the depression is by gravity. There are thus four physiographic divisions of the blowout: (1) the basin, from which sand is being removed by wind; (2) the windward slope, from which sand is being removed by gravity; (3) the lee slope, or blowsand division, over the surface of which the sand is being merely drifted, without

change of level; and (4) the deposit, which is continually being added to by sand from the basin. The differences between these physiographic divisions are reflected in the plants and animals which inhabit them; the groups are sufficiently distinct to be different associations, which take their names from the physical divisions of the blowout.

Professor Gleason makes the point that the character of the plant-covering is determined not merely by the *kind* of movement of the sand (removal or deposition) but by the *rate* of movement as well. Thus if deposition in a bare sand area is only one-fourth inch in a certain season, seeds will be buried to that depth and will not germinate, for the surface layer of the sand is very dry. If the burial is to a depth of two inches, the seeds will probably germinate (different species having different optimum depths for seed-burial). If the burial should be to a depth of a foot or more, none of the seedlings will reach the surface. Different depths of burial favor different species of plants. Where plants are already established, deposition of sand may favor those which can grow upward as fast as the sand deepens. Where deposition is extremely rapid, however, even the most rapid growers can not resist burial. As the degree of deposition varies in any one place from year to year, conditions for plant growth will be very unstable. In the same manner, removal of the sand, if very slight, makes very little difference to most of the plants. As the degree of removal increases, many of the plants are killed, such species as can endure the undermining having the advantage. When removal becomes very great, even the hardiest of these plants are killed, and the result is bare sand.

Plant growth in the blowout formation is thus extremely scanty, as the plants are not adapted to the severe and continually changing physical conditions. Most of the plants are slender annuals, the species composition being almost the same as that of the bunch-grass interstitials. A few perennials sometimes persist as relics from former bunch-grass. The animals are for the greater part the same species as those of the bunch-grass interstitial animals, though a few are distinctive of blowout associations, and are almost exclusively species characteristic of open associations. Where the plant growth is well developed, the animals are what may be termed resident or endemic; but in large expanses of bare sand the animals consist largely of roving invaders from neighboring associations. Plant-feeders in such situations are not so well represented as predaceous animals, the former consisting in large part of more sedentary ani-

mals. Very large stretches of bare sand have almost no animals except about the margin.

THE BASIN ASSOCIATION

The basin association occupies the circular or oval area in the bottom of the blowout, from which the sand is being removed by wind (Pl. III, Fig. 1). Plants which persist in the basin must therefore be able to withstand excavation. The only plants that can withstand undermining to any appreciable extent are the green milkweed, *Acerates viridiflora* Ell., and its variety *lanceolata* (Ives) Gray, which thrives even better than the type. These plants are sometimes found in bunch-grass or in the *Panicum pseudopubescens* association, but are much more numerous in the basins. The roots are very long, and the plant is procumbent upon the sand. The blowout basins of the Nebraska sand-hills are usually grown over with the grass *Redfieldia*. A few perennials persist in the basin if the sand-removal is not too rapid. These are *Lithospermum gmelini, Euphorbia corollata,* and *Lespedeza capitata.*

Animals of the basin are principally invaders from neighboring associations. The blowsand animals and interstitial species from the bunch-grass make frequent incursions. At the margin of the *Cassia* zone in a blowout at the Devil's Hole are seen many mutillids, wasps, and spiders. The basin has several distinctive species. Sand-wasps of the genus *Tachytes* hover about the flowers of *Acerates;* and *Cicindela lepida* and *Stachyocnemis apicalis,* the color of which matches that of the sand, are found all over the bare sand of the basin. *Lycosidae* often burrow in the open sand. *Terrapene* has been taken at the edge of a blowout, *Cnemidophorus* has been taken in a burrow in a large basin, and one often finds the tracks of mice and rabbits, and the sinuous trail of the blow-snake crossing the basin. *Mutillidae* and their burrows are found in the bare sand, and at the margin are *Schistocerca alutacea* and *Melanoplus flavidus.* Other *Cicindelidae* than *Cicindela lepida* are quite frequently taken in the basin. *Alydus,* the peculiar ant-like bug, is represented by several species. Like the plant life of the basin association, the animal life is very scanty, and represents the extreme conditions of the combined effect of wind and sand.

