Theodore Tuson
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Chas. A. Hart.

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ON THE BIOLOGY OF THE SAND AREAS OF ILLINOIS.

BY

CHARLES A. HART AND HENRY ALLAN GLEASON, Ph.D.

ERRATA AND ADDENDA.

Page 55, line 15, for *1854* read *1855*.

Page 55, line 16, for *Horticultural* read *State Agricultural*.

Page 60, in second table, Illinois, for *240* read *241*.

Page 65, first line above foot-note, for *ventricosa* read *ligamentina*.

Page 72, line 9, for *imbecilis* read *imbecillis*.

Page 79, line 19, for *asperimus* read *asperrimus*.

Page 80, above *Quadrula rubiginosa* insert Section *Fusconaia* Simpson.

Page 76. The record of Calkins for *Margaritana margaritifera* is without doubt erroneous and should be eliminated. This species is not found in Illinois.

Page 95. *Pomatiopsis sheldonii* Pilsbry should read *Amnicola sheldonii* and should be transferred to the genus *Amnicola* on page 93.

Page 100. *Physa gyrina oleacea* Tryon is the immature stage of *Physa gyrina*.

Page 103. *Lymnæa tazewelliana* is a synonym of *Lymnæa parva*.

Page 105. *Lymnæa palustris michiganensis* is the immature form of *Lymnæa reflexa*.

Page 106. *Lymnæa reflexa iowensis* and *Lymnæa reflexa crystalensis* are synonyms of *Lymnæa reflexa*.

Page 112, line 6 from bottom, for *gouldi* read *gouldii*.

Page 114, line 5 from bottom, for *juxtigens* read *juxtidens*.

Page 115, line 21, for *Witter* read *Walker*; line 23, *Polygyra sayii* Binney should be changed to *Polygyra sayana* Pilsbry.

Page 116, line 1. *Polygyra exoleta* Binney (1885) should be changed to *Polygyra zaleta* Binney (1837).

Page 117, line 11 from bottom, for *leai* read *leaii*; line 3 from bottom, *Polygyra monodon fraterna* is a good species and should read *Polygyra fraterna*.

Page 119, foot-note. A specimen of *alliarius* in the collection of Mr. Aldrich, received from Calkins, proves to be *draparnaldi*.

Page 121, line 3 from bottom, for *Champaign* read *Piatt*.

Page 122, line 12 from bottom, for *Pyramidula striatella* Anthony read *Pyramidula cronkkitei anthonyi* Pilsbry; line 4, for *Held* read *Hald*.

Page 123, for *Helicodiscus lineatus* Say read *Helicodiscus parallelus* Say.

Page 162, line 7, for *glandulosa* read *linearis*.

Page 171, line 17, for *riparia* read *vulpina*.

Page 176, line 8 from bottom, for *canadense* read *majus*.

Page 180, line 9, for *virginica* read *virginiana*.

Page 221, line 6 from bottom, for *rectangulus* read *rectangularis*.

Page 226, line 3, for *fasciatus* read *fasciata*.

Page 239, line 11, strike out Lake Co. entry.

Page 246, lines 6 and 7, and page 248, lines 1, 14, 20, and 23, for *Œnothera* read *Onagra*.

Page 248, line 4, for *candida* Horn substitute n. sp.

Page 249, line 8 from bottom, for *Olethreutes dimidiana* Sodoff? read *Olethreutes separatana* Kearfott, and strike out parenthetical matter.

Page 251, line 7, for *grossa* read *thoracica*; line 21, for words preceding H. 6, read *Asilus rufipennis* Hine; line 18 from bottom, for words preceding H. 2, substitute *Asilus cacopilogus* Hine.

Page 253, line 8, for *Linn.* read *Emory.*

Page 257, line 15, for *pennsylvanicus* DeG. read *auricomus* Rob.

Page 261, Note 6. *Melanoplus macneilli* is very probably *M. fluviatilis* Brun.

Page 262, Note 9. Dr. Bergroth writes that *Nabis elongatus* is preoccupied. The original is *elogantus* in the check list. Comparison with long-winged *vicarius* is desirable before re-naming it.

Page 309, in table, for *59* read *57*, and for *743* read *741*.

Page 310, in table, for *59* read *57*.

Page 314, line 5, for *1587* read *481*; line 16, after *stubble* insert *meadows*; line 17, after *pastures* strike out *and meadows*, and after *1500* strike out *each*.

Page 315, last line, for *553* read *481*.

Page 362, line 7 from bottom, for *longa* read *parvilamellata*.

Page 373. As a second entry in synonymy insert as follows:

1854. *Nothrus bistriatus*, Nicolet, Acariens des Environs de Paris, p. 397, Pl. VII., Fig. 7.

Page 376, line 13 from bottom, for *Oribata* read *Oribates*.

Page 378, line 1, for *XXV.* read *XXXV.*

Page 384, after line 5 insert as follows:

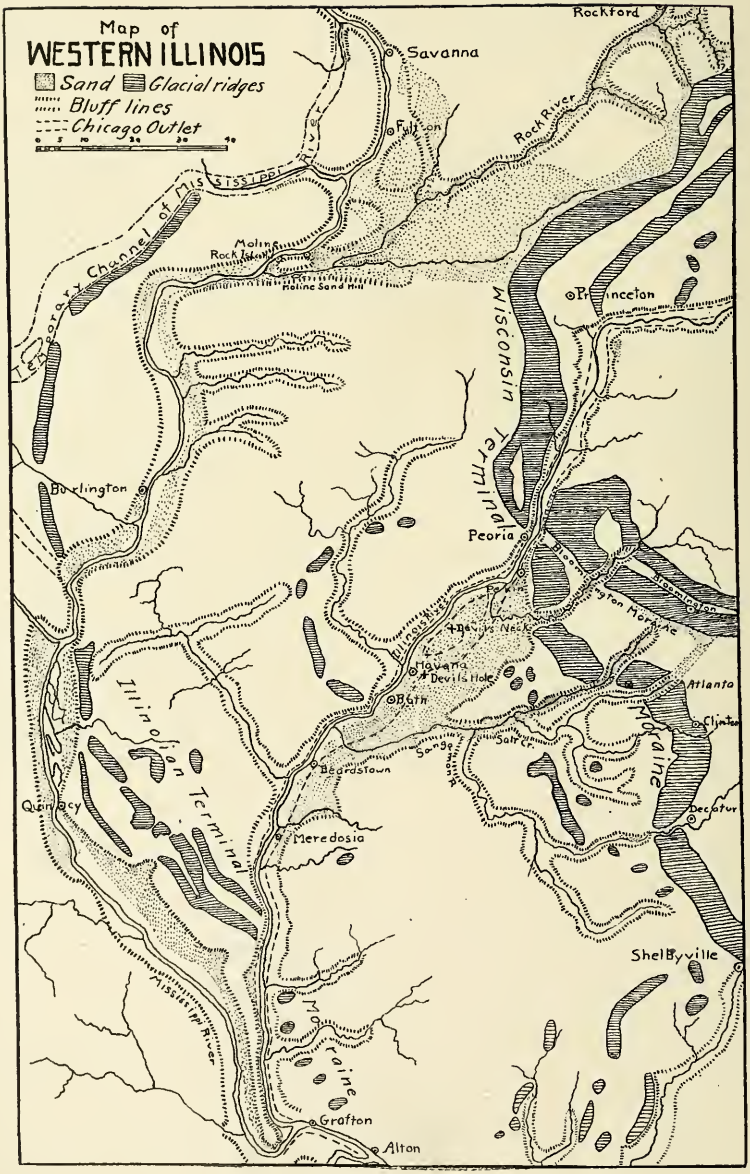
N. bipilis Hermann. Mem. Apt., p. 95.
In moss, Arcola and Parker, Ill.

Page 384, line 5 from bottom, for *pyrostigma* read *pyrostigmata*.

Page 386, after line 11 from bottom insert as follows:

H. bistriata Nicolet. Acariens des Environs de Paris, p. 397, Pl. VII., Fig. 7.
Under logs and in moss, Urbana and Arcola, Ill.

Page 388, line 12, for *sphærulum* read *sphærula*.


Map of
WESTERN ILLINOIS
Sand
Glacial ridges
Bluff lines
Chicago Outlet
Rockford
Savanna
Fulton
Rock River
Mississippi River
Temporary Channel of Mississippi
Moline
Rock Island
Moline Sand Hill
Princeton
Wisconsin Terminal
Burlington
Peoria
Illinois River
Devil's Neck
Tiskilwa
Bloomington Moraine
Iowana
Devil's Hole
Bath
Atlanta
Clinton
Illinoian Terminal
Salt Fk.
Sangamon River
Beardstown
Quincy
Meredosia
Decatur
Shelbyville
Mississippi River
Illinois River
Morraine
Grafton
Alton

ARTICLE VII.—*On the Biology of the Sand Areas of Illinois.*
By CHARLES A. HART AND HENRY ALLAN GLEASON.

INTRODUCTION.

While located at Havana in connection with the work of the Illinois Biological Station on the Illinois River, the writer made a few trips to the tract of waste sandy land lying east of the city, locally known as the Devil's Hole. A novel fauna and flora were noted, but no systematic study of either was attempted until August, 1903, when a brief survey was made of this locality and of similar regions southeast and south of Havana in company with Mr. H. A. Gleason, of the Department of Botany at the University of Illinois, who studied the flora, the writer giving attention to the fauna, especially to the insect life. At the same season in the following year we made a second visit to these regions, and also examined the sandy tract lying northeast of Havana, between that city and Pekin, which culminates in a remarkable barren area called the Devil's Neck. The botanical results of these two trips are presented by Mr. Gleason as the second part of this joint article. In 1905 I was enabled to make brief comparative examinations of these same regions in the early part of the season, and of similar sand areas in other parts of western Illinois in August and September. In 1906 I paid a brief visit June 23 to the Illinois valley sand region, stopping off at Bishop, Ill.; and in August spent a few days studying the sandy reaches on the flats bordering Lake Michigan above Waukegan, Ill. Delays in going to press have enabled me to include herein some important data from the latter locality concerning species already on the list. The limited amount of time available for these visits enabled me merely to secure some knowledge of the abundant, varied, and largely unfamiliar insect fauna, and to develop a large crop of highly interesting biological problems for future investigation.

Part III. consists largely of some discussion of these problems, followed by an annotated list of species which it is hoped may be an acceptable contribution to the knowledge of the insect life of Illinois. A comparison of these western Illinois areas with those of the northeastern part of the state is greatly to be desired, as the indications are that their biotas differ considerably, and are derived more or less from different geographical sources.

In addition to the faunal studies, I have given particular attention to the topography and remarkable glacial history—especially with regard to the origin of the sand areas and their fauna—of the Illinois River valley, nearly the entire length of which I have traversed at one time or another. These subjects are treated in Part I. as a preliminary to the biological studies.

The map is adapted from Leverett ('99, Pl. VI.); plates XXII. and XXIII. are from photographs belonging to the State Laboratory of Natural History; and the remaining plates are from photographs by Mr. Gleason.

The authors are greatly indebted to Professor S. A. Forbes, Director of the Illinois State Laboratory of Natural History, for his kindly interest and for the publication of this paper; and they desire to acknowledge gratefully the cordial hospitality and assistance of various citizens of Havana and vicinity.

C. A. Hart.

Part I. Glacial Geology and General Characters of the Illinois Sand Areas, especially those of Western Illinois. By Charles A. Hart.

Glacial Geology.

Illinois as a land area has been subjected to at least two principal glacial invasions from the direction of Lake Michigan, the limits of these being roughly concentric with the lower end of this lake. Much of our knowledge of them is derived from the work of Leverett ('99), whose statements, supplemented by my personal observations, form the principal basis of this account.

The earlier of these ice invasions, the Illinoian, apparently much more remote from the later one than this is from the present time, reached about as far west as the Mississippi River, and covered nearly all of Illinois except the northwest corner and the hill country in the extreme south. The later invasion, the Wisconsin, reached about half as far across the state. The heavy deposits of gravel, sand, and clay brought down by these ice-sheets have largely filled up and often entirely obliterated the previous lines of drainage.

The contour of the rock surface beneath these deposits is very imperfectly known, and deserves specific investigation. Records of wells, borings, etc., show, however, that it is deeply carved by immense river valleys of which there are often no surface indications whatever. The great depth of these valleys, usually about one hundred feet below present river levels, does not necessarily indicate a subsidence of this part of the earth, but merely the undisturbed action of water for a vast period of time, or of a greater volume for a lesser period, deepening them to a low gradient nearing base-level, after which the energy of the stream was mostly occupied in widening them.

The Mississippi from Keokuk down and the Illinois below the bend at Hennepin are still in ancient preglacial valleys,

and apparently the entire area of Mason county lies within the boundaries of the latter valley. The highest known point of its rock surface is lower than that of any other county in Illinois, and fifty feet below the present level of the river. Quite probably this county lies in a forking of the preglacial valley, an eastern fork being perhaps indicated by the drainage line now occupied by Sugar Creek and the lower ends of Salt Creek and the Sangamon River, the two latter sections being in a preglacial valley at least four miles wide. Records of wells and coal shafts indicate great valleys beneath Bloomington and Champaign, and another valley leading south from Lake Michigan near the Indiana line, but at present it is impossible to trace these old drainage lines.

In northwestern Illinois the Illinoian invasion evidently caused a radical readjustment of the river systems, turning them westward across adjacent divides into other valleys beyond. (Leverett, '99, Pl. XII.) The buried northward extension of the preglacial Illinois valley above Hennepin is apparently continuous with that of Rock River above Rockford. At a point just below this city the river now leaves its evident preglacial channel, turning westward along side lines of its preglacial tributaries, and is still cutting narrow passages across the rock of the intervening divides. A considerable section of the Mississippi was temporarily crowded over some distance into Iowa, where it has left a fairly well-marked channel that has greatly modified the course of minor streams. It now leaves its great preglacial valley not far below Fulton, Ill., and runs southwest at right angles across the still evident lines of preglacial drainage, which appear to be directed eastwardly and to converge in that direction. In the vicinity of Rock Island the flow of both the Mississippi and Rock rivers seems to be upstream with regard to preglacial lines, in order to cross into another ancient valley at Muscatine. The probability that the preglacial Mississippi channel swings eastward beneath the present lower Rock River valley, and thence across to the bend of the Illinois, is confirmed by the remarkably low sag, especially in rock levels, along this line. In that case, it must have

joined the Rock River somewhere in Bureau county, and the lower Illinois valley was then part of one of the main drainage lines of the continent. The question naturally arises as to the effect of this former relation on geographical distribution. Apparently it had none, since the entire Illinois valley was subsequently covered by the Illinoian glaciation, at which time our river systems were shifted to about their present lines.

The exact rock limits of the preglacial Illinois valley are but imperfectly known. Apparently in obedience to the general law of the westward shift of southward-flowing streams, the present river flood-plain from Peoria down (Pl. V.) follows the west border of the immense valley, never very far from the west bluff, which has a rock core throughout, and exhibits practically all the few rock exposures of the lower valley. Below Meredosia the valley is excavated in limestone strata and is comparatively narrow, usually three or four miles wide, narrowing to a minimum of two and a half miles. From Meredosia up to Beardstown (fifteen miles) it widens out to six miles or more. Above Beardstown the general rock surface was apparently rather low originally and composed of softer strata, and the valley is enormously expanded. The low east bluff is completely concealed by subsequent deposits, yet from the Sangamon to the Mackinaw the original valley is probably not far from twenty miles wide. Above Peoria the limits of the rock valley are largely undetermined, for reasons given further on.

The deposits of the Illinoian glaciation are not very deep. The water action seems to have been moderate, and the surface sand deposits caused by it in Illinois are of little consequence. The larger preglacial valleys, although usually filled with these deposits to a depth of about one hundred feet, are as a rule still traceable, and are usually reoccupied by the main streams, although slight deflections are not uncommon. The terminal ridges pushed up by the ice in this period are now discontinuous, fragmentary, or entirely wanting, although often still prominent and massive. Probably the greater part

of the deposits which now lie between the Illinois valley bluffs over the ancient rock bed are due to the Illinoian glaciation.

The next ice invasion, probably the Iowan, came from the northwest, and to this stage have been assigned deposits in Illinois in the vicinity of the lower Rock River watershed. It seems to have had no marked effect in our state.

Long ages after the close of the Illinoian period, came an event which profoundly affected the future of Illinois, and caused, among other things, the sand deposits studied by us. The Wisconsin glacial invasion was not so extensive as the Illinoian, but it is characterized by voluminous deposits, deeply covering and almost entirely obliterating the previous surface contours; by large and continuous ridges thrown up along the terminal lines and during the successive stages of its retreat; and by abundant and powerful water action. Upon or near the terminal ridges in Illinois are the cities of Princeton, Peoria, Pekin, Atlanta, Clinton, Shelbyville, Mattoon, and Charleston.

A later substage of less extent but even greater intensity was that called the Bloomington, whose terminal ridges branch off eastward near Peoria, and pass under Bloomington and Gibson City, and to the north of Danville, Ill., and Covington, Ind. The enormous outwash of sand and gravel has left more or less of its deposits in all the valleys leading away from these ridges. The west side of the rock valley above Peoria was covered by the terminal ridge to a height, near Peoria, of about 350 feet above the present river, making a total depth of about 450 feet of glacial deposits upon the bottom of the ancient rock valley.

The Illinois, clogged with more than it could carry, filled its bed with sediment to a depth of about 170 feet above present levels at Peoria within the gap in the terminal ridges, and spread out in a vast detrital fan over the great expansion of the valley below, with a comparatively rapid gradient of descent. At the mouth of the Sangamon the filling reached about 75 feet above present levels; and at the river's mouth, about 50 feet. As the ice retreated and the water cleared, nearly all of this vast deposit was swept out of the valley, leav-

ing only a worked-over sandy surface, and, along the valley margins, occasional gravel terraces.

The re-excavated expansion below Peoria is now about twenty miles wide between Pekin and Havana, narrowing gradually below Havana to about twelve miles near the mouth of the Sangamon, and to seven miles at Beardstown, then widening to about twelve miles in western Cass county. At this point the expansion suddenly narrows, and the valley, now in Mississippian limestones, assumes a fairly uniform width of three or four miles. The eastern border of the expansion is indicated by a low bluff, often obscured by subsequent wind action. Teheran, Mason county, lies at the foot of this bluff.

After the ice had retreated from Illinois but still occupied the lower lake-region and St. Lawrence valley, the upper lakes discharged for a time over the low divide at Chicago, along present drainage lines, the valley in this stage of its history being called the Chicago Outlet. The clear and abundant flow excavated the present river flood-plain along the western side of the valley to a depth of fifty to seventy feet below the glacial flood-plain, about thirty feet below its present level. It also spread out to some extent over the glacial flood-plain. Peoria Lake was scooped out in the comparatively narrow opening through the terminal Wisconsin ridges. Leverett ('99, Pl. VI.) has indicated the existence at this time of an eastern channel below Pekin, occupying a depression now approximately followed by the line of the Chicago, Peoria and St. Louis railway from the Mackinaw River below Pekin to Havana. The Mackinaw enters this depression about ten miles south of Pekin, and, turning abruptly northward, reaches the Illinois by way of the upper end of the channel. Quiver Creek enters it near Forest City, and follows it down to the Illinois. The railroad runs along the eastern side of the ancient island included between the two channels. The topography along this line has probably been altered to a considerable extent by wind action upon the loose surface deposits since the formation of the eastern channel. With the establishment of the St. Lawrence drainage the Illinois assumed its present size and position. The lessened flow

in this river, and probably in the Mississippi also, has resulted in a slight and gradual filling, in the Illinois River amounting now to twenty-five or thirty feet.

Topography.

The present lower Illinois River is an inconsiderable stream, normally six hundred to one thousand feet wide, flowing in a belt of very low bottom-land extensively occupied by large swamps, sloughs, and lakes. (Pl. ~~V., VI.~~ Map X XXII) This bottom-land is usually two to four miles in width, narrowest where it passes through the Wisconsin terminal ridges near Peoria and in the narrower part of the valley towards the mouth. Its naturally slow current is still further reduced by the series of government dams, permitting a deposit of soft mud over nearly the entire under-water surface. A few expansions occur, such as Peoria Lake and Havana Lake, respectively a mile and a half-mile wide, but these are shallow, and the river is gradually filling them up and building an enclosed channel down through them. On the other hand, the bottom-lands, although below normal levels for a stream of this size, are so extensive that their general filling up would require a comparatively long period of time. Doubtless under present conditions of the watershed the river is depositing silt vastly more rapidly than it did before the original prairies were broken up and drained for cultivation.

The remaining spaces between this modern flood-plain and the upland bluffs are occupied by the glacial flood-plain or "second bottom," thirty to fifty feet above the river and twenty to forty feet above the lower flood-plain. (Pl. ~~VII.~~ XXIII) That portion of this glacial flood-plain which occupies the great expansion of the central part of the lower valley contains the principal sand deposits of the valley, and has been especially studied by us. This lies entirely between the distant low eastern bluffs and the present flood-plain, which closely follows the west bluff. It is about seventy-five miles long, extending from the morainic border below Peoria to the vicinity of Meredosia, Morgan county. It occupies the southwest part of Taze-

well county and extends across nearly the whole of Mason county to the Sangamon, with a maximum width of eighteen miles near the upper end, narrowing southward to about ten miles. The lower part—that below the Sangamon—forms a minor expansion of about half this width in western Cass county and the northwestern corner of Morgan county.

The total area is approximately seven hundred square miles. Except for light superficial deposits its substance is largely sand, which usually reaches to considerable depths. The surface exhibits broad level areas capped by a shallow but rich soil, many of which were originally wet or swampy, but are now drained and cultivated. These alternate with large areas of surface sand—the great sand-bars of the glacial river—drifted by long-continued wind action into irregular, undulating dunes, often barren and desolate, which have traveled northeastward with the prevailing winds. Frequently these dunes form long ridges parallel to the general direction of the valley. Even the bordering uplands are frequently capped with small sand-dunes and ridges which presumably came from the adjacent valley-margin. In drifting with the wind these sand masses have of course overridden to some extent the soil of the level areas, but were probably originally continuous with the underlying sands.

THE SURFACE SANDS.

The surface sand begins at the north with a few narrow strips along the river near Pekin, above the mouth of the Mackinaw. Below this river the sand-covered area is quite large. Only an estimate can be given of its actual extent. The governmental Soil Survey (Bonsteel, '03) reports 22,976 acres of it in southwestern Tazewell county, within a flood-plain area of about eighty square miles, or 51,200 acres. The sand therefore occupies rather more than forty percent of the total flood-plain area in this county. This ratio is doubtless larger in Mason county, which has not yet been examined by the Soil Survey, but accepting it for the entire basin of seven

hundred square miles, it would indicate 179,200 acres, or 280 square miles, of sand.

In an agricultural state like Illinois the economic aspect of such a body of sand becomes of importance. Farm land on the neighboring uplands is valued at $100 to $150 per acre, and yields good crops of corn and oats—the grains most generally cultivated. A considerable part of the sand area also yields excellent grain crops, but in these fields patches of more or less barren or worthless sand often occur. This land is in fact much better adapted to truck crops. Much of the sand is usable only for pasture, and in Mason county alone there are thousands of acres, assessed at a one-fifth valuation of one dollar per acre, which are not used for any purpose. In no other part of central or northern Illinois, except in the larger river-bottoms, are there such extensive tracts of waste land.

The surface configuration, wind action on sand, plant-covering, and similar details of this sand area, are described in connection with the biological studies which follow.

OTHER SAND AREAS.

The remaining sand areas of Illinois are but imperfectly known to me as yet, but a brief statement concerning the principal ones seems desirable.

The presence of sand in the soil is not sufficient to modify the character of the biota until it becomes so abundant as to affect the physical character of the surface and cause it to drift easily with the wind, when it is called blow-sand. When this point is reached, cultivation becomes difficult, and the land is usually left undisturbed even by pasturage. In addition to the biotic change due directly to the excess of sand, the absence of cultivation favors the development of a rich and varied fauna and flora. A large part of the areas usually mapped as sandy do not reach this extreme stage, and are consequently of less interest biologically.

In the large sand area of the expanded middle section of the lower Illinois valley, blow-sand is of frequent occurrence. The upper section, about fifty-five miles in length, lying with-

in the limits of the Wisconsin glaciation, includes but small areas of the glacial flood-plain, and these are not especially sandy, although it is stated (Leverett, '99, p. 267) that there are some dunes capping the eastern bluff-line near the upper end. The lower section, extending from Meredosia to the mouth of the river, about sixty-five miles long, is also narrow, and although the strips of glacial flood-plain are often quite sandy, they are, so far as I know, destitute of blow-sand.

In the Mississippi River valley also, well-developed sand areas of the same general character as the large Illinois River area are similarly present a little farther northward. Large tracts of sand lie on the sag over the supposed preglacial connection between the two rivers, and a similar very sandy glacial flood-plain extends interruptedly along the east side of the valley of the Mississippi, with small dunes capping some of the bordering uplands, from near Burlington, Iowa, up to the vicinity of Savanna, Ill. Blow-sand is known to be present, with all its attendant phenomena, in considerable quantities. The glacial flood-plain along this river is also quite sandy below Burlington over considerable distances, as far as the mouth of the Illinois, but so far as known without true blow-sand development. The blow-sand areas of these two rivers are apparently very similar also in organic life, and evidently should be grouped together.

East of the Illinois River, along the Wisconsin morainic border, especially in eastern Illinois and in adjacent Indiana counties, there is considerable sandy outwash along the rivers, but no definite development of blow-sand is known to me. These sandy strips appear in the Sangamon valley near Niantic, along the Embarras in Cumberland and Jasper counties, and in the Wabash valley near Covington, Ind., and from Terre Haute, Ind., to the mouth of the river, the sand at Covington resulting from the Bloomington glacial substage.

There is an important sand area in northeastern Illinois, with considerable development of blow-sand, derived from the glacial outwash and sand beaches of the upper Kankakee val-

ley. It extends into northwestern Indiana, and is not far distant from the dunes about the south end of Lake Michigan. It is probably similar to these in its plant and animal life, but differs definitely in this respect from the western Illinois areas, judging from published records of collections in the district.

*Part II. A Botanical Survey of the Illinois River Valley Sand Region.**—By Henry Allan Gleason.

Introductory.

The ecological study of sand-dune vegetation has in recent years attracted the attention of numerous American botanists, and many noteworthy contributions to it have been made. Dune vegetation is especially well adapted to ecological investigation, since the changes in the physical factors of the environment are usually considerable, the component associations are sharply distinguished, physiographic processes go on with comparatively great rapidity, and the plant inhabitants show characteristic features in habit and structure. The vegetation of the dunes bordering Lake Michigan has been studied in detail by Cowles, while Rydberg, and Pound and Clements have described the sand-hills of Nebraska. Intermediate in position between these two regions lie the sand deposits now to be considered, and it is hoped that the matter presented may be of some value, not only in the study of sand vegetation in general, but in extending a knowledge of the origin of the prairie flora and of the relation of the forest to the prairie.

The field work upon which this study is based, was carried on during the summers of 1903 and 1904, mainly in the vicinity of Havana, Mason county.

Ecological Factors.

The varying structure and distribution of vegetation are an expression of the various conditions to which it is subjected. Any force or condition, present or past, which has in any way an effect upon vegetation may be termed an ecological factor. The use of this term is, however, more generally restricted to

* Mr. Gleason's manuscript for this paper was filed for publication early in 1905. Its appearance has been retarded by inevitable delays in the completion of the contributions of Mr. Hart, it being the intention and desire of both the authors that their work should be published jointly in a single paper.—S. A. F.

those forces or conditions which have or have had direct influence, and among them may be mentioned the historical factors of migration, succession, and the like; the physical factors of water, temperature, and soil; and the biotic factors, including competition, layering, and others. The various factors are by no means independent, but each influences the others and is to some degree influenced by them. The biotic and historical factors are here mentioned either incidentally or under the heading of phytogeography, but the physical factors are in many cases so different from those normal to other parts of Illinois that they are discussed more in detail.

The physical factors which aid in the control of the vegetation of any area have been divided by Schimper ('98, p. 174) into two groups, climatic and edaphic. The climatic factors are temperature and rainfall, and they determine respectively the specific composition of the flora and the general character of the vegetation, whether forest, prairie, or desert. Similar climatic factors are operative over broad areas, and the changes from one type of climate to another are usually very gradual. Local variations in the vegetation are due to the physical or chemical composition of the soil, to its exposure to the sun, to the available supply of water, and to other such factors, designated collectively by the term edaphic. Edaphic factors are always influenced by, and are sometimes the direct result of, the climate. They are also modified to a greater or less extent by the plant-covering, as will be shown later in the discussion of the plant associations.

Although the climate of the Illinois River valley sand region is in every essential respect like that of other parts of central and western Illinois, a strikingly different vegetation has been developed. Receiving the same amounts of heat, light, and rainfall, and exposed to the same winds, the differences in vegetation are due in every case to the sand in its relation to wind, moisture, and available food supply.

The designation Miami fine sand has been applied by the United States Bureau of Soils to the sand composing these extensive deposits along the Illinois River, and the following

description of it is taken from the report of this bureau on the soil survey of Tazewell county (Bonsteel, '03).

"The sand consists of partly rounded grains of quartz stained rusty yellow or orange by iron, and made slightly loamy by the presence of silt or clay. There is no distinction between soil and subsoil. Organic matter is very deficient, as is shown in the following table giving the mechanical analysis of a sample of Miami fine sand from $7\frac{3}{4}$ miles west of Delavan, Tazewell county.

"Organic matter,	0.53%	Fine sand, .25–.1 mm.,	62.20%
Gravel, 2–1 mm.,	0.10%	Very fine sand,.1–.05mm.,	6.24%
Coarse sand, 1–.5 mm.,	3.92%	Silt, .05–.005 mm.,	2.86%
Medium sand,. 5–.25 mm.,	22.26%	Clay, .005–.0001 mm.,	2.42%"

The soil in the depressions between the sand deposits, known as Miami loam, contains from 1.69% to 2.80% of organic matter, while other soils in the county contain as high as 4.69%.

In every region where large quantities of sand are exposed, the wind plays an exceedingly important part in the ecology of the plant life. Inland it is by no means so active a factor as on or near the shores of large bodies of water, where its velocity is greater and the sand is less protected by a covering of vegetation. Sand blown by the wind may do considerable mechanical injury to the leaves, young stems, and other succulent parts, but as the plants growing in the sand associations are usually adapted to it they are seldom much affected. Growing crops, however, are sometimes badly damaged. The native plant-covering is normally sufficient to prevent much blowing, but if it is any way destroyed, large excavations called blowouts are formed, which, as they increase in size, undermine and destroy most of the vegetation. The sand in these blowouts is so loose and easily disturbed by the wind that only a few species of plants are able to grow in it. The sand removed by the wind is deposited on the leeward side in a fan-shaped heap nearly or quite bare of vegetation (Pl. XII., Fig. 2), or is blown on as a traveling dune. To protect themselves against this shifting of the sand, many plants are especially adapted as sand-binders, and effectually hold the sand in position.

Of far greater importance as an ecological factor is the sand in its relation to the water supply and, indirectly, to the supply of plant food. It is a known fact that coarse soils, such as sands, have a smaller capacity for water than fine soils, the water being held as a thin film surrounding the soil particles, and surface-tension being less effective over large surfaces than over small ones. The water capacity of soils, according to experiments by Schuebler and Wollny (Warming, '96, p. 51), is least in quartz sand. Schimper ('98, p. 94) states that the water which loose sand can hold is but 13.7 percent of its own volume, while clay has a capacity of 40.9 percent. Experiments by the United States Bureau of soils (Whitney and Hosmer, '97, pp. 14–17) on sandy soil in Alabama showed a water content varying from maxima of 11 percent and 14 percent after rains to minima as low as 1 percent and .6 percent during periods of drought. This is in marked contrast with the results of similar experiments on prairie sod in Kansas, where the water content varied from a maximum of 15 percent to a minimum of 7.4 percent, and on blue-grass land in Kentucky, where the average content was over 20 percent, and the line of drought, at which the vegetation began to suffer, was at 15 percent. The actual size of the particles composing these soils is not stated. Warming (*l. c.*) quotes Wollny as saying that the water capacity of quartz sand composed of particles 1–2 mm. in diameter is only one tenth that of sand with particles .01–.07 mm. in diameter. No data are as yet available concerning the actual water capacity of the Miami fine sand in Illinois, but it must be much lower than that of the other soil types of the district.

The power of capillary action to lift water from lower levels is also less in coarse-grained than in fine-grained soils; and in fine sand, according to Ramann (Warming, '96, p. 50), water will rise only 40 centimeters, or about 16 inches, above the surface of the ground-water. In sand with grains from .25 mm. to .1 mm. in diameter, such as constitutes 62 percent of the Miami fine sand in Mason county, water should rise by capillary attraction from 19 to 48 inches. It is evident that no

water could by this means be brought within reach of the smaller plants when the level of the ground-water is twenty feet or more below the surface, as it is in Mason county.

The water-retaining properties of the sand are also of importance to the vegetation. The effect of the percolation of rain water is the saturation of the upper layers of sand to a depth dependent upon the amount of rain. If the surface is dry or only partially saturated, that will first be brought to full saturation, and the surplus water will sink down to lower levels. None is removed by surface drainage, so that, aside from the small quantity remaining attached to plants and other objects, all the rainfall sinks at once into the sand. Evaporation from the surface removes large quantities of water, but according to results obtained by King ('04, p. 159) in North Carolina this is less from sand than from loams or clays. By the drying out of the upper few inches a mulch of loose sand is formed, which still further reduces evaporation. King found that eight ninths of the water which might be expected to evaporate is thus retained, and that during twenty-eight days in July and August, 1902, only .205 in. evaporated from the surface. The climate of central Illinois during the summer is not so different from that of North Carolina as to lead us to expect here any considerable variation from the above record. The moisture in the deeper layers of sand is thus effectually conserved. After a considerable period of drought, as in August, 1894, when only .21 in. of rain had fallen in eighteen days, the sand at a depth of three inches was still moist enough to compact readily in the fingers. Thus, while the actual amount of water present is small, it is nevertheless constant, and it is a common statement of the farmers in Mason county that corn grown upon the sand is less susceptible to drought than that on the more fertile fields of loam. According to Professor J. G. Mosier, of the Illinois Agricultural Experiment Station, the "firing" of corn on the sand is due to a deficiency of plant food and not to lack of water. Some interesting cases of other soil types, having similar but more marked powers of water conservation, are reported by Whitney ('98).

He describes soils in California which can mature crops without any rain during the growing season, and without irrigation.