THE WINDWARD SLOPE ASSOCIATION

The windward slope of the blowout is quite steep, and the sand is continually sliding down by gravity. Usually the top of the slope

is held by plants of the bunch-grass growth which more often adjoins the blowout (Pl. III, Fig. 1). In an active blowout the sand which falls to the bottom of the slope is removed by the wind, and the windward slope thus works its way back, enlarging the blowout in the direction of the wind.

No annual plants are found on the windward slope, as there is no chance for burial of seeds. The plants of the association are always in the form of relics from the surrounding associations, usually bunch-grasses. In the Havana region, *Sporobolus cryptandrus* (Torr.) Gray is often found on the windward slope. Most grasses are killed as soon as they become dislodged from the top of the sand-bluff, but this species seems to grow nearly as well on the steep slope as in more stable sand in competition with other species. A few other grasses and a few perennials are also occasionally found on the windward slope. The tufts of grass are always very few and scattered, the whole face of the slope being sometimes altogether bare. The grasses sometimes become a part of the basin association, after reaching the bottom of the slope, but more often they are undermined and blown away.

The animals of the windward slope association are very few indeed, and the forms that are found are accidental species. Burrowing animals are excluded, because of the instability of the sliding sand. Many animals of other associations, however, cross the windward-slope areas, and practically all the animals of the bare sand are seen there, particularly *Cicindela lepida, Stachyocnemis,* mutillids, and spiders. The windward slope is very closely related to the basin association; the same process is involved in each association. The removal of sand and the biotic conditions in each area approach those of the desert.

THE BLOWSAND ASSOCIATION

This association occupies the lee slope of the blowout, which is of gentle gradient. The sand movement is merely a drifting in the direction of the wind, with but little removal or deposition of the sand. The constant shifting of the surface layer may allow the burial and germination of a few of the countless seeds which are blown across the blowouts, and consequently a large number of annual plants are regularly found in this association. The conditions of burial vary, however, from year to year, so that the growth of annual plants is not always present. The plant species found on the lee slope of a nearly typical blowout at the Devil's Hole are as follows: *Cassia chamaechrista* and *Ambrosia psilostachya* are the two

commonest species; *Cenchrus carolinianus* and *Aristida tuberculosa* are the two annual grasses; tufts of *Sporobolus cryptandrus* are quite common; and other annuals are *Oenothera rhombipetala, Croton glandulosus* var. *septentrionalis, Euphorbia geyeri, Froelichia floridana, Tephrosia virginiana, Cycloloma atriplicifolia, Polanisia graveolens, Crotonopsis linearis, Monarda punctata,* and the western species *Cristatella jamesii. Euphorbia corollata* and *Lespedeza capitata* are two perennials sometimes seen on blowsand. In the other sand regions of Illinois the floristic composition of the blowsand association varies considerably.

The animal assemblage of the blowsand is quite distinctive, though most of the species occur also in bunch-grass, just as is the case with the plants. The blowsand species are, however, much less numerous than those of the bunch-grass, though *individuals* of many species common to both associations are very much more numerous in blowsand than in bunch-grass.

PHYTOPHAGOUS ANIMALS OF THE BLOWSAND

Herbicolous Phytophagous Animals

Conocephalus robustus	*Disonycha triangularis*
Jassidae	*Bruchus cruentatus*
Aphididae	*Anthrax* spp., adults
Thyreocoris ciliata	*Bombus* sp.