All the water held in the soil by capillary action is not available for plants, but the percentage which can be absorbed is greater in coarse-grained soils, like sand, than in those of finer texture. Experiments by Sachs showed that in a clay with a water capacity of 52.1 percent, only 44.1 percent could be used by a tobacco plant, leaving 8 percent of unavailable water; while in a sand with 20.8 percent water capacity, 19.3 percent, very nearly the whole amount present, was available. These results are substantiated in the field, plants suffering from drought in some soils with 15 percent water, while in others, of more sandy nature, they are still healthy with a water content of less than 5 percent.

In contrast with the foregoing data mention should be made of the experiments of Livingston and Jensen ('04), who have shown that the fertility of the soil is dependent on the size of the component particles, and that coarseness alone "can produce sterility in spite of a plentiful supply of water." It is entirely possible, then, that the mere size of the sand particles may be an important ecological factor in the sand region along the Illinois River.

But independently of the quantity of water present in the sand, the precipitation must have a marked bearing on the quantity and kind of available plant food. In all the sand region, as before stated, there is no surface drainage. Water falling as rain sinks at once into the sand, and the excess is removed by underground drainage to the Illinois River, where it issues through countless springs along the east bank. After the heaviest rains, water may collect for a time in the blowouts and interdunal depressions, but it soon sinks into the sand. By this rapid percolation through the upper layers of sand much of the soluble matter must be dissolved and carried down to the level of the ground-water, which in this region is never less than twenty feet below the surface (Leverett, '96, p. 759;

'99, p. 688), and on the higher sand-hills is certainly much lower. It is here beyond the reach of all plants except the larger trees, and they, too, must be able to live in the poorer surface sand until their roots have penetrated nearly to the level of the ground-water.

The importance of the relation of food supply to vegetation has probably been greatly underestimated, while too much stress has been placed on the water supply and the physical condition of the soil. Whitney and Cameron ('03) have even declared that all ordinary soils contain plant food sufficient for the growth of crops, and this may well be so in a soil containing relatively large amounts of calcium, potassium, magnesium, and phosphorus, even though little may be available at any one time; but in a sand composed in very large proportion of silica, the leaching action of the rainfall must ultimately tend toward the exhaustion of the plant food, leaving a residue of silica and other insoluble substances. Such has been found the case in various places. Livingston ('05, p. 26) has remarked upon the low content of soluble salts in some sands in northern Michigan. Graebner ('01, p. 64) has discussed the leaching action of rain on the sandy soils in Germany, and decides that the formation of heaths there is due in great part to the insufficient supply of plant food. No full determinations of the soluble matter in the Miami fine sand have as yet been made, but, according to Professor Mosier, this sand is deficient in plant food of all kinds. The relative height of plants growing in Mason county on sand and on loam soils, certainly indicates a scarcity of plant food in the former. Indian corn tassels on the sand at a height of three to four feet; *Monarda punctata* is usually little over a foot high; and many other species are conspicuously below the size reached in the neighboring woods and on the prairies.

Unfortunately none of the foregoing theories has been tested by actual experiment on sand plants in the region under discussion, and until more definite knowledge is available, one can only believe that in general the supply of food matter

and the physical properties of the sand, including the size of the particles and to some extent the water content, are both of importance, and by their combined effect determine the peculiar type of vegetation. Direct observation alone, however, is sufficient to show that the water supply on the dunes is reasonably constant, and the plants owe their xerophytic habit to the rapid loss of water by transpiration, and not to a deficient soil content.

The climate in these sand regions is of course similar to that of the surrounding parts of the state, and has no direct influence in causing the marked differences in vegetation. Nevertheless, temperature is of importance in determining the flora of any region, and the mixed prairie and forest type of vegetation of central and northern Illinois is to some extent the result of the seasonal distribution of rainfall. For these reasons, as well as to show the general climatic conditions of the area under discussion, tables showing the precipitation and temperature are included. The data are taken from Mosier's "Climate of Illinois", and are given for Havana so far as observations at that place are available. The records are also given for Peoria and Springfield, Illinois, and for Keokuk, Iowa, three cities forming a triangle, with Havana and the sand region in its approximate center. It should be noted that the temperature readings are taken under the regular shelters used by the U. S. Weather Bureau, and consequently do not represent the degree of heat to which plants are normally subjected.

Monthly and Annual Mean Temperature.

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Havana....	27.8	27.7	39.9	53.4	63.8	74.2	77.5	75.9	69.0	57.8	40.8	31.5	53.3
Keokuk...	24.7	24.0	37.5	52.5	59.9	72.4	78.6	74.6	66.7	55.0	39.2	26.4	50.9
Peoria	24.6	27.3	38.7	53.4	63.6	74.3	78.3	74.8	67.3	54.4	39.8	30.7	50.8
Springfield	26.4	29.4	39.2	53.4	63.1	72.0	76.4	73.9	66.8	56.7	41.4	32.0	52.5

The average annual range of temperature in the central district of Illinois is 109°, while the extreme range is 140°, from — 28° in January, 1884, to 112° in July, 1901. The average

range in summer is 50°, but no data are available showing the daily range. The average date in the central district for the last killing frost in spring is April 21, and for the first in autumn, October 10, thus including a growing season of 172 days.

Mean Monthly and Annual Rainfall.

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Havana...	2.21	2.17	3.06	3.07	3.75	3 23	3.81	3.08	3.44	1.19	2.18	1.89	33.08
Keokuk...	1.72	1.64	2.30	3.18	4.41	4.37	4.33	3.06	3.68	2.66	1.98	1.63	34.96
Peoria.....	1.73	1.93	2.51	3.01	3.80	4.01	3.44	2 88	3.57	2.26	2.63	2.21	33.98
Springfield	2.26	3.16	3.03	3.22	4.76	4.45	2.64	2.67	3.56	2.57	2.94	2.43	36.69

The amount of rainfall in this same district during the growing season, assuming that to be from April to September inclusive, is at Springfield 60.8 percent, at Havana 61.6 percent, at Peoria 63.6 percent, and at Keokuk 66.0 percent. At Cairo, at the extreme southern end of the state, only 48.4 percent of the total rainfall occurs during this period. There is thus seen in central Illinois a resemblance, increasing toward the west, to the type of rainfall found on the western prairies, where as much as 80 percent of the total falls during the growing season. This unequal seasonal distribution is an important factor in determining the prairie type of vegetation in the West, and is certainly not without some influence in directing the eastward migration of the prairie flora.

The Plant Associations.

The plant associations occurring in this region belong to both of the prevailing types of vegetation in the state, the forest and the prairie. They may be classified as follows:

I. The prairie formation.
   1. The bunch-grass association.
   2. The blow-sand association.
   3. The blowout association.

II. The forest formation.
   4. The black-jack oak association.

It is difficult to estimate the relative areas occupied by the two formations, although the impression gained by traveling

across the country, by rail and on foot, is that the two are about equal in extent.

THE BUNCH-GRASS ASSOCIATION.

Through the prairie formation the bunch-grass association is the prevailing one, covering alike the level areas of sand and the dunes, and broken only by cultivated fields or by blowouts and blow-sand. The association derives its name from, and is characterized by, several species of grasses which grow in compact stools or bunches varying from a foot to two feet in diameter. They are not crowded so closely as to produce a sod, as in the typical Illinois prairies, but stand a little distance apart, thus making the bunch character prominent (Pl. XVIII., Fig. 1). There is but little of the bunch-grass prairie remaining in its original state, most of it having been pastured with horses or cattle, which by their grazing have greatly changed the character of the vegetation. Southeast of Bath there is a field which has apparently never been pastured (Pl. VIII., IX.), and the following description of the original type of bunch-grass prairie is based on its character there and on small strips along the railroads.

The principal grasses are *Eragrostis trichodes*, *Stipa spartea*, *Panicum cognatum*, and an undetermined species of *Panicum*. The first two species produce large loose bunches, one to two feet in diameter and almost as high, with the culms rising to a height of three to five feet. *Panicum cognatum* grows in dense flat bunches scarcely a foot high, exclusive of the widely spreading panicles, and the undetermined *Panicum* is even lower, with the basal leaves and culms almost prostrate. *Tricuspis sesleriioides*, with loose bunches much like those of *Eragrostis trichodes*, is abundant in some places, especially near the edge of timber; *Calamovilfa longifolia*, with culms six feet high, occurs sparingly in patches; and *Eragrostis pectinacea*, *Bouteloua hirsuta*, *Panicum virgatum*, *Paspalum setaceum*, and *Sporobolus cryptandrus* also produce more or less well-developed bunches. *Carex gravida* and *Cyperus Schweinitzii* have tufts of basal leaves from which several culms arise, and may also be grouped with the

bunch-formers. Three other grasses, *Syntherisma filiformis*, *Aristida tuberculosa*, and *Cenchrus tribuloides*, and two sedges, *Cyperus Bushii* and *C. filicalmis*, are abundant, but do not form bunches.

The distribution of the remaining members of the association, about fifty in number, is very irregular, and a group of representative species can not be chosen from them. *Rosa humulis*, *Solidago missouriensis*, *Amorpha canescens*, *Opuntia humifusa*, *Callirrhoe triangulata*, and *Monarda punctata* are the most conspicuous, but as the quantitative study of the plants shows, not so numerous as *Teucrium canadense*, or *Ambrosia psilostachya*. With the exception of *Monarda punctata* and the last two species, these grow in rather dense, rounded patches. The same is true to a lesser extent of almost every other species in this class, but since the individuals are smaller or less abundant, many other species may be included, or two or more patches, each with traceable outlines, may overlap. If the plants are at all conspicuous the overlapping is plainly seen, and in any case it is brought out by quantitative study of the area. This form of distribution is characteristic of associations where there are no progressive changes in any of the ecological factors, and consequently no zonal arrangement of the plants. Annuals with limited means of seed dispersal, and perennials spreading by rootstocks or runners, naturally grow in rounded patches under those conditions. It is evident, then, that while the bunch-grasses are representative, the other species, of merely local distribution, are to be considered as secondary members of the association.

Table I. shows the distribution of the species in a piece of original bunch-grass prairie. The letters after each name here and in subsequent tables, indicate the number of individuals, if any, in one quadrat of one hundred square feet, *a* signifying 1 to 5; *b*, 5–10; *c*, 10–25; *d*, 25–50; *e*, 50–100; *f*, 100–200; *g*, over 200; and *o*, none. These counts were estimated for the most part, although care was taken to make actual counts at intervals in order to avoid so far as possible any serious errors of observation. The quadrats in this table, as well as in all the oth-

er tables, were side by side, in this instance extending in a strip 110 feet long by 10 feet wide. Near the area covered by these quadrats, but not included in them, were patches of *Solidago missouriensis* (*c*) and *Rosa humilis* (*e*); *c* and *e*, as above defined, indicating their respective numbers per quadrat.

TABLE I. ORIGINAL BUNCH-GRASS PRAIRIE.

Eragrostis trichodes	d*d	d	d	d	d	c	c	c	c	c
Panicum cognatum	c	c	c	c	d	c	d	d	d	d	e
Panicum sp.	o	a	b	c	a	b	b	c	c	c	b
Ambrosia psilostachya	e	e	e	c	d	d	e	d	c	e	c
Teucrium canadense	c	b	c	e	e	e	e	e	d	d	f
Leptilon canadense	c	b	o	b	e	e	c	b	c	o	b
Monarda punctata	a	a	a	a	a	a	b	a	o	a	b
Cassia chamæcrista	a	a	o	a	o	a	a	a	a	o	a
Opuntia humifusa	o	o	o	o	b	a	b	c	c	c	a
Lespedeza capitata	a	o	a	o	a	o	a	o	o	o	b
Cyperus Schweinitzii	a	a	o	a	o	a	b	a	o	o	o
Crotonopsis linearis	o	a	o	a	o	o	a	o	c	c	o
Croton glandulosus	o	o	o	o	a	b	o	a	a	o	o
Commelina virginica	o	o	o	o	o	o	a	a	o	b	a
Aristida tuberculosa	o	o	a	a	o	o	o	o	a	o	o
Cyperus filiculmis	o	o	o	o	o	o	o	o	a	b	a
Froelichia campestris	o	a	o	o	o	o	o	o	o	o	o
Œnothera rhombipetala	o	o	o	o	o	o	a	o	o	o	o
Lactuca canadensis	o	o	o	o	o	o	o	o	o	o	a
Chrysopsis camporum	o	o	a	o	o	o	o	o	o	o	o

In this instance it will be seen that *Eragrostis trichodes* was the most prominent bunch-grass. That is not always so, but its place is frequently taken by other species. For example, near this survey was another tract of undisturbed bunch-grass composed of *Carex gravida* and the undetermined *Panicum*, with an abundance index of *c* and *g*, respectively, per quadrat.

* See p. 159.

Grazing results in the destruction of the larger species of bunch-formers, leaving *Panicum cognatum* and the undetermined *Panicum*, *Paspalum setaceum*, and *Bouteloua hirsuta* as the predominant grasses. The other species, such as *Eragrostis trichodes* and *Stipa spartea*, so prominent in the original vege-

TABLE II. PASTURED BUNCH-GRASS.
(Not pastured for two years preceding count.)

Bouteloua hirsuta	a*	f	f	f	e	d	c	o	c	c
Panicum cognatum	e	c	a	o	o	o	o	o	o	o
Panicum sp.	b	c	c	b	d	d	o	d	b	o
Paspalum setaceum	c	a	a	b	d	b	o	a	e	f
Opuntia humifusa	a	c	b	c	c	b	c	b	a	a
Leptilon canadense	b	b	c	o	c	g	e	e	d	b
Ambrosia psilostachya	c	b	a	b	d	e	e	f	d	c
Monarda punctata	a	c	o	a	o	a	b	c	b	c
Cassia chamæcrista	a	a	a	o	o	a	a	b	a	o
Petalostemon candidus	a	b	b	a	a	a	o	o	o	o
Carex gravida	o	b	o	o	a	b	a	c	a	o
Eragrostis trichodes	o	o	b	c	a	a	a	a	o	o
Ionactis linariifolius	a	a	b	b	a	a	o	o	o	o
Polygala verticillata	o	b	a	a	a	a	o	o	o	o
Cyperus Schweinitzii	a	a	o	a	o	o	o	o	a	o
Crotonopsis linearis	c	o	o	o	o	o	o	o	a	c	o
Poa pratensis	o	o	a	a	o	o	a	o	o	o
Polygonum tenue	c	o	a	o	o	o	o	o	o	o
Commelina virginica	a	a	o	o	o	o	o	o	o	o
Croton glandulosus	o	o	o	o	o	o	o	a	o	a
Chrysopsis camporum	o	o	o	o	o	o	o	o	o	b
Lithospermum linearifolium	o	o	o	o	o	o	o	a	o	o
Callirrhoë triangulata	a	o	o	o	o	o	o	o	o	o
Phlox bifida	o	o	o	o	o	o	a	o	o	o

tation, are present only rarely and in scattered bunches. The

*See p. 159.

four predominant species are all small, and produce low flat bunches, giving the association an appearance widely different from the original. The sedges, especially *Cyperus Schweinitzii* and *Carex gravida* still persist, almost as abundantly as before. Certain other species are much more abundant, such as *Monarda punctata, Cassia chamaecrista,* and *Opuntia humifusa,* as well as the less important *Polygonum tenue, Crotonopsis glandulosa,* and *Polygala verticillata. Leptilon canadense* and *Ambrosia psilostachya* are usually very abundant, but on account of their slender habit are not very conspicuous. *Euphorbia Geyeri,* more characteristic of blow-sand, is in some places common, and *Chrysopsis camporum, Froelichia campestris, Œnothera rhombipetala, Croton glandulosus, Lespedeza capitata, Lithospermum linearifolium,* and *Commelina virginica* are well distributed, but seldom plentiful.

Table II. shows the composition of the vegetation of a pastured bunch-grass prairie, which, however, has not been in pasture for two years preceding. The first quadrat is near the foot of a dune, and the survey ran up the dune, ending near its top.

Table III. gives the results of a survey of a field which has been used for pasture for several years. The bunch-grass has been largely destroyed, and is replaced by *Opuntia, Ambrosia,* and *Leptilon.*

THE BLOW-SAND ASSOCIATION.

The bunch-grass prairie, while of a more or less permanent nature, is in no sense a climax association, but may be modified, through the action of certain physical factors on the one hand and of biotic factors on the other, along two definite and distinct lines, culminating in two widely different plant associations. In the first case the wind is the principal factor, and primarily through its influence the bunch-grass association is changed into blow-sand and blowout associations and ultimately into a prairie. In the second case, biotic factors are of chief importance, and the prairie is finally succeeded by the black-jack forest, representing an entirely distinct formation.

Wherever considerable bodies of sand occur, the wind

plays a prominent part in determining the physiography, causing migrating dunes and blowouts, where the sand shifts so readily that it remains entirely without vegetation (Pl. XII., Fig. 1), or is colonized only by those few species able to adapt themselves to the peculiar ecological conditions (Pl. XIII.). Some resistance to the wind action is usually offered by the vegetation, so that the area occupied by the blow-sand is lim-

TABLE III. PASTURED BUNCH-GRASS.

(In pasture up to time of count.)