Thyreocoris ciliata and *Bruchus cruentatus* are selective in food-habits, both being associated with *Cassia chamaechrista.*

Terricolous Phytophagous Animals

(1) Surface animals

**Spharagemon wyomingianum*	*Tettix hancocki*
Psinidia fenestralis	*Geocoris bullatus*
**Schistocerca alutacea*	**Pheidole vinelandica*
**Melanoplus flavidus*	*Peromyscus maniculatus bairdii*
Melanoplus angustipennis	*Sylvilagus floridanus mearnsi*

Melanoplus flavidus and *Schistocerca alutacea* are very abundant in blowsand, but rare in bunch-grass. *Melanoplus angustipennis* is rare in blowsand, but is the dominant species in bunch-grass.

(2) Sub-surface animals

Harpalus spp.
**Anisodactylus rusticus*
Harpalini, sp. nov.
**Lacon rectangularis*
Cardiophorus carisce
**Opatrinus notus*

PREDACEOUS ANIMALS OF THE BLOWSAND

Herbicolous Predaceous Animals

**Sinea diadema*
Hippodamia parenthesis
Coccinella novemnotata
**Tachytes* spp.
Polistes pallipes
Prionony x bifoveolatus

Terricolous Predaceous Animals

(1) Surface animals

**Lycosa* spp.
Phidippus insolens
Phidippus mc-cookii
**Alydus* spp.
Stachyocnemis apicalis
**Cicindela formosa generosa*
Cicindela scutellaris lecontei
**Asilidae* (partly aericolous)
**Sphaerophthalma occidentalis*
Sphaerophthalma ferrugata
**Sphaerophthalma chlamydata*
Sphaerophthalma vesta
Mutilla dubitata
**Anoplius* spp.
Sphex violaceipennis
Heterodon nasicus
Cnemidophorus sexlineatus
Terrapene ornata

(2) Sub-surface animals

Nothopus zabroides
Hister biplagiatus

The sub-surface habitat is very poorly represented in the blowout formation.

Subterricolous Predaceous Animals

Geopinus incrassatus
Scalopus aquaticus machrinus

PARASITIC ANIMALS OF THE BLOWSAND

Trombidium locustarum
Bombyliidae, larvæ
Tachinidae, larvæ
Nomadidae

SCAVENGERS OF THE BLOWSAND

Termes flavipes
Onthophagus pennsylvanicus
Aphodius inquinatus
Aphodius terminalis

The abundant and conspicuous animals of the blowsand are the surface forms—a few *Acridiidae* and a large number of roving predaceous animals.

The blowsand association, though consisting often of an abundant growth of plants and animals, is nevertheless dependent upon the physical environment, and may be exterminated in a winter of severe wind action. Several times lee slopes of blowouts were found with the horizontal roots of the last year's annuals exposed at the surface, which indicates that a depth of about three inches of sand had been blown away during the winter.

THE BLOWSAND COMPLEX

The large waste areas of bare sand (Pl. IV, Figs. 1, 2, 3) are also referred by Gleason to the blowsand association. The bare areas are not always, however, of the same origin as the lee slope area of the blowout, nor is the vegetation homogeneous. The large areas originate in three ways; by the continued growth of a large blowout, by the confluence of a number of blowouts, or through plowing, or trampling of cattle. The second cause is perhaps most influential. The tendency in bare sand, when obstructions are absent, is towards a slow drifting of the sand across the level surface, with very little deposition or excavation. The only plants to be found are annuals, particularly *Cenchrus* and *Aristida.* In general, physical conditions and vegetation approximate those of the blowsand association of lee slopes. Practically, however, in any considerable area one finds complications in the form of dunes, blowouts, and relic colonies of bunch-grass vegetation. It would therefore, seem preferable to distinguish between the large bare areas and the lee slope areas by giving the former the name *blowsand complex.*

The vegetation of the blowsand complex is quite varied in nature. In abandoned fields, where plowing has started wind action, the dynamic tendency is in either of two directions, according to the degree of humus in the soil, and, perhaps, the degree of exposure to wind. When the sand is almost pure, wind action dominates, and the result is an unvegetated area of shifting sand. If, however, there is enough humus in the soil, the vegetation dominates, and there is a gradual development from plant growth of very sparse type to bunch-grass. Such areas are frequently covered with *Oenothera rhombipetala,* which is one of the successful invaders. *Lespedeza capitata* is another frequent pioneer species. *Cenchrus* and *Aristida* are found in abandoned fields also, and are succeeded by *Eragrostis trichodes*

and *Panicum virgatum*, which are among the first of the bunch-grasses to become established.

The growth of annual plants in parts of the blowsand complex is sufficient to support a considerable animal population, usually similar to that of the blowsand association of lee slopes. Where the plants are very few and scattered, however, as is more often the case, the animals are in large part roving forms, more being predaceous than phytophagous. These animals (practically all of them insects) are quite numerous, too, and it is clear that their food supply must come from outside the blowsand area. It is then observed that in large areas of bare sand the animals are very much more numerous towards the margin, and when it is remembered that the blowsand species are the same as the interstitial species of bunch-grass, the conclusion is reached that there must be a continual shifting of individuals from one area to the other. This has been observed in the case of tiger-beetles and grasshoppers. As the blowsand animals get their food largely in the bunch-grass area, it might appear that they are members of two associations, being at one time blowsand animals, and at another time interstitial members of the bunch-grass association. The question is raised whether they may properly be spoken of as blowsand animals when they depend absolutely on the near-by presence of the bunch-grass association. But if in reality they are members of the bunch-grass association, why do they not stay there? Why should they enter the bare areas at all, when the food supply is lacking? A possible explanation is that in their random activities the bunch-grass animals move about in every direction, and, accordingly, those individuals near the margin of the bunch-grass are continually wandering out into the blowsand complex. The junction of the two areas is seldom abrupt, and would probably never be recognized by animals so small as these interstitial insects. There is, therefore, no well-defined or appreciable environmental difference which might influence the animal to turn back, but sooner or later it returns to the bunch-grass. In this way the margin of the bare sand-area becomes populated with transient interstitial animals of the bunch-grass.

Not all the animals of the blowsand complex are necessarily dependent upon the bunch-grass association, even indirectly, though it so happens that most of them are. It is to be remembered that there is almost always some plant growth, which allows development of a self-contained animal assemblage. Few sand expanses of considerable size are absolutely devoid of vegetation; but where such areas do exist, animal life is almost entirely absent except near the

margin. The fauna of the blowsand complex is thus on the whole derived from the bunch-grass, and consists primarily of wandering forms, both predaceous and phytophagous.

THE DEPOSIT ASSOCIATION

The manner of deposition of sand on the lee side of a blowout is influenced greatly by the vegetation. If none is present the sand spreads out over the general level in a broad, thin, fan-shaped layer. Plants growing on the lee side of the blowout, particularly if they be bunch-grasses, tend to check the velocity of the wind, which thus becomes unable to carry its load. Sand is then deposited at the base of the plants. If, now, the plants, by upward growth, can continue to act as obstacles to the wind, the deposition of sand will continue, and a dune will gradually be built up. The obstacle grows upward with the dune. Many of the sand-prairie plants are efficient dune-formers, and these species are quite common in the deposit association. The principal species are *Rhus canadensis* var. *illinoensis, Panicum virgatum,* and *Tephrosia virginiana.* A *Rhus* dune, the side of which is being undermined by a large blowout, is shown in Figure 1, Plate IV. (See also Pl. III. Fig. 2.) The process of dune-formation at the lee side of blowouts is not well shown in the Havana region; the deposit associations are not typical, and for this reason very little study has been given them. A study of the animals of the association was not even attempted, but the general character of the assemblage is transitional between the animals of the blowsand and those of the bunch-grass. Future work in the other sand areas should include a study of this association.

The deposit association is subject to two influences; the stabilizing action of the vegetation and the destructive action of the wind. The direction in which the succession proceeds, will depend upon which set of conditions predominates.