Paspalum setaceum	a*	a	a	c	a	a	c	c	c	b
Panicum cognatum	o	a	c	a	a	b	o	a	o	b
Bouteloua hirsuta	o	a	o	o	o	b	b	o	o	o
Opuntia humifusa	b	a	c	b	b	b	b	o	o	a
Ambrosia psilostachya	g	f	f	e	e	f	e	b	f	f
Leptilon canadense	g	f	f	a	f	d	c	o	o	o
Monarda punctata	a	a	c	a	b	b	a	a	b	b
Cassia chamæcrista	a	o	a	d	b	a	a	a	a	a
Œnothera rhombipetala	a	o	a	a	a	a	o	o	a	a
Euphorbia Geyeri	o	o	a	a	o	a	b	c	c	a
Croton glandulosus	o	o	a	a	a	a	a	a	a	o
Froelichia campestris	o	o	a	a	o	o	a	o	o	a
Commelina virginica	o	a	a	o	o	o	o	a	o	o
Chrysopsis camporum	o	o	a	a	o	o	o	o	o	o
Cyperus Schweinitzii	o	o	a	o	o	o	o	o	o	o
Cenchrus tribuloides	o	o	o	o	o	o	o	o	o	a
Lespedeza capitata	o	o	o	o	o	o	o	a	o	o

ited. In the present case the covering of bunch-grasses, with their fibrous roots, and of such other sand-binding plants as the matlike *Opuntia*, or the dense clumps of *Amorpha canescens* or *Chrysopsis camporum*, is very effectual. Blowing still takes place, as is shown by the slight excavations between the bunches on the hilltops (Pl. XIV., Fig. 2), but it results merely in a general redistribution of the sand, the quantity removed being vir-

* See p. 159.

tually balanced by that deposited, and the whole remaining approximately in a state of equilibrium. On the crests of the dunes, however, where the sand is more exposed to the wind and more is blown away than is deposited, the plants are frequently separated by shallow excavations, and may sometimes be uprooted entirely, thereby permitting the free action of the wind, and leading to the formation of a blowout. In fields that have been pastured, there is frequently a black crust an inch or so deep formed over the surface, probably by the decay of the grass and leaves trampled into the sand by cattle. In dry weather this crust is quite hard, and effectually checks the shifting of the sand.

The resistance offered by the vegetation is, indeed, very effectual, and some old settlers say that there were no blowouts in the sand region in the middle of the last century, when settlements were first begun, but that they have all been formed since then. The report of the Illinois Geological Survey published in 1870 does not mention them, and it is improbable that such conspicuous blowouts as exist to-day could have escaped the attention of the State Geologist, who traveled over the country on horseback. There are, however, a few large fields of blowouts and blow-sand that have been in existence as long as the neighboring residents can remember, such as the Devil's Neck (Pl. XII., Fig. 1; XIV., Fig. 1), north of Topeka, where a field of about eighty acres is entirely covered with blow-sand.

Plowing is generally believed to be the cause of the formation of blowouts, the natural vegetation being thus destroyed, and the sand left exposed to the winds of winter and spring after the cultivated crops are removed. All of the Miami loam between the sand deposits is under cultivation, and the frequent efforts of the farmers to extend their fields upon the dunes have often led to disastrous results. Adjacent fields of fertile soil are known to have been ruined in that way (Pl. XI.), and at present most farmers let the sand stand unused, or use it for pasture only. It is also said that cattle may destroy the vegetation, and that blowouts may be started in this way.

When the protective covering of vegetation is once broken,

by whatever means, blowing proceeds rapidly, resulting in the saucer- or bowl-shaped excavations known as blowouts (Pl. VIII., IX., XV.). Their depth may finally be as great as the depth of the sand itself, and their area is sometimes several acres in extent. Their sides usually have a gentle slope, but are sometimes quite steep where the bunch-grass along the crest has restricted the blowing (Pl. XIV., Fig. 2). The sand removed from the blowouts is piled up on the leeward side in a more or less fan-shaped heap, and this in turn is blown on by the wind as a traveling dune (Pl. XII., Fig. 2). Blowouts may be partially or wholly refilled by sand, being thus transformed into level tracts (Pl. XIII.), generally called blow-sand, and when these become large the individual blowouts lose their identity and the whole tract becomes a vast undulating surface of shifting sand. The limit of size is reached when the blowout becomes so large that it no longer offers much resistance to the wind, or so deep that the wind does not have sufficient force to carry the sand from the bottom up over the sides, or when moister layers of sand are reached which can not be blown.

In young blowouts, when the excavation is being carried on most rapidly, vegetation is very sparse, and the few species able to grow in such conditions constitute the typical blow-sand association. They are mostly plants with a short period of development, which may mature before the shifting of the sand has undermined their root-system, and they frequently possess methods of seed distribution by which they are enabled to colonize rapidly on barren areas of sand. The most characteristic species are *Ambrosia psilostachya*, *Cassia chamæcrista*, *Cenchrus tribuloides*, *Cycloloma atriplicifolium*, *Cristatella Jamesii*, and *Aristida tuberculosa*. Of these, *Cassia* and *Cenchrus* are the most abundant. Six to ten thousand plants of *Cenchrus*, none of them more than six inches high, sometimes grow on a single quadrat ten feet square, and a third of them produce seeds. *Cassia* prefers sand that is loose from blowing or that has been otherwise disturbed. Wagon tracks across the sand are quickly occupied by it, and are marked by long parallel lines of the plants, which are very conspicuous in the blooming season.

Cassia, however, can not grow upon such rapidly shifting sand as *Cenchrus* can, and both are surpassed in this by *Cycloloma atriplicifolium*. *Cristatella Jamesii* is absolutely confined to blow-sand (Pl. XX., Fig. 1), and disappears when the blowing is stopped.

Numerous other species may occur, such as *Croton glandulosus*, *Euphorbia Geyeri*, *Ambrosia psilostachya*, *Sporobolus cryptandrus*, *Mollugo verticillata*, and *Acerates viridiflora*. Others, less abundant, are usually relics of the bunch-grass association, the original occupant of the territory, which have persisted because their sand-binding adaptations have prevented their being undermined and blown away.

Blowouts of any age may be filled up and converted into level stretches of blow-sand, covered with the blow-sand association already described, but with more *Cycloloma* and less *Cassia* in the older ones. The vegetation is always sparse, and the blowing of the sand during the fall and winter is sufficient to prevent the perennials of the bunch-grass association from gaining a foothold. Over wide stretches of blow-sand there is frequently absolutely no vegetation, while on others there is nothing but *Cycloloma*, *Ambrosia*, *Cassia*, and *Cenchrus*.

Counts in a developing blowout and in a few typical areas of blow-sand are here given.

TABLE IV. SMALL BLOWOUT.

Cassia chamæcrista	f*	f	e	d	d	d
Ambrosia psilostachya	e	e	e	d	d	f
Cenchrus tribuloides	e	e	d	e	d	g
Cristatella Jamesii	o	a	b	c	c	e
Froelichia campestris	o	a	o	a	a	a
Euphorbia Geyeri	o	b	o	c	c	b
Lithospermum linearifolium	o	c	b	b	b	o
Cyperus Schweinitzii	o	o	b	o	b	o
Cycloloma atriplicifolium	o	o	o	o	a	a
Monarda punctata	a	o	o	a	o	o

* See p. 159.

TABLE V. BLOW-SAND.

Cycloloma atriplicifolium	d* d c c c
Cassia chamæcrista	a o b o o
Euphorbia Geyeri	o a o a a
Cenchrus tribuloides	b o o o o
Commelina virginica	o a o o o

TABLE VI. BLOW-SAND.

Cassia chamæcrista	g* f b o o
Ambrosia psilostachya	e e d o o
Euphorbia Geyeri	c d b o o
Commelina virginica	a a o a o
Cenchrus tribuloides	e a o o o
Croton glandulosus	a o o o o
Cristatella Jamesii	a o o o o

TABLE VII. BLOW-SAND.

Cycloloma atriplicifolium	f* f g a f
Cassia chamæcrista	c e g g f
Ambrosia psilostachya	f e e e c
Cenchrus tribuloides	o o o o a

THE BLOWOUT ASSOCIATION.

When the excavation of the blowout has proceeded so far that the maximum depth is reached, the blowout association is developed at the bottom, in response to the changed ecological conditions. These are (1) a slight protection from the wind, (2) a more stable substratum, and (3) a larger supply of soil moisture. The result is an association essentially mesophytic in nature. Most of the members of the blow-sand association, excepting *Cycloloma* and *Cristatella*, persist for a time,

* See p. 159.

and numerous species of the bunch-grass may also spring up, but a new group of species appears, and by their predominance the aspect of the vegetation is entirely changed (Pl. XV.).

Among the first to appear is *Stenophyllus capillaris*, which grows in a carpet over the flat bottom of the blowout, but never extends up the sloping sides. Its growth soon results in the formation of a thin layer of black humus over the surface. Associated with it usually are large clumps of *Panicum virgatum* and *Sorghastrum avenaceum*. These grasses are typical plants of damp blowouts and interdunal depressions, but retain their place even when the blowout is subsequently covered by blow-sand. *Andropogon furcatus*, another grass common on the black-soil prairies, is frequent, and with these herbaceous species are often associated a number of woody forms not found at all in the bunch-grass prairie or in the black-jack timber. These are *Vitis vulpina*, *Menispermum canadense*, *Populus deltoides* (Pl. IX.), and *Acer Negundo* (Pl. XVII.). All of these have effective methods of seed dispersal, and are probably disseminated widely over the sand area, but are able to effect ecesis only in these more favorable conditions. The two vines scramble over the ground, but the trees grow rapidly and, like the grasses above mentioned, persist even when the blowout is refilled with sand. The past history and position of the blowouts are frequently shown by a large cottonwood or box-elder tree, buried in sand to its lower branches. Two species of *Cladonia* soon appear, and are active as soil formers. They are not restricted to the very wettest part, as is *Stenophyllus*, but extend out upon the naked sand, and also occur in shallower blowouts which have never reached a condition suitable for the sedge. Following the *Cladoniæ* are *Antennaria* sp. and *Helianthus occidentalis*, and, a little later, such other species as *Hieracium longipilum*, *Helianthus scaberrimus*, *Meibomia canadensis*, *Lacinaria scariosa*, *Mesadenia atriplicifolia*, and others common on the black-soil prairies, and the association is converted into prairie scarcely distinguishable, in vegetation at least (Pl. XVII.), from the typical prairies of central Illinois.

A blowout succession is therefore as follows:

1. *Cassia—Ambrosia—Cycloloma* (Blow-sand association)
2. *Stenophyllus—Panicum—Sorghastrum* } (Blowout association)
(2a. *Populus—Acer*) }
3. *Cladonia—Antennaria* }
4. *Helianthus—Hieracium* } (Prairie association)

It is in only a small proportion of the numerous blowouts that this succession is followed to the culmination in a prairie. In fact, only one was observed that had reached the stage numbered 4. Probably not more than a tenth ever reach stage 2.

Although the wind alone is instrumental in the excavation of the blowouts, it has in general a leveling action. The sand removed from each blowout is distributed over a larger area than that from which it was taken, so that the tendency of the wind action is toward a level surface of sand.

Reversion to Bunch-grass.

It has just been shown that in certain cases the blowout association may develop into one of the prairie associations. Similarly, if for any reason the blowing of the sand ceases, recolonization is begun by the bunch-grass association. Naturally the species most active in this are those members of the bunch-grass association that are able to live on blow-sand, and particularly the sand-binder *Sporobolus cryptandrus* (Pl. XVIII., Fig. 2). The bunch-grasses themselves are among the last to appear, and their place is previously filled by *Callirrhoe triangulata*, *Rhus aromatica*, *Chrysopsis camporum*, and other sand-binders, or sometimes even by the Kentucky blue-grass, *Poa pratensis*. Two stages in the regeneration of the bunch-grass are shown in the following tables.

Even after the sand is completely fixed, the bunch-forming grasses are much less abundant than in the normal association, their places being filled by *Chrysopsis camporum*, *Opuntia humifusa*, *Callirrhoe triangulata*, and *Rhus aromatica*.

The blowouts may be fixed without first filling up with blow-sand, and in this case they are occupied directly by the species of the bunch-grass association, which extend down into it, and ultimately occupy it completely. The stools growing

near the crest of an active blowout are constantly being undermined, and slide down with the loose sand towards the bottom (Pl. XVI.). They are not killed directly by this, but are frequently seen alive near the bottom, and in this way are directly available in holding the sand.

TABLE VIII. BLOW SAND.

(Fixation just begun.)

Sporobolis cryptandrus	d*	d	d	c	d
Chrysopsis camporum	d	d	c	d	d
Cassia chamæcrista	d	c	a	c	c
Ambrosia psilostachya	c	d	c	d	d
Monarda punctata	o	o	o	a	a
Euphorbia Geyeri	d	o	o	o	o
Cyperus Bushii	o	o	o	o	a
Paspalum setaceum	o	o	a	o	o
Commelina virginica	o	o	o	o	a

TABLE IX. BLOW-SAND.

(Nearly fixed.)

Sporobolus cryptandrus	e*	e	d	d	e
Chrysopsis camporum	d	c	c	d	d
Lespedeza capitata	c	c	c	b	a
Ambrosia psilostachya	b	c	c	b	o
Cyperus Schweinitzii	o	a	a	a	b
Monarda punctata	o	a	a	a	a
Paspalum setaceum	o	o	a	o	o
Aristida tuberculosa	o	o	o	b	b
Croton glandulosus	a	o	o	o	o
Leptilon canadense	o	a	o	o	o

But one other result of the movement of the sand remains to be considered, and that is the effect of the blow-sand on the

* See p. 159.

vegetation which it covers. Small trees are usually killed, but larger ones will withstand burying to a considerable depth. Frequently the only sign indicating the former position of a blowout is a cottonwood tree (Pl. IX.) buried to its lower limbs, but still alive. Walnut, butternut (Pl. X.), box-elder, and hackberry have also been observed partially buried in the same manner. The vegetation of the front of a dune which has reached such a grove (Pl. XX., Fig. 2) is quite different from that of a dune advancing in the open. The sand, shaded and protected from evaporation, is much moister in the upper layers, and the face of the dune is at a steeper slope. The herbaceous vegetation is sparse, probably because of the weak light, since in the sunnier spots the individual plants are more numerous. The principal species are *Solanum nigrum*, *Euphorbia heterophylla*, *Sicyos angulatus*, *Clematis Simsii*, *Parthenocissus quinquefolia*, *Menispermum canadense*, *Ribes missouriense*, *Allionia nyctaginea*, *Vitis riparia*, *Campanula americana*, and *Urticastrum divaricatum*. The same species occur in the valleys of the Miami loam below. Near the top various photophile forms, such as *Cenchrus tribuloides*, *Monarda punctata*, and *Asclepias syriaca*, appear in great abundance. The three first-mentioned species are evidently pronounced mesophytes, as specimens wilt very rapidly when pulled. Nevertheless, the *Solanum* is finely pubescent, while the usual mesophytic form in loamy soil is nearly always glabrous.

To summarize the preceding statements concerning the development of plant associations from the bunch-grass, the action of the wind may lead to the development of the blow-sand and the blowout associations, but either of them may normally revert to the bunch-grass association unless the blowout excavation has continued until most of the sand is removed, when a normal black-soil prairie ensues.

THE BLACK-JACK ASSOCIATION.

Throughout the central part of the state the prairie represents the most primitive plant formation. It has been shown that in the sand region,—and the same holds true throughout

central Illinois,—variations in local conditions may produce minor changes in the plant-covering, but that the resulting subsidiary associations revert in every case to the typical bunch-grass prairie. The great extent of the prairie formation, the aggressiveness with which it displaces the minor associations within it, and the resistance which it offers to the encroachments of the forest, characterize it as a temporary climax type of vegetation. That the prairie of Illinois is, however, being rapidly displaced by the forest is no longer a matter of doubt. Cowles ('01) has shown that for the Chicago district the culminating, or climax, type of vegetation is the mesophytic forest. While a similar mesophile association is the climax for the central part of the state, the intermediate stages here may be very different on account of differences in the physiography or in the biotic environment.

In the typical Illinois prairies the encroachment of the forest upon the prairie progresses along the drainage lines. The prairie soil always contains a sufficient amount of humus for the growth of many species of forest plants, and the succession of associations is hastened by the changes in soil and topography due to stream action. The more permanent supply of soil-moisture along the streams is a condition not found on the prairie, and this constitutes a weakness at the most critical point of its defense. In this sand region none of these favorable conditions is found. There is no humus in the sand, and there is no surface drainage, and consequently no erosion, no base-leveling, and no increased water supply,—all of which in other places so facilitate the extension of the forest.