Successional Relationships in the Sand Prairie

Most of the Illinois River sand area was covered originally by the bunch-grass. The natural process of vegetative development caused a gradual change in part of the area, until the black-soil transition stage was reached. In other places, where the exposure to the wind is considerable, the sand between the tufts of grass is blown away, and the *Panicum pseudopubescens* association results. Continued wind action in parts of this association results in the formation

of blowouts. The successions between the basin and the blowsand associations, and between the blowsand and the deposit associations, may take place in either direction. The confluence of a number of blowouts may cause the development of a large blowsand complex. This may also result from accidental causes. Stabilization by the bunch-grass may occur in any association of the blowout formation.

The forest formation succeeds the sand prairie either through the black-jack oak or the black oak association. The association invaded is usually the bunch-grass, though the large areas of nearly bare sand may perhaps also be directly succeeded by forest growth. In this type of succession a sand-thicket stage consisting of *Rhus, Ptelea, Robinia, Populus,* and other species, would probably intervene. The successional relationships are shown graphically in Gleason's bulletin article ('10:133) by means of a diagram.

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EXPLANATION OF PLATES

Plate I

Map of the region studied. The sand ridges or islands are stippled; the sandy loam flats or ancient stream channels appear as unshaded areas between the ridges.

Plate II

Fig. 1. A bunch-grass pasture at the Devil's Hole. A large blowout is partly shown in the background; and to the right of it is shown a dune, partly blown away, indicating the former level of the area now occupied by the blowout.

Fig. 2. Bunch-grass at the Devil's Hole. The bunch-grasses and the cactus plants are discernible. Wind action is starting on the slope to the left. Beyond is the very large blowout shown in Figure 1 of this plate, which has now reached the stage known as the blowsand complex. This same area of bare sand is seen also in Figure 2, Plate IV.

PLATE III

Fig. 1. A nearly typical blowout at the Devil's Hole. The basin is shown in the center, the windward slope at the right, and the blowsand association of the lee slope in the right background. The forest in the rear is the black oak of the ridge between Crane Creek and the Black-jack Ditch.

Fig. 2. Summit of "Tower Hill", north of the Devil's Neck. The "tower", a rude platform used by the Illinois River Survey, was blown over early in 1911. Dunes of *Rhus canadensis illinoensis* to the left. The blowout is being actively excavated.

PLATE IV

Fig. 1. An area of almost bare sand showing the very sparse vegetation. The *Rhus* dune to the left is being blown away.

Fig. 2. The sandy waste known as the Devil's Neck—a large blowsand complex three miles north of Topeka, Illinois. Most of the area is quite barren.

Fig. 3. The large bare sand area at the Devil's Hole. The entire windward exposure of a dune has been denuded of vegetation—a not infrequent occurrence.

PLATE V

Mixed forest of the Quiver Lake marginal dune, north of Havana.

PLATE I

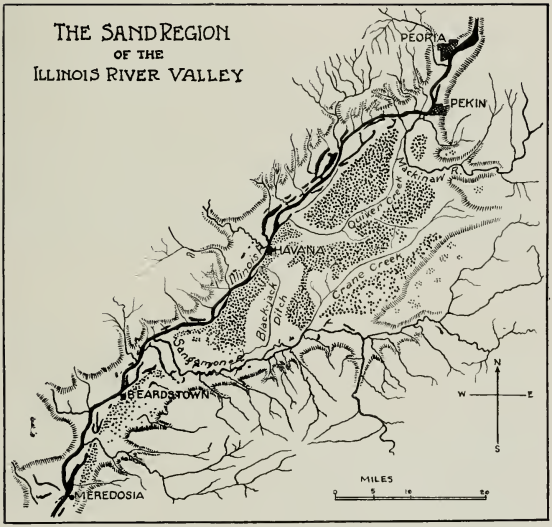
THE SAND REGION
OF THE
ILLINOIS RIVER VALLEY
PEORIA
PEKIN
Mackinaw R.
Quiver Creek
Illinois R.
HAVANA
Crane Creek
Sangamon R.
Black Ditch
BEARDSTOWN
MEREDOSIA
N
W
E
S
MILES
0
5
10
20

PLATE II

FIG. 1

FIG. 2

PLATE III

FIG. 1

FIG. 2

FIG. 1

FIG. 2

FIG. 3

PLATE V