The first tree-growth that invades the sand prairies is a xerophytic association composed mainly of the black-jack oak, *Quercus marylandica*, and usually known as black-jack timber (Pl. XXI., Fig.1). The almost complete absence of water-courses prevents its extension in long belts paralleling streams, and, instead, it is found in large masses, with more or less rounded outlines, on the larger sand deposits, or in narrow strips following the dunes. It is limited entirely to the sand, never invading the more fertile fields of Miami loam, nor en-

croaching upon the bottoms of the Illinois River. Besides the black-jack oak, which constitutes, by rough estimate, fifty per-cent of the forest, there is about thirty-five percent of black oak, *Quercus velutina*, and fifteen percent of hickory, *Hicoria microcarpa*. These three are the only arborescent species of the black-jack timber, and in some places but one of them (*Quercus marylandica*) is present. The trees seldom exceed a foot in diameter, and they are generally very crooked, gnarly, and full of dead branches. The hickory is nearly always sterile, only the very largest trees producing fruit. The underbrush consists mainly of young trees of hickory and the two oaks, with occasional clumps of *Rhus aromatica*. Other shrubby species of less prominence occur, such as *Amorpha canescens* and *Salix tristis*. Since the ecology of the black-jack association, at least during its early stages, differs from that of the original bunch-grass association only in the smaller amount of light received by its plants, the herbaceous and shrubby flora of the two are very similar. Of the species observed on the prairie, all but thirteen were also found in the black-jack forest. These were *Spartina cynosuroides*, *Stipa spartea*, *Calamovilfa longifolia*, *Stenophyllus capillaris*, *Populus deltoides*, *Acer Negundo*, *Cristatella Jamesii*, *Populus dilatata*, *Gleditsia triacanthos*, *Lesquerella spathulata*, *Acerates viridiflora*, *Hieracium longipilum*, and *Equisetum robustum*. This number would probably be reduced by extended observation. The principal distinction between the two floras is the poorer quantitative development of the bunch-grasses in the black-jack association, and a corresponding increase in the representation of the other species. In the edge of the woods, which differs the least from the prairie both in age and in ecology, the bunch-grasses are well developed, and the majority of the species may be found. In the older and more densely shaded parts the bunch-forming species are *Panicum cognatum*, *Tricuspis sesleroides*, *Eragrostis trichodes*, *Paspalum setaceum*, and *Andropogon furcatus*, and the bunches are few and widely scattered. This difference in development in the two formations is probably due entirely to the amount of light. The remainder of the flora is characterized by the great-

er proportion of *Callirrhoe triangulata* and *Cracca virginiana*. The latter is extremely abundant, and grows in dense circular patches ten feet or more in diameter. *Callirrhoe triangulata* is likewise abundant, and, although not forming dense patches like *Cracca*, displays its showy purple flowers in profusion, producing an effect rivaled only by the yellow beds of *Cassia chamæcrista* on the prairies. Other prominent members of the flora are *Opuntia humifusa*, *Allionia nyctaginea*, *Cassia chamæcrista*, *Froelichia campestris*, *Meibomia sessilifolia*, *Helianthus occidentalis*, and *Helianthemum majus*, all of which are found also on the prairies. There are, however, a number of species which apparently do not occur beyond the forest. Most important among these are the following:

Pteridium aquilinum	*Anychia canadensis*
Polygonum cristatum	*Erysimum arkansanum*
Talinum rugospermum	*Cassia nictitans*
Meibomia nudiflora	*Hypericum sphærocarpum*
Meibomia paniculata	*Lechea villosa*
Ipomœa pandurata	*Pentstemon hirsutus*
Nabalus asper	*Galium pilosum*
Artemisia caudata	*Helianthus illinoensis*

The structure of the vegetation of the black-jack association is remarkably uniform, the only variations being due to differences in the light intensity. In natural clearings there is a preponderance of *Cracca virginiana*, *Helianthus occidentalis*, and *Rhus aromatica*, while a few species of the bunch-grass association, such as *Cassia chamæcrista*, *Ambrosia psilostachya*, and *Monarda punctata*, may be found with them. In the clearings *Crotonopsis linearis* is the prevailing form, associated with a number of other species.

Tables X. to XII. give counts in the black-jack association.

A tension zone, with intermediate ecological characters and a mixture of species is not developed between the black-jack association and the prairie. Its absence is an indication of the relatively slight ecological differences between the earlier stages of the black-jack and the mature prairie, but with the gradual development of the forest great changes occur. The

soil is still a pure sand, but since it is protected by the trees from the wind and from the light and heat of the sun, it does not dry out so rapidly. For the same reasons the atmospheric humidity is conserved, and the oxidization of organic matter

TABLE X. BLACK-JACK ASSOCIATION.

	Open					Brush										
Cracca virginiana	b*	d	c	a	a	o	d	g	b	d	o	b	o	f	c	f	o
Opuntia humifusa	a	b	a	a	b	a	b	c	c	o	o	o	b	b	b	a	b
Aristida tuberculosa	o	o	g	f	f	c	d	c	f	c	f	e	o	e	e	d	f
Euphorbia corollata	o	a	a	b	a	a	a	o	o	o	a	b	a	a	a	o	a
Teucrium canadense	o	a	a	b	o	d	o	b	a	o	o	c	b	o	o	a	c
Rhus aromatica	f	o	o	o	o	g	f	o	o	e	o	o	g	o	e	a	o
Crotonopsis linearis	c	f	c	d	d	o	o	o	o	o	o	o	o	o	o	o	d
Helianthemum majus	o	a	o	a	a	o	o	o	o	o	o	a	a	a	o	o	o
Monarda punctata	o	o	a	a	a	o	o	o	b	o	b	c	a	o	o	o	o
Ambrosia psilostachya	o	o	o	o	o	o	o	o	a	o	b	o	o	o	b	o	o
Helianthus occidentalis	o	o	o	c	b	o	o	o	o	o	o	o	o	o	o	o	o
Œnothera rhombipetala	o	o	o	o	o	o	o	o	a	o	o	a	o	o	o	o	o
Leptilon canadense	o	o	o	o	o	o	o	o	o	o	o	a	o	o	o	o	a
Asclepias tuberosa	o	o	o	o	o	o	a	o	o	o	o	o	o	o	o	o	o
Sporobolus cryptandrus	o	o	o	o	o	o	o	o	a	o	o	o	o	o	o	o	o
Cyperus filiculmis	o	o	o	o	o	o	o	o	o	o	o	o	o	o	a	o	o
Lespedeza capitata	o	o	o	o	o	o	o	o	o	o	o	o	a	o	o	o	o
Panicum sp.	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	a

Other species: *Chrysopsis camporum*, *Rudbeckia hirta*, *Bouteloua hirsuta*, *Euphorbia Geyeri*. The trees were not included.

lying on or near the surface of the sand is retarded. The annual leaf-fall is of course much larger, and instead of being blown about by the wind it is held by the dense growths of *Rhus* and *Cracca*, and forms a layer over the sand which increases annually in thickness. This holds a portion of the rain-water at the surface of the sand, and is eventually con-

* See p. 159.

verted into a thin layer of leaf-mold. The deeper roots of the trees penetrate to, and draw a portion of their inorganic food from, the lower strata of sand, and much of this is returned to the soil in the dead leaves, thus restoring to the upper layers of the sand some of the food matter leached out by years of rainfall.

TABLE XI. CLEARING IN BLACK-JACK ASSOCIATION.

Crotonopsis linearis	g*	g	g	g	g	b	g
Opuntia humifusa	b	b	c	c	c	c	b
Monarda punctata	b	a	b	a	a	a	d
Cracca virginiana	a	o	d	o	d	b	a
Rhus aromatica	a	c	b	o	o	g	a
Ambrosia psilostachya	o	o	o	d	c	o	c
Chrysopsis camporum	a	o	o	o	o	o	o

Other species: *Teucrium canadense*, *Euphorbia corollata*.

TABLE XII. NATURAL OPENING IN BLACK-JACK ASSOCIATION.

Helianthus occidentalis	f*	f	f	f	g	f	
Cracca virginiana	e	e	f	e	f	f	
Rhus aromatica	a	c	a	c	d	c	
Opuntia humifusa	c	c	o	b	c	c	
Ambrosia psilostachya	c	o	o	c	c	c	
Onosmodium carolinianum	o	o	a	c	o	o	
Helianthemum canadense	o	o	o	a	a	o	
Eragrostis trichodes	o	o	a	o	a	o	
Asclepias verticillata	o	o	o	o	a	a	
Monarda punctata	o	o	o	a	o	o	
Cassia chamæcrista	b	o	o	o	o	o	

Other species: *Callirrhoe triangulata*, *Carex gravida*.

* See p. 159.

These changes go on very slowly. There are now areas of black-jack covering several square miles with scarcely a trace of leaf-mold. This is illustrated especially by the black-jack timber south of Havana between Bath and Kilbourne, where, in a belt five miles wide, there is nothing but pure sand without any covering of humus. In the country east of Havana, where the sand is mostly confined to long wooded dunes, and near the Illinois River, the formation of the soil appears to be more rapid. Some of the wooded ridges back from the river have a coating of leaf-mold only half an inch to an inch in thickness, and the cacti still growing in it show that it has been but a few years since its formation.

With the first traces of leaf-mold such semi-xerophytic plants as *Aquilegia canadensis*, *Triosteum aurantiacum*, *Silene stellata*, *Anemone virginiana*, and *Agrimonia mollis* begin to appear, together with many other species common to most upland-wood associations, although many of the sand-loving xerophytes, such as *Callirrhoe triangulata*, *Rhus aromatica*, and *Lespedeza capitata*, still persist. As the soil increases in depth more characteristic mesophytes appear, including *Vagnera racemosa*, *Vagnera stellata*, *Geum canadense*, *Asclepias exaltata*, and *Eupatorium ageratoides*. *Parthenocissus quinquefolia* becomes very abundant, climbing up most of the trees, and trailing prostrate on the sand, covering it with a dense mat. The arborescent flora is still unchanged; the two oaks and the hickory constitute nearly all of the forest, and the only additions are small scattering trees of *Cercis canadensis*, *Morus rubra*, and *Celtis occidentalis*.

None of the black-jack forests observed has as yet passed beyond this semi-mesophytic stage except in a narrow belt along the Illinois River (Pl. XXI., Fig. 2), where plants from the neighboring mesophytic and hydrophytic forests may spread more quickly over the sand ridges. In such places the forests of the wooded dunes contain but a small proportion of black-jack oak, its place being taken by bur-oak (*Quercus macrocarpa*) and white oak (*Quercus alba*). The leaf-mold is deep, and the

herbaceous flora resembles that of the most mesophytic of our upland woods.

Some Adaptations of the Plants to the Environment.

The plants of the sand region are nearly all xerophytes, and as such show many xerophytic adaptations for the reduction of transpiration. Some of the more important of these are given below, and illustrative plants mentioned.

1. *Reduction of the Leaf Surface.—Opuntia humifusa*, the cactus or prickly pear so common throughout the region, is the best example. The leaves are no longer functional, and the green succulent stem is divided into flat obovate joints which transpire very slowly.

2. *Thick or Succulent Leaves.—Talinum rugospermum* has a basal cluster of cylindrical succulent leaves one to two inches long. *Physostegia virginiana* when growing on the sand prairies has blunt-toothed leaves, slightly folded along the midrib, and greatly thickened. The difference between this leathery-leaved xerophytic form and the thin-leaved mesophyte abundant along ditches and sloughs elsewhere in the state, is very striking.

3. *Narrow or Linear Leaves.*—A reduction of the transpiring surface by linear leaves occurs in many species, among which are *Polygonum tenue*, *Polygala verticillata*, *Petalostemon candidus* and *P. purpureus*, *Phlox bifida*, and *Ionactis linariifolius*.

4. *A Protective Covering of Hairs or Scales.*—This is one of the commonest adaptations for preventing excessive transpiration, and is found on a great many of the species. *Froelichia campestris* is softly gray-hairy throughout; *Amorpha canescens*, *Cracca virginiana*, and *Chrysopsis camporum* are densely hairy, giving them a gray appearance; and *Croton glandulosus* has a thin covering of stellate hairs. The linear leaves of *Crotonopsis linearis* are silvery with stellate hairs, and in *Lesquerella spathulata* there is a basal rosette of spatulate leaves silvery with stellate pubescence. The glandular hairs with which the stem of *Cristatella Jamesii* is covered, hold the sand blown against it by the wind, so that the plants become encased in a veritable

armor, which may be of some use in reducing transpiration. Many other species also have hairy leaves or stems. In fact, such a protective covering is so common that the landscape has not the ordinary green color, but is distinctly gray in general tone.

5. *Involute or Conduplicate Leaves.*—This adaptation is shown by many of the grasses.

6. *Position of the Leaves.*—In *Helianthus occidentalis* the thick, rough basal leaves stand with their blades nearly vertical. Prostrate plants, like *Mollugo verticillata* and *Euphorbia Geyeri,* may also be protected against excessive transpiration by their position.

As the surface of the sand dries out quickly after rains, the first few inches contain very little water, and the roots of the plants must penetrate through this dry upper layer into the moist sand below. Many species accordingly have straight tap-roots, which give off few lateral branches or none at all for the first six to twelve inches. Some of the plants of this habit are *Polygonum tenue, Cycloloma atriplicifolium* (Pl. XIX., Fig. 1), *Froelichia campestris, Cristatella Jamesii, Croton glandulosus, Euphorbia Geyeri.* and *Œnothera rhombipetala.* Others have thickened roots or rootstocks which serve for water storage, *Talinum rugospermum, Ceanothus americanus,* and *Ipomœa pandurata* being examples.

The sand-binding habit is best developed on the prairies, where the action of the wind is most vigorous. Chief among the sand-binders are the bunch-grasses (Pl. XIV., Fig. 2; XVIII., Fig. 1), which protect the sand from the wind by their dense tufts of culms and basal leaves, and at the same time bind it with their rootstocks and fibrous roots. If the bunches are far apart, so that the sand is exposed between them, they frequently become raised several inches above the general level, having held the sand beneath them while that not so protected has been blown away. Species without sand-binding adaptations are usually associated with the bunch-grasses and protected by them. This condition is also found in the bunch-

grass on the sand-hills of Nebraska (Pound and Clements, '00, p. 353).

Next in importance as sand-binders are certain species which grow in close hemispherical or flattened bunches, and hold the sand in the same manner as the bunch-grasses. *Rhus aromatica* (Pl. XIX.) grows in dense thickets, sometimes twenty feet in diameter, its long branching roots descending to a depth of six feet or more, and effectually resisting the movement of the sand. *Cracca virginica*, *Lithospermum linearifolium*, *Salix tristis*, *Chrysopsis camporum*, and especially *Amorpha canescens*, have the same habit as *Rhus*, but on account of their smaller size are less effectual as sand-binders.

Sporobolus cryptandrus, and *Commelina virginica* have stems prostrate and rooting at the nodes, and both are quite effectual sand-binders, although the latter species is not frequent, and neither reaches a large size. *Sporobolus* is quite abundant on level blow-sand, where it builds up mounds from four to eight inches high (Pl. XVIII., Fig. 2). It is one of the principal species concerned in fixing blow-sand and preparing it for the re-establishment of the bunch-grass association. *Commelina* also builds up small mounds and ridges of sand.

A third type of sand-binders is composed of mat plants, which have prostrate stems radiating from a central root. *Euphorbia Geyeri* is common on blow-sand, where it grows in circular mats from six inches to two feet in diameter. It thus effectually holds the sand beneath it, and is frequently seen on a flat mound an inch of two high, closely similar in shape to the plant itself. *Mollugo verticillata*, frequently naturalized on blow-sand and in the bunch-grass, has the same habit. *Opuntia humifusa* may be classed in the same group. It forms dense mats two to five feet in diameter, and effectually holds the sand. The center of the mats, however, are frequently buried. *Acerates viridiflora*, usually erect in a richer soil, is prostrate when growing on blow-sand, and builds up small mounds.

Intermediate between prostrate forms like the last and bunch-forming species like *Chrysopsis* are such plants as *Solidago missouriensis*, and *Callirhoe triangulata*. These have sev-

eral stems in a cluster ascending from a common center, and while of little importance in holding the sand they frequently collect considerable quantities about their bases.

No attempts have been made toward controlling the movement of the sand and rendering it available for agricultural purposes, but much could be accomplished in that direction. Hedges have been planted in some places, and thickets of plum-trees have been allowed to grow between cultivated fields and sand-hills. The Lombardy poplar (Pl. XX., Fig. 1) might be used with good results, as it thrives on the sand and spreads rapidly by its long underground roots.

List of the Plants Observed.*

Polypodiaceæ.

Pteridium aquilinum (L.) Kuhn.

Equisetaceæ.

Equisetum arvense L.
Equisetum robustum A. Br.

Gramineæ.

Andropogon scoparius Michx.
Andropogon furcatus Muhl.
Sorghastrum avenaceum (Michx.) Nash.
Paspalum setaceum Michx.
Syntherisma filiformis (L.) Nash.
Panicum cognatum Schultes.
Panicum virgatum L.
Panicum sp.†
Chætochloa viridis (L.) Scribn.
Cenchrus tribuloides L.

* Only those species of spermatophytes and pteridophytes which grow on the sand prairies or in the black-jack forest proper, without a covering of leaf-mold, have been included in this list. Some additional species have been reported by Patterson ('76) and McDonald ('00). The nomenclature followed is essentially that of Britton's Manual.

† Abundant on the bunch-grass prairies and of sparing occurrence in the black-jack; conspicuous and well marked by the dense tufts with the crowded, almost fastigiate, ascending leaves. The primary panicle fruits in July, and the spikelets have nearly all fallen off when the secondary panicles appear, in the middle of August. The specific identity of the plant is in doubt.

Aristida tuberculosa Nutt.
Stipa spartea Trin.
Sporobolus cryptandrus (Torr.) Gray.
Calamovilfa longifolia (Hook.) Hack.
Spartina cynosuroides (L.) Willd.
Bouteloua hirsuta Lag.
Atheropogon curtipendulus (Michx.) Fourn.
Tricuspis seslerioides (Michx.) Torr.
Eragrostis pectinacea (Michx.) Steud.
Eragrostis trichodes (Nutt.) Nash
Poa pratensis L.

CYPERACEÆ.

Cyperus Schweinitzii Torr.
Cyperus Bushii Britton.
Cyperus filiculmis Vahl.
Stenophyllus capillaris (L.) Britton.
Carex gravida Bailey.

COMMELINACEÆ.

Commelina virginica L.
Tradescantia virginiana L.

CONVALLARIACEÆ.

Salomonia commutata (R. & S.) Britton.

SMILACEÆ.

Smilax hispida Muhl.

SALICACEÆ

Populus deltoides Marsh.
Populus dilatata Ait.
Salix tristis Ait.

JUGLANDACEÆ.

Juglans nigra L.
Hicoria microcarpa (Nutt.) Britton.

FAGACEÆ.

Quercus velutina Lam.
Quercus marylandica Muench.

ULMACEÆ.

Celtis occidentalis L.

MORACEÆ.

Morus rubra L.

URTICACEÆ.

Urticastrum divaricatum (L.) Kuntze.

POLYGONACEÆ.

Polygonum emersum (Michx.) Britton.
Polygonum tenue Michx.
Polygonum cristatum Engelm. & Gray.

CHENOPODIACEÆ.

Chenopodium album L.
Cycloloma atriplicifolium (Spreng.) Coulter.

AMARANTHACEÆ.

Froelichia campestris Small.

NYCTAGINACEÆ.

Allionia nyctaginea Michx.

AIZOACEÆ.

Mollugo verticillata L.

PORTULACACEÆ.

Talinum rugospermum Holz.

CARYOPHYLLACEÆ.

Silene stellata (L.) Ait.
Silene antirrhina L.
Anychia canadensis (L.) B. S. P.

RANUNCULACEÆ.

Anemone cylindrica Gray.
Clematis Simsii Sweet.

MENISPERMACEÆ.

Menispermum canadense L.

LAURACEÆ.

Benzoin Benzoin (L.) Coulter.

CRUCIFERÆ.

Lesquerella spathulata Rydb.
Arabis lævigata (Muhl.) Poir.
Erysimum arkansanum Nutt.

CAPPARIDACEÆ.

Cristatella Jamesii T. & G.
Polanisia graveolens Raf.

GROSSULARIACEÆ.

Ribes missouriense Nutt.

ROSACEÆ.

Fragaria virginiana Grayana (Vilm.) Rydb.
Potentilla canadensis L.
Rosa humilis Marsh.

CÆSALPINIACEÆ.

Cassia nictitans L.
Cassia chamæcrista L.
Gleditsia triacanthos L.

PAPILIONACEÆ.

Baptisia bracteata Ell.
Amorpha canescens Pursh.
Petalostemon candidus (Willd.) Michx.
Petalostemon purpureus (Vent.) Rydb.
Cracca virginiana L.
Meibomia nudiflora (L.) Kuntze.
Meibomia sessilifolia (Torr.) Kuntze.
Meibomia paniculata (L.) Kuntze.
Meibomia canadensis (L.) Kuntze.
Lespedeza virginica (L.) Britton.
Lespedeza capitata Michx.
Falcata comosa (L.) Kuntze.
Strophostyles helvola (L.) Britton.
Strophostyles umbellata (Muhl.) Britton.

OXALIDACEÆ.

Oxalis violacea L.

RUTACEÆ.

Xanthoxylum americanum Mill.

POLYGALACEÆ.

Polygala verticillata L.

EUPHORBIACEÆ.

Croton glandulosus L.
Crotonopsis linearis Michx.
Euphorbia Geyeri Engelm. & Gray.
Euphorbia corollata L.
Euphorbia heterophylla L.

ANACARDIACEÆ.

Rhus aromatica Ait.
Rhus radicans L.

CELASTRACEÆ.

Celastrus scandens L.

ACERACEÆ.

Acer Negundo L.

RHAMNACEÆ.

Ceanothus americanus L.

VITACEÆ.

Vitis vulpina L.

MALVACEÆ.

Callirrhoe triangulata (Leavenw.) Gray.

HYPERICACEÆ.

Hypericum sphærocarpum Michx.

CISTACEÆ.

Helianthemum majus (L.) B. S. P.
Lechea villosa Ell.

CACTACEÆ.

Opuntia humifusa Raf.

LYTHRACEÆ.

Parsonsia petiolata (L.) Rusby.

ONAGRACEÆ.

Onagra biennis (L.) Scop.
Œnothera laciniata Hill.
Œnothera rhombipetala Nutt.
Gaura biennis L.

UMBELLIFERÆ.

Sanicula canadensis L.
Thaspium trifoliatum aureum (Nutt.) Britton.
Polytænia Nuttallii DC.

APOCYNACEÆ.

Apocynum cannabinum L.

ASCLEPIADACEÆ.

Asclepias tuberosa L.
Asclepias Sullivantii Engelm.
Asclepias amplexicaulis J. E. Smith.
Asclepias syriaca L.
Asclepias verticillata L.
Acerates viridiflora (Raf.) Eaton.

CONVOLVULACEÆ.

Ipomæa pandurata (L.) Meyer.

POLEMONIACEÆ.

Phlox bifida Beck.

BORAGINACEÆ.

Lappula virginiana (L.) Greene.
Lithospermum Gmelini (Michx.) A. S. Hitchcock.
Lithospermum linearifolium Goldie.
Onosmodium carolinianum (Lam.) DC.

VERBENACEÆ.

Verbena stricta Vent.
Verbena bracteosa Michx.

LABIATÆ.

Teucrium canadense L.
Prunella vulgaris L.
Physostegia virginiana (L.) Benth.
Monarda punctata L.
Blephilia ciliata (L.) Raf.
Hedeoma pulegioides (L.) Pers.
Koellia flexuosa (Walt.) MacM.
Koellia pilosa (Nutt.) Britton.

SOLANACEÆ.

Physalis virginiana Mill.

Physalis heterophylla Nees.
Solanum nigrum L.
Solanum carolinense L.

SCROPHULARIACEÆ.

Verbascum Thapsus L.
Scrophularia marylandica L.
Pentstemon hirsutus (L.) Willd.
Pedicularis canadensis L.

ACANTHACEÆ.

Ruellia ciliosa Pursh.

PHRYMACEÆ.

Phryma leptostachya L.

RUBIACEÆ.

Diodia teres Walt.
Galium pilosum Ait.
Galium circæzans Michx.

CUCURBITACEÆ.

Sicyos angulatus L.

CAMPANULACEÆ.

Campanula americana L.
Specularia perfoliata (L.) A. DC.
Lobelia spicata Lam.
Lobelia leptostachys A. DC.
Lobelia inflata L.

CICHORIACEÆ.

Lactuca canadensis L.
Hieracium longipilum Torr.
Nabalus asper (Michx.) T. & G.

AMBROSIACEÆ.

Ambrosia artemisiæfolia L.
Ambrosia psilostachya DC.

COMPOSITÆ.

Eupatorium purpureum L.
Eupatorium serotinum Michx.
Kuhnia eupatorioides L.

Kuhnia glutinosa Ell.
Lacinaria scariosa (L.) Hill.
Chrysopsis camporum Greene.
Solidago ulmifolia Muhl.
Solidago missouriensis Nutt.
Solidago nemoralis Ait.
Solidago rigida L.
Euthamia caroliniana (L.) Greene.
Aster ericoides L.
Leptilon canadense (L.) Britton.
Ionactis linariifolius (L.) Greene.
Antennaria sp.
Anaphalis margaritacea (L.) Benth. & Hook.
Gnaphalium obtusifolium L.
Heliopsis scabra Dunal.
Rudbeckia triloba L.
Rudbeckia hirta L.
Ratibida pinnata (Vent.) Barnh.
Helianthus scaberrimus Ell.
Helianthus occidentalis Riddell.
Helianthus illinoensis Gleason*.

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*Helianthus illinoensis.—Erect, six to ten dm. high, from a long running root-stock. Stem simple, slightly angled, densely villous below, pubescent above. Leaves six to eight pairs, strictly opposite, slightly scabrous above, softly pubescent beneath and villous on the veins, obtuse; the lowest four or five pairs oblong-lanceolate to ovate-lanceolate, three-nerved, entire, ten to fifteen cm. long, tapering at the base into a villous winged petiole equaling or but little shorter than the leaves; the upper two or three pairs much smaller or bractlike, petiole, short or none. Lower internodes five to eight cm. in length, or the two lowest pairs of leaves approximate, upper internodes much longer. Inflorescence of one to seven heads; peduncles three to ten cm. long; involucre broadly campanulate or hemispherical, eight mm. high; scales lanceolate, acuminate, ciliate. Disk flowers yellow, rays about thirteen, two to three cm. long, bright yellow, achenes minutely pubescent. Flowers in August.

On the sand dunes along the Illinois river near Havana, where it is common in the black-jack oak woods, especially along the edges and in the more open and sunny places. Material was collected in 1903 and 1904, and the type, collected on August 17, 1904, is in the herbarium of the Missouri Botanical Garden.

Helianthus illinoensis is evidently closely related to *Helianthus occidentalis* Riddell, which it resembles in the reduction in size of the upper leaves. It is at once distinguished from the latter species by the villous pubescence and the greater length of the lower internodes. The two are sometimes associated in the field, but in general appearance they are entirely distinct. *Helianthus occidentalis* has broad, scabrous,

Helianthus strumosus L.
Coreopsis palmata Nutt.
Achillea Millefolium L.
Artemisia caudata Michx.
Mesadenia atriplicifolia (L.) Raf.

Phytogeographical Relationships of the Flora.

A casual inspection of the preceding list of species, 188 in number, will show the presence in the sand vegetation of numerous plants of western distribution. Some of these occur in Illinois only in the sand regions, so far as known, and others are of limited range in various parts of the state. In order to study more carefully this western relationship the flora has been divided into two groups, including, first, those species living in the prairie formation, and, second, those found only in the black-jack forest. It is believed that this separation will distinguish the older and more primitive flora, inhabiting the older plant-formation, from the younger and more recent flora, occupying the younger formation, and doubtless derived to a large extent from the vegetation of the surrounding woodlands and prairies. It has been mentioned that nearly all the species of the sand prairie grow also in the black-jack, and that their presence there is probably due frequently to persistence through the changed ecological conditions. It is also evident that many of the more recent species have penetrated into the bunch-grass prairies and are now mingled with the endemic element there. A third and minor group of five species has not been included in this division, since its members occur only on the front of dunes which have invaded natural groves on the Miami loam, and are undoubtedly derived directly from the vegetation of that soil. These are *Clematis Simsii*, *Euphorbia heterophylla*, *Sicyos angulatus*, *Solanum nigrum*, and *Urticastrum divaricatum*.

The vegetation of Illinois, with the possible exception of the extreme southern part, has been developed since the close of the glacial period. Postglacial migration into the state has

light green, short-petioled leaves which are nearly erect in a basal cluster, while in *Helianthus illinoensis* they are darker green, more or less spreading and scattered on the stem.—Ohio Naturalist, Vol. V. (1904), p. 214.

proceeded from three principal centers or zones: the Austroriparian zone or Coastal plain, a U-shaped area lying along the Atlantic and Gulf coasts and the lower Mississippi valley; a southeastern center lying within the U, and a southwestern one lying to the west of it. The last two centers have furnished most of the plants of the sand region and, indeed, of Illinois as a whole, and the floral elements from them will be spoken of as the Atlantic and the Sonoran elements respectively. A northern extension of the Sonoran element has occupied the inland territory designated by Engler as the Prairie province, and an eastern arm of this province reaches across northern Illinois into Indiana. This is shown by Pound and Clements on their map of the Prairie province ('98, '00). This arm is almost surrounded on the north, east, and south by the Atlantic province, and it is also intersected along the streams by broad or narrow strips of woodland, representing the same province. When we consider also the fact that in Illinois the forests are climatic and the prairies edaphic, it is not surprising that the Sonoran floral element in the Illinois prairies is obscured by the presence of a large number of species of the Atlantic element derived from the adjacent forests.

Of the 117 species growing on the prairie formation of the sand region 34, or 29 percent, are of typically western range, that is, from Illinois west across Nebraska and thence south into Texas, a distribution in many cases practically coincident with the Prairie province and clearly indicative of their Sonoran origin. These are as follows:

**Equisetum robustum*
Stipa spartea
**Calamovilfa longifolia*
**Bouteloua hirsuta*
**Eragrostis trichodes*
**Cyperus Schweinitzii*
**Cyperus Bushii*
Carex gravida
**Cycloloma atriplicifolium*
**Froelichia campestris*
Petalostemon purpureus
**Euphorbia Geyeri*
**Callirrhoe triangulata*
**Opuntia humifusa*
**Œnothera rhombipetala*
Asclepias Sullivantii
Lithospermum Gmelini
Lithospermum linearifolium
Verbena stricta
Verbena bracteosa

**Allionia nyctaginea*	**Ambrosia psilostachya*
Anemone cylindrica	*Hieracium longipilum*
**Lesquerella spathulata*	**Kuhnia glutinosa*
**Cristatella Jamesii*	**Chrysopsis camporum*
**Polanisia graveolens*	*Solidago missouriensis*
Baptisia bracteata	*Helianthus scaberrimus*
Amorpha canescens	*Coreopsis palmata*

This group in the prairie formation is obscured by the presence of 65 species, or 56 percent, of eastern distribution, to be regarded as derivatives of the Atlantic floral element; and the remaining 18 species, or 15 percent, include 9 of transcontinental distribution, 4 introduced species, 2 (**Aristida tuberculosa* and **Sporobolus cryptandrus*) with a range along the coast of the Atlantic and Great Lakes and locally in the interior, and 3 whose range is local or unknown, namely, **Panicum* sp., *Phlox bifida*, and *Antennaria* sp.

The importance of the Sonoran element can be shown to better advantage by excluding all those species which occur commonly in other associations in the state, limiting the list to the plants most characteristic of the sand region. Of the 28 species thus selected, 1 is local, 2 range along the coast and the Great Lakes, 6 are eastern or southeastern, and 19, or 68 percent, are western or southwestern. In the preceding list and in the paragraph following it, 22 of these species are marked with an asterisk. The 6 eastern species included are

Panicum cognatum	*Polygonum tenue*
Cyperus filiculmis	*Monarda punctata*
Salix tristis	*Ionactis linariifolius*

The 66 species of the sand region which are found only in the black-jack association include 1 of local distribution, *Helianthus illinoensis*; 1 introduced species, *Chætochloa viridis*; 9 of western distribution; and 55 of eastern and southeastern range, indicating plainly the eastern relationships of the flora, and the floral similarity of the black-jack to the other forests of central Illinois. Of these 55, all but one, *Polygonum cristatum*, occur also in other plant associations within the state, while of

the 9 western species, three, starred in the following list, are practically confined to the sand region.

Atherpogon curtipendulus	*Polytænia Nuttallii*
**Talinum rugospermum*	*Nabalus asper*
**Erysimum arkansanum*	*Ratibida pinnata*
Ribes missouriense	**Artemisia caudata*
Petalostemon candidus	

A comparison of the vegetation of the Illinois River valley sand region with that of the dunes along Lake Michigan is of interest on account of the short distance between the two regions. Excepting the temperature, the difference in the ecological conditions is scarcely sufficient to cause a wide variation in the floras. The dunes of Lake Michigan, however, are essentially a beach formation, and the vegetation as described by Cowles ('99) shows but slight relationships with the western prairies. On the beach proper only eight species occur which are common to the two dune areas, and three of these, *Artemisia caudata*, *Calamovilfa longifolia*, and *Lithospermum Gmelini*, are western in their range. The flora of the shifting dunes shows scarcely more similarity. In the established dunes the resemblances are stronger. Six species of the basswood dunes and nearly all those of the oak dunes are found also in the inland region, and Cowles's list includes *Quercus velutina*, *Rhus aromatica*, *Cracca virginiana*, *Cyperus Schweinitzii*, *Opuntia humifusa*, *Œnothera rhombipetala*, *Monarda punctata*, and other species abundant on the sand along the Illinois River. In both localities these plants belong principally to the derived element; and as the adjacent forests are of the same type in both regions it is to be expected that the same species would be able to adapt themselves to the sand. It is in the endemic element that the greatest contrast lies. The dunes of Lake Michigan have no *Cristatella*, *Eragrostis trichodes*, *Bouteloua*, *Ambrosia psilostachya*, *Froelichia*, *Euphorbia Geyeri*, *Callirrhoe*, or *Chrysopsis*, all characteristic of the inland region; while the latter lacks *Cakile americana*, *Corispermum hyssopifolium*, *Euphorbia polygonifolia*, *Lathyrus maritimus*, *Ammophila arenaria*, and

Prunus pumila, representing the endemic element along the lake.

A comparison with the flora of the sand-hills of Nebraska, on the other hand, shows some striking similarities. Rydberg ('95) lists 35 species as characteristic of the sand-hill region, and of these, 15, or nearly one half, grow also in the central-Illinois sand region, and this includes a number of the most abundant species. Of the 188 species enumerated in this paper, 75, or 40 percent, are included also in Rydberg's list.

It is evident from the preceding paragraphs that as a whole the flora is essentially western in its relationships. Its position within the Prairie province, as defined by Pound and Clements, can not be questioned, and the region may well be regarded as an isolated portion of the sand-hill division of the Prairie province, formed under peculiar conditions, but closely resembling the main body in its ecology and vegetation. The species found only in the black-jack oak forest are almost entirely eastern in their distribution, and have usually a wide range through the state in different plant associations.

Of especial interest from a phytogeographical standpoint are *Cristatella Jamesii* and *Lesquerella spathulata*. This is the first report of their occurrence in Illinois, and, so far as known, at any station east of central Nebraska. The former ranges through the sand-hill region from Nebraska south into Texas, and according to Britton's Manual into Louisiana. In Nebraska it lives in almost precisely the same conditions as in this state; that is, in the bottoms of blowouts, where there is a comparatively rapid shifting of the sand In 1903 it was found in but a single blowout near Havana, and the total number of individuals was probably less than five hundred. In 1904 it had spread to two other blowouts in the same field, and it was also found in great profusion in a large blowout about ten miles northeast of Havana. *Lesquerella spathulata*, described in 1896 from the Black Hills, ranges, according to Britton, from Nebraska to Montana and the Northwest Territory. Rydberg's original plants ('96) grew on dry hilltops, a habitat paralleled by its growth in Illinois in the bunch-grass

association on some of the highest dunes of the region. It is not mentioned by Pound and Clements in the "Phytogeography of Nebraska." It was collected in Illinois in but one station, northeast of Havana, near the second station for *Cristatella*.

Part III. Zoological Studies in the Sand Regions of the Illinois and Mississippi River Valleys. By Charles A. Hart.

General Features.

As a preliminary to the zoological discussion, the general topography of the principal sand areas, given in Part I. of these studies, may be briefly summarized. These areas occur on the glacial flood-plain of the broad central basin of the lower Illinois valley between Peoria and Meredosia, and of the upper Mississippi from near Burlington, Iowa, to Savanna, Ill., aggregating approximately 280 square miles in the Illinois valley alone; and considerable tracts of loose wind-blown surface sand, or "blow-sand" (Pl. X.–XV., XIX.), occur in both these areas, which in the Illinois basin are scattered in broad undulating tracts of dune formations, or in ridges running lengthwise of the valley, and reaching a maximum height of about one hundred feet.

In Part II. Mr. Gleason has quite fully discussed the present condition of the surface of these areas in the Illinois valley and the effects of wind action in their intimate relation to the plant covering, and a knowledge of these conditions is necessary to an understanding of the sand fauna, which, of course, consists largely of insects and their near relatives.

The areas of nearly pure sand are the only ones having a distinctly different flora and fauna from that of the ordinary Illinois prairie. They are most extensively developed upon the western half of the glacial flood-plain—the half next the present river bottom. Here there is little or no surface drainage, the rainfall being quickly absorbed. After a rain the sand soon dries perfectly at the surface, both in winter and summer, thus approximating the conditions of an arid region notwithstanding the greater precipitation. The striking affinities of its fauna and flora with those of the arid West are evidence of this. Nevertheless, as is more or less the case even in arid lands, the

deeper sands are always moist,—in the Illinois valley only a few inches below the dry surface layer.

Much of the blow-sand is a remnant of the greater areas which existed before vegetation invaded these sands. There is little doubt, however, that attempts on the part of man to cultivate or pasture the vegetation-covered sand land have in many cases resulted disastrously and renewed the drifting action, the destruction of the plant-cover giving the wind a chance to cut in and set the sand in motion again, starting, as it were, an open sore on the face of nature. For this reason large tracts of such land have never been disturbed, and still retain their original flora and fauna; and other fields, after attempts at cultivation, have been allowed to go to waste. The processes for the redemption of sandy land now being devised by the United States government should be utilized here, at least to keep this sand where it is and prevent its invasion of cultivable ground. These wind excavations are called blowouts (Pl. VIII., IX.), and if large enough they soon become the windward side of an advancing dune (Pl. XI.). Usually they are rounded pits, sometimes large enough to contain a house, the shifting slopes barren of vegetation, and the marginal vegetation being undermined and swept away. When their depth becomes excessive, moisture at the bottom checks the wind action at this point, and a flora and fauna approximating the ordinary prairie type takes possession of this part of the blowout. The sand from blowouts may pile up in a barren dune or ridge, over the crest of which it drifts in a fine mist with every wind, thus steadily advancing and burying the smaller trees and bushes in its path (Pl. X.; XII., Fig. 2); or it may scatter out over comparatively level areas (Pl. XIII.). Clumps of trees or small groves, by checking the wind and thus favoring the deposition of sand, occasion the formation of an active dune surrounding them on their windward side, which at least partially submerges them in the course of time (Pl. XX., Fig. 2).

At the earliest opportunity, however, a growth of vegetation, scanty at first, tries to take possession of all blow-sand areas, thus tending to stay the drifting and to fix the surface

as it is. (Pl. XIII.; XIV., Fig. 1; XV.) Frequently a later stage of this evolution is the growth of large tracts of a scrubby black-jack forest (Pl. VIII.; XXI., Fig. 1.), and this, in turn, by the gradual formation of leaf-mold, approaches the character of the ordinary Illinois forest. Forests of the latter class (Pl. XXI., Fig. 2) are especially noticeable on the fixed dune ridges which lie along the edge of the sand plain, next the river or its bottom-lands, such as the ridge extending through the city of Havana. The areas of blow-sand and black-jack are about equal, that of the final stage comparatively small.

A very different and characteristic sand fauna and flora may be found upon the constantly moist strip of sand which usually occurs along the present stream valleys at the margin of the sand plain, twenty to forty feet below its surface level, not only upon the present shores (Pl. XXIII.), but also along the line where the absorbed rainfall of the sand plain drains out upon the river bottoms at the foot of the present low marginal bluff.

The Localities Visited.

The most remarkable sand area known to me in Illinois is in the out-of-the-way interior of the low sand plateau indicated by Leverett ('99, Pl. VI.) as an island in the channel of the Chicago outlet north of Havana (see map; also p. 143 of this article). The eastern margin of this ancient island is skirted by the Chicago, Peoria and St. Louis Railway, but from the train only a suggestion of its character appears. It is approximately five or six miles wide and twenty miles long, having an area of about one hundred square miles. The middle third is especially sandy and almost entirely waste land. About half of this is covered with black-jack, and the other half, especially the south-central part, contains blow-sand to an extent not surpassed anywhere else in the state, this region being locally known as the Devil's Neck (Pl. XII., Fig. 1; XIV., Fig. 1; XX., Fig. 1). One tract of about eighty acres is almost entirely blow-sand in successive ridges, suggesting great ocean waves in a storm. Blowouts of unusual extent surround it on all sides, and

vegetation is scanty or altogether absent. The fauna and flora here are so distinctly western that this tract might almost be considered as a detached islet of the Upper Sonoran life zone.

The other localities most frequently visited, were (1) the Devil's Hole (Pl. XIII.; XIX., Fig. 1; XX., Fig. 2), a similar but much smaller tract of blow-sand a mile or so east of Havana; (2) the exceptionally broad area of very sandy land south of Havana (Pl. VIII.–XI., XV.–XVII.), with numerous small tracts of blow-sand and large bodies of black-jack timber; (3) the less sandy and better-forested submarginal ridges, often fifty feet or more in height, which extend through Havana, especially those a mile or two north of the city, in the vicinity of Quiver Lake (Pl. XXI., Fig. 2); and (4) the moist sand strip at the base of the low marginal bluff of the sand plain (Pl. XXIII.), saturated more or less extensively with outflowing ground-water, in part forming the east shore of the river and of bottom-land lakes bordering on the sand plain.

Two additional localities, both at a considerable distance from Havana, were visited in 1905. One of these was Meredosia, near the southern end of the central basin, about forty-five miles below Havana. A small tract of blow-sand, with a few blowouts and some black-jack, lies immediately south of the town, and the distinctive sand fauna observed about Havana seemed well represented here also. Aside from this, there seemed to be very little blow-sand in the vicinity. The other locality was the Moline Sand Hill, described by McNeill ('91, p. 73). This extends along the Rock River, near its mouth, only a few miles from the city of Moline, on the Mississippi, just across the narrow intervening divide. It is a conspicuous elongate sand-hill, about a quarter of a mile long, near the south bank of the river. At the east end of the crest is an acre or two of undisturbed waste land, with a group of several good-sized blowouts, bordered by a small fringe of willow and Carolina poplar on the east slope of the hill. The sand is here apparently finer than at Havana. The fauna differs slightly from that of the Illinois valley regions, but not to any marked degree. While there are other and larger blow-sand areas in this

part of the Mississippi valley, none of them are in this immediate vicinity, and it seems remarkable that the distinctive sand fauna should be so well represented in so restricted an area.

Geographical Distribution of the Species.

Professor A. P. Morse has truthfully said of the *Acridiidæ* ('99, p. 332): "Locust distribution is primarily and very distinctly climatal in character. * * * In its details it is influenced to a very high degree by physiography and its attendant conditions, such as character of the soil, humidity, etc. In its broader features it is eminently characteristic of life zones and regions. * * * It is in many cases dependent on and confirmatory of geological changes. For these reasons and those noted at the beginning, viz., wide distribution, terrestrial and conspicuous habits, numerical abundance, size, etc., the family and its distribution are of high importance in a study of life zones in their relation to agriculture, and of faunal regions in their relation to general science."

The *Acridiidæ* of the sand region received my especial attention, and, fortunately, the work of Blatchley ('03), Bruner ('97), and Gillette ('04) has furnished very satisfactory lists for a comparison of species with those of neighboring states in the same faunal zone.

There are now known from the United States and Canada, in round numbers, about 650 *Acridiidæ*. Blatchley has listed 64 in Indiana. McNeill's Illinois list ('91) was somewhat incomplete, and contained only 55 species. Our present Illinois list numbers about 78 species, to which may properly be added for this discussion four species found by Blatchley near the Illinois line, but which we have not yet searched for in the same kind of situations near by on our side of the line. This makes a practical total of 82 species for Illinois. Conversely, we have found in eastern Illinois, although not near the boundary line, two species which probably occur in Indiana, though not listed by Blatchley. Bruner has recorded 150 species in Nebraska, and Gillette 133 for Colorado. Groups of species variously recognized by different authors have been equalized in these counts.

We have, then, as the nearest approximation to the truth attainable at the present time:

Indiana, 66 species,	Nebraska, 150 species,
Illinois, 82 species,	Colorado, 133 species.

The excess in Illinois as compared with Indiana is very largely due to its western sand districts; while the great variety in Nebraska may properly be ascribed to its wide range of soil and climate, from the humid Missouri valley to the arid sand hills of its western part. The suitability of an arid environment for acridiid development is also evident in these figures. A comparison of the species of the three states first mentioned shows that with the exclusion of the *Tettiginæ*, which cannot be accurately compared at present, Nebraska contains nearly all the species of Indiana and Illinois, and Illinois probably nearly all of those of Indiana. Ten species of Illinois or Indiana do not occur in Nebraska lists. These include two quite rare Illinois species, *Mecostethus platypterus* and *Melanoplus walshi*; five northern species, *Trimerotropis maritima*, *Paroxya scudderi*, and *P. hoosieri*, *Melanoplus extremus*, and *M. islandicus*, the last three of which have not yet been taken in Illinois; and three southern species, *Trimerotropis saxatilis*, *Eritettix virgatus*, and *Melanoplus impudicus*, the first two not yet taken in Indiana.

The *Acridiidæ* of Champaign county in the vicinity of the University of Illinois have received a great deal of attention, and 32 species have been taken. This is a typical series of the ordinary prairie and forest, not only of east-central Illinois, but also of Indiana, of western Illinois, and of at least the adjacent parts of Missouri and Iowa. These species should certainly be found in the Illinois River valley, as there is no lack of suitable situations for all; they have merely not yet been searched for, except in the sand region. There, 19 of them are known to occur, and the same region, moreover, has 26 species not yet found in Champaign county and not likely to be found there, making an actual total of 45 (about one half more than in Champaign county), and a probable total for the central lower valley of 58—nearly twice that of Champaign county.

Selecting the more distinctive sand *Orthoptera* of the Illinois valley district, only three of which (*Syrbula admirabilis*, *Spharagemon bolli* and *Melanoplus atlanis*) have been found in Champaign county in dry situations, and comparing them with those of other sand regions, the results are especially significant. The principal sand areas examined by Blatchley were two: the area of northeastern Indiana near the lower end of Lake Michigan, and that of the Wisconsin morainic outwash in Vigo county, southern Indiana, near Terre Haute. Opportunity is thus afforded for a triangular comparison, the Illinois locality being about midway between the two in latitude. There are 36 species in the comparison, 32 of which are in the Illinois district, 17 in the lake region, and 12 in Vigo county. Only four of the list are common to all three localities, but that is apparently because the Vigo county area is not so sandy as the others, these four being species of dry, but not necessarily sandy, ground. They are

Spharagemon bolli — *Melanoplus atlanis*
Schistocerca alutacea — *Melanoplus luridus*

Five more Vigo county species occur also on the Illinois valley sand, but are not recorded from the Indiana lake region. These are

Tettix arenosus — *Melanoplus impudicus*
Syrbula admirabilis — *Melanoplus minor*
Ageneotettix scudderi

The presence of *A. scudderi* and *M. minor* in this series is a little strange; the others increase in numbers southward and hence were not found in the more northern situation.

One species (*Nomotettix compressus*) common to the two Indiana localities, although it occurs also in Illinois, has not yet been taken in the Illinois valley sand region.

Of the species common to the Illinois valley and the Indiana lake region there are 11 not found in Vigo county, most of them decided sand lovers. The four marked with a star are at or near the eastern limit of their range; the others reach the Atlantic coast states. The list is as follows:

Orphulella pelidna	*Psinidia fenestralis*
Orphulella speciosa	*Hesperotettix pratensis*
**Hippiscus tuberculatus*	*Melanoplus fasciatus*
**Hippiscus haldemanii*	**Melanoplus angustipennis*
Spharagemon wyomingianum	**Phœtaliotes nebrascensis*
	Conocephalus robustus

Of the species known from only one of the three localities, there are in Vigo county two, *Ceuthophilus latens* and *uhleri*, inhabiting dry sandy ground; in the lake region there is just one species, *Gryllus arenosus*, which seems peculiar to that region; and in the Illinois locality twelve have been found, the range of several of these species being extended to a very unexpected degree by their discovery here. Their previously known range is given in the appended list, which shows clearly the alliance of this sand fauna with that of the Great Plains.

Mermiria neomexicana. Wyoming to N. M., Neb. to Tex. "Rocky Mts. to Miss. R."

Mermiria bivittata. Fla., N. J., Kan., Utah, N. M., Tex., and intervening states. Lower Austral (Morse), Ill.? (McNeill).

Eritettix virgatus. Tex., Ark.

Amphitornus bicolor. "Mont. to Kan." A characteristic species of the Great Plains (Bruner).

Hippiscus phœnicopterus. "Southern U.S. east of Great Plains." Moline, Ill.

Trachyrhachis thomasi. "Upper Miss. Valley and Colorado." S. Ill. (Thom.). Ky., Ind. Classed by Blatchley as Austro-riparian. Its records are confused with those of other species, but it probably occurs also from Minn. to Neb.

Campylacantha olivacea. Neb. to Tex. S. W. Ark.

Campylacantha acutipennis. Tex., Kan.

Hesperotettix speciosus. "Rocky Mts. to Miss. R." Neb. to Tex. N. M.

Melanoplus flavidus. Ariz., N. M., Tex., Kan., Col., S. W. Neb., Mont. N. W. Ill. (McNeill).

Udeopsylla robusta. "W. of Miss. R." Iowa (Osborn).

Gryllus personatus. Ariz., N. M., Tex., Col., Kan., Neb.

It now remains to compare the Illinois sand regions with the sand-hills of western Nebraska. Unfortunately, I have not a definite list for the latter locality. The general Nebraska list shows that all the *Acridiidæ* of the Illinois valley sand district are found in that state with the exception of the southern *Melanoplus impudicus* and *Eritettix virgatus*, and about half of them in the western part, but that a number of additional sand species appear in that part of the state. As to the intervening states, Missouri and Iowa, we have only an old list of about 41 *Acridiidæ* for Iowa (Osborn '92), in which 19 of the 30 Illinois-Nebraska sand species are lacking. Further knowledge of the *Orthoptera* of these states is very desirable. The occurrence of *Melanoplus impudicus* and *Eritettix virgatus* in our district gives force to Morse's suggestion ('99, p. 316) that a southern species of sandy or light-soil situations may have a more elastic northern limit than one of damp and heavy soil.

So far, therefore, as the *Orthoptera* are concerned, the evidence indicates that the fauna of the Illinois valley sand region has much stronger western affinities than that of the south end of Lake Michigan; that it is quite closely allied with that of the eastern part of Nebraska, which is within the Carolinian life zone, but can hardly be called Sonoran; and that it is of western derivation, and migrated eastward, probably by way of the glacial outwash in Iowa, at an early period.

Our entire list of western Illinois sand insects numbers 596 species. From these has been selected the following list of 85 species which seem to be not generally distributed east of the Rocky Mountains. These, of course, are the significant ones in a study of distribution. They fall into six classes with regard to the extent and direction of their range outside of western Illinois, the scattering, the local, the northern, the southern, the eastern, and the western species, and are correspondingly listed in this connection as being of especial interest, a summary statement of their previously known distribution being appended to each species. The last two groups are divided into near and distant species, the distinction being based on their presence or absence, so far as known, in states adjoining Illinois.

Each locality record from the collections of the Illinois State Laboratory of Natural History is separately indicated by the letter I, and from the Bolter Collection of Insects by B.

SCATTERING SPECIES (4).

Zuphium longicolle. Cal., Tex., Ohio (B).

Adalia bipunctata. Can. and N. S., south to N. J., west to Neb.; Col. to Ariz. Until the last few years practically unknown in Illinois; now frequent.

Lucanus placidus. Pa., Ill., Ark. (I), Minn. (B).

Lema cornuta. S. C., Kan., N. W. Ind.

LOCAL SPECIES (8).

Bacunculus blatchleyi. Ind., Wis. (B). [Throughout Ill.]

Melanoplus macneilli, n. sp. [Rock Island Co.]

Nabis elongatus, n. sp. [Mason Co.]

Harpalini, sp. [Rock Island Co.]

Harpalus testaceus. Ia., Ill.

Meroptera cviatella. Cook Co.

Sphœrophthalma chlamydata. Mason Co.

Ammophila argentata, n. sp. [Mason Co.]

NORTHERN SPECIES (2).

Melanoplus fasciatus. Can., north half U. S., south limit N. J., Pa., Ind., Mo. to Col.

Melanoplus minor. Can., north half of U. S., Okl. and Ariz.

SOUTHERN SPECIES (11).

Ischnoptera inœqualis. Ga., Ind. and Tex., to C. Am.

Mermiria bivittata. Fla. to N. J., thence to Utah and N. M., Kan. to Tex., Ill.?

Hippiscus phœnicopterus. S. U. S. east of Great Plains, S. Ill., S. Ind. to N. J.

Melanoplus impudicus. N. J., S. C., and Ga., to S. Ind. and Ark.

Cicada marginata. N. J. to Utah, S. Ill., and southward.

Tettigia hieroglyphica. N. J. to Mex. Tex. (B).

Carabus sylvosus. Mass. (I)., N. Y. to Tex., Kan. (I)., Ill.

Saprinus ferrugineus. Tex., Fla. (B).

Chalcodermus collaris. N. J., D. C., Va. (B), Ky. (B), Fla. (B), Tex.

Xanthoptera semiflava. S. States, N. J. to Tex.

Bembidula capnoptera. Ga., Ky., Tex.

EASTERN SPECIES (13).

Near (9).

Sphæridium scarabæoides. Atl. Coast to Chicago. [Rock Island Co.] Introduced.

Clerus thoracicus. Pa. (I), D. C., N. J., N. Y. (B), Ill.

Opatrinus notus. Pa., D. C., N. J., Ill., Ind.

Chalepus smithi (*Odontota horni*). Mass., N. J., D. C., N.E. Ill., N.W. Ind.

Scotobates calcaratus. Vt., N. J., D. C., Mich. (B), La. (B), Ill.

Xylopinus saperdioides. Miss. R. east to Fla. (B) and Vt. (I); Wis. (B).

Proctacanthus brevipennis. N. J. to Fla., Ky.

Sphærophthalma harmonia. Mass. to Fla., Ind.

Epeolus pusillus. N. H., Mass., N. J., Ill.

Distant (4).

Mecostethus platypterus. N. Eng.

Pentatoma juniperina. E. States north of N. J., thence into Can.; Col.; Duluth, Minn. (I).

Haltica fuscoænea. Mass., Ga.

Psilocephala pictipennis. N. J., Ga., Fla.

WESTERN SPECIES (47).

Near (16).

Mermiria neomexicana. "Rocky Mts. to Miss. R.", Neb. to Tex., Wyo. to N. M.

Hippiscus haldemanii. N. W. Ind. to the Rocky Mts., N. M.

Hesperotettix pratensis. Fla., N. W. Ind., S. Ill., Ark. to Ia. and west to Cal.

Hesperotettix speciosus. Miss. R. to Rocky Mts., Neb. to Tex., N. M., S. Ill. prairie (I).

Melanoplus flavidus. N. W. Ill.; S. W. Neb., Kan., Tex. and Ariz. to Mont.

Melanoplus angustipennis. S. E. Ind., Ia. to Kan. and Mont., Tex.

Phœtaliotes nebrascensis. N. W. Ind., N. W. Ill., Ia., Tex. to Alberta.

Udeopsylla robusta. "W. of Miss. R.", Ia., N. M.

Cicada dorsata. Ill. to Tex., Ia., Kan., Col.

Nothopus zabroides. "Western States", C. Ill., Ia., L. Sup. (B), Neb. (B), Col. to Ariz. and N. M.

Lacon rectangularis. Ind. and Ill. to Col.; Kan., Tex. (B), S. States.

Chrysomela auripennis. N. W. Ind., Fla. (B), Neb. to Tex., Col.

Heliocheilus paradoxus. "Mid. Miss. Valley, south and west." Col., Tex.

Olethreutes dimidiana. Mo. (Identification doubtful.)

Anthrax halcyon. Ind. to N. D., and Ariz.

Tetralonia dilecta. Ill. (Robertson), Kan., Col., Tex., N. M.

Distant (31).

Eritettix virgatus. Ark., Tex.

Amphitornus bicolor. Mont. to Kan.

Campylacantha olivacea. S. W. Ark., Neb. to Tex., S. Ill. prairie (I).

Gryllus personatus. Neb., Kan., Col., Tex. to Ariz.

Sinea confusa. Tex., Ariz., Cal.

Zelus socius. Dak., Kan., Tex., Ariz., Col., Id., Cal.

Zelus renardi. "W. St.", Cal.

(The next four species have each a single eastern record, probably in areas similar to the Illinois sand region.)

Stachyocnemis apicalis. Dak., Tex., Mex., Cal. Fla.

Catorhintha mendica. I. T. and Col. to C. Am., Dak., Cal. Fla.

Cydnus obliquus. Col., Utah, Tex. to Cal., Mex. N. Y.

Corimelæna ciliata. Kan., Col., Oreg., Cal. Fla.

Brachynemurus irregularis. Tex. Havana (Currie).

Myrmeleon immaculatus occidentalis. La., Col., Nev., Ariz., N. M. Havana (Currie).

Polyphylla hammondi. Tex. to Ariz.

Mecas pergrata. Dak to Tex., Col., Kan., and N. M. (B), S. Ill. prairie (I).

Metachroma angustulum. Mont.

Metachroma parallelum. Mont., Kan.

Epitragus acutus. Kan., Tex., Mex.

Phacepholis candida. Kan., Col., Tex. and N. M. (B).

Acontia lactipennis. Tex.

Crambus haytiellus. Tex., Hayti.

Asilus angustifrons. Wash.

Rhadiurgus leucopogon. Neb., S. D.

Zodion obliquefasciatum. S. D., Kan., Tex. to Ariz., Mex., Mont., Wash.

Chelonus angheri. Neb.

Sphœrophthalma 4-guttata. Kan., Tex.

Trielis octomaculata. Ark.

Odynerus geminatus. Tex.

Anthophilus pulchellus. Col.

Tachytes texanus. Tex.

It will be seen that the above general list fully bears out the inference drawn from the *Orthoptera* alone that the derivation of this sand fauna is predominantly western. Of 85 species, in all, which are not of general distribution, and which, therefore, according to Morse, are of especial value in studying faunal differentiation, 73 range in some definite direction from the sand region. Less than three percent of these (2 species) can be classed as northern, and neither of these is confined to sandy land. Over 14 percent (11 species) are southern, the increase over the northern species being related to the southward extension of the Great Plains fauna. The range of several on this list seems to be imperfectly defined. Eighteen percent (13 species) are eastern species, one of them (*Sphœridium scarabœoides*) lately introduced, and its western limit carried by this record still farther westward. Several of these are apparently rare species, really of larger range. *Pentatoma juniperina, Chale-*

pus smithi, *Opatrinus notus*, and *Sphæropthalma harmonia*, are probably true eastern species, the *Pentatoma* and *Opatrinus* giving way in the arid region to other dominant species, though the former has lately been found to occur in Colorado. Sixty-four percent (47 species) are western, most of them definitely so, and over 42 percent (31 species) have not even been recorded from any adjacent state.* Four of the *Heteroptera*, however, have each been listed once at the Atlantic coast, three of them in Florida; and there is no apparent reason, except that of greater distance, why the eastern sand areas should not acquire species of the arid West in the same way as is assumed for Illinois.

Several species of the Illinois valley sand region—*Campylacantha olivacea*, *Hesperotettix pratensis*, *H. speciosus*, and *Schistocerca alutacea*—are not rare on the dry soils of the Illinoian glaciation in southern Illinois, and last season (1905) the *Campylacantha* was actually abundant there, in both the western and the eastern portions, on the common *Ambrosia* of that district, *A. bidentata*. These species probably do not exist on the black soil of central Illinois.

The presence in the Illinois valley sand region, as reported by Mr. Gleason, of several characteristic plants of the Great Plains flora, would doubtless attract their own insect fauna, and thus may directly account for the presence of a number of insect species.

Sand as a Factor of Animal Environment.

It has already been stated herein that the presence of sand in the soil has little effect on the fauna—and this is true of the flora also—until the sand reaches a stage of purity which permits it to dry readily and to drift gradually with the wind, in which condition it is called blow-sand; and that except for brief periods at times of rain or melting snow, this is dry and loose at the surface, but always moist a short distance below.

In what way these blow-sand conditions have so marked

* A comparison of these data with those independently obtained from the flora by Mr. Gleason, on p. 191, second paragraph, will be of especial interest.

an influence on the character of the biota is not very evident. The fact that some organisms are attracted by the presence of others, only complicates the problem. After casting about for species that appeared to be directly influenced by these conditions with the least likelihood of complications of any kind, I selected the acridiid genus *Melanoplus*. Just why *M. flavidus* should occur only in the most barren blow-sand situations while *M. femur-rubrum* seems interdicted by even a suggestion of blow-sand, seems at first sight almost unaccountable. Factors which might possibly have an influence in this case are (1) food supply, (2) moisture, (3) temperature, (4) sparseness of vegetation, (5) the mechanical effect of sand, by its drifting, etc., (6) protection, (7) competition, and (8) the effect of sand on the immature stages.

Considering these factors successively, the matter of food supply might be expected to solve the problem, since McNeill ('91, p. 75, *M. cenchri*) found *flavidus* constantly associated with the sand-bur (*Cenchrus*) which grows on sandy ground; but the sand-bur is locally vastly more wide-spread than *flavidus*, and in our field-work *flavidus* was found in blowouts whether sand-burs were present there or not. Morse ('99, p. 315) says that the food question with grasshoppers is a matter of quantity rather than quality, indicating that they have but little preference as to food supply. As to the subject of moisture, there is doubtless at times much difference between sand and ordinary soil in this respect. Capillary action is stronger in ordinary soil, which therefore dries out more deeply, and at the surface more slowly, than sand; but ultimately one is as dry as the other. The factor of atmospheric humidity at close range with the soil may have some influence upon these geophilous species, as its variations over sand and earth would doubtless be expressed by quite unlike curves. With regard to the direct water supply of these insects it must be remembered that they drink dew only, which is at least not noticeably deficient over our sand regions as compared with prairie soils. The third consideration also, that of temperature, presents only vague possibilities which seem insufficient to limit the local

range of these species. In clear weather the temperature over the blow-sand is probably higher by day and lower at night than in the case of ordinary soil, but the difference in this respect can not be great between some grassy tops of sand-hills occupied by *flavidus* and a close-cropped prairie pasture where *femur-rubrum* abounds. With regard to the sparseness of the vegetation usual on sand-dune tops, this can hardly be an influential factor, as it is not a constant feature of the areas known to be occupied by *flavidus*; and the mechanical effect of drifting or loose sand upon such active insects with so well-developed an exoskeleton, is surely of little consequence to them. As to protective coloration, both of these species are protectively colored. McNeill ('91) notes the strongly imitative coloration of *flavidus* on sand; *femur-rubrum* is slightly darker above than *flavidus*, and therefore better suited to an ordinary soil surface; but, in any case, protective coloration is an effect rather than a cause. Insects which are adapted to obtain food in exposed situations usually approximate the appearance and color of something in their normal surroundings, but surely do not fit themselves in wherever their original coloration matches best. The next factor, competition for space, is suggested in explanation of the limitation to sand of insects such as *flavidus*, the idea being that they are species also fitted for existence in more favored situations, but simply unable to hold their own there in competition with other species such as *femur-rubrum*. The facts of general and local distribution, however, do not support any such idea. Lastly, the effect of sand on the immature stages comes up for consideration. This is an important factor, analogous to taking root and dissemination among plants, and may ultimately prove to have a considerable influence on local distribution; but we have no data as to these stages in *flavidus*. Grasshoppers ordinarily choose a rather hard soil in which to place their egg masses, and excavations in sand are not maintained with the same facility as in earth without special adaptations for the purpose.

In general, therefore, it may be said that while there are a number of minor differences in the biotic environment on

blow-sand and ordinary soil which further observation and experiment may show to have a controlling influence on the local distribution of species, these factors do not, so far as our present information goes, satisfactorily account for the observed peculiarities of specific distribution.

The Relation of Sand and Climate to Insect Coloration.

One of the most evident color adaptations among sand insects is that of direct imitation of the color effect of the sand. The exposed condition of insects upon any surface where the vegetation is more or less scanty makes it advantageous that all species existing there and lacking other means of protection should be as inconspicuous as possible; and species on our list belonging to various orders, have developed remarkably pale dorsal colors, apparently for this reason. In the case of the Carolina grasshopper (*Dissosteira carolina*), which inhabits not only the sand surfaces in this district but also the darker bare surfaces, individuals taken on the sand seemed to show a decided approximation towards its color when compared with those from darker ground in Champaign county. Vosseler, who has studied out and described in detail the fundamental pattern of the *Acrididæ* ('02, Bd. 17, p. 22), calls attention to the fact that the molting occurs in daylight, and that the nearly colorless fresh exterior is then exposed to the action of reflected rays from surrounding surfaces, which, he suggests, may in some way, by photographic action, produce an approximation to their general color. How this can occur is not clear, but Poulton's experiments on *Lepidoptera*, and various other observations, all point to some such effect. The observations concerning the Carolina grasshoppers above recorded (made before reading Vosseler's paper), and the great differences in the ground color of individuals of this species can be satisfactorily accounted for only in this way.

The more evident examples of sand imitation are the pale brown of *Harpalus testaceus*, *H. erraticus*, and *Geopinus incrassatus*, the broad white markings of *Cicindela lepida* and *Tetragonoderus fasciatus*, the ashy grays of *Stachyocnemis* and *Emble-*

this griseus, the brown color of *Gryllus personatus* and *Udeopsylla robusta*, and the remarkable approximation to sand-color effects in *Trimerotropis citrina*, *Spharagemon wyomingianum*, and other *Acridiidæ*.

The subject of the protective colorations of the phytophilous species is an extensive one, and not closely related to the subject under discussion. The phytophilous, yet undoubtedly xerophilous, green grasshoppers of the genera *Campylacantha* and *Hesperotettix* provoke additional questions as to the environmental factors which limit them to dry soils. *Corimelæna ciliata*, both phytocolous and arenicolous, unless protected by the usual "bug" odor or flavor, may escape its enemies by what Dr. Forbes has called a resemblance to nothing in particular; and apparently the same is true of the *Tenebrionidæ*. It is perhaps going a little too far, however, to tell here that I was once, for a moment, completely deceived on seeing *Rhyssematus lineaticollis* lying in the axil of a milkweed leaf alongside a railroad track, by its exact resemblance to a locomotive cinder.

A type of coloration quite opposed to mimicry is that of the non-sympathetic, or contrasting and conspicuous, colors. Examples of this type are seen in the bright colors—presumably serving as a warning—of certain exposed sand insects otherwise protected, such as the stinging *Mutillidæ* and *Bembecidæ*, the bug *Perillus circumcinctus*, and some of the tiger-beetles (*Cicindelidæ*). A curious fact was noted with regard to the large female mutillid, *Sphærophthalma occidentalis*. This is not rare in southern Illinois and is of the usual bright scarlet color. So also is an example from Meredosia; but the six individuals captured near Havana were all of a faded golden-ochreous tint when taken. The latter locality is about its northern limit, and we have never taken it elsewhere in central Illinois.

Other species are apparently colored in imitation of the preceding class. *Phidippus insolens*, a spider of the blow-sand, is colored and shaped in close imitation of a mutillid. *Laphystia 6-fasciata*, a fly of the blowout pits, resembles a sand wasp (*Microbembex monodonta*) of the same situations both in actions and appearance. *Volucella fasciata*, a very prettily striped syr-

phid fly common in these sand regions, resembles a wasp. A marked case of imitation was that of *Chelonus texanus*, flitting in sparse low vegetation in company with an undescribed *Schizocerus*, and with difficulty distinguishable from it while in action.

The non-sympathetic colors of the *Acrididæ*, such as those of the hind wings and hind tibiæ, are of unusual interest, especially as they seem to be subject to alteration—to a varying degree in different species but always in the same direction—as the effect of certain climatic influences, apparently that of the degree of humidity, or of humidity and temperature combined.

The bright colors of the hind wings, especially noticeable in the *Œdipodinæ*, are curiously at variance with the modest protective tints of the insect at rest. Vosseler suggests that these rainbow hues, which rival in brightness even those of the *Lepidoptera*, constitute a "contrast-mimicry." While the pursuer is dazzled by the flashing colors, the wings are suddenly closed, and the insect settles quietly to the ground, all track of it being lost in a monotony of color. The genus *Catocala*, among the *Lepidoptera*, is apparently an exactly parallel case. These depend for protection on the close resemblance of the fore wings to the bark of the trees on which they rest. It would seem, however, from the data which follow, that any explanation of the origin of the hind-wing colors of *Orthoptera* should apply to those of the hind tibiæ also.

Bruner ('93) has pointed out that red-winged species—and he might have also said individuals—of grasshoppers are most common in humid regions, and yellow-winged ones in more or less arid regions; that in mountainous regions "just between the dry and wet conditions" blue-winged forms occur; and that from the Atlantic coast to the eastern edge of the Great Plains red or orange is the characteristic color, while on the plains and in other arid districts west and southwest these give way almost entirely to yellow.

In Illinois the hind wings of *Hippiscus tuberculatus* and *H. phœnicopterus* are red, rarely yellow. Those of our common

and only prairie species, *H. rugosus*, and also those of *H. haldemanii*, show a wide variation from bright red to nearly white. The variation is usually discontinuous, there being three or four fairly distinct colors: red, pinkish, yellow, and yellowish white. Our collections of *rugosus* in the Illinois State Laboratory of Natural History, mostly from the humid prairie of central Illinois, were classed as red and yellow. There are 141 *rugosus* in all, 37 red-winged and 104 yellow, the latter number including 46 taken in 1905, of which 15 were clear yellow, and 31, taken mostly on the drier southern Illinois soils, were pale whitish yellow. *Haldemanii* from the sand region in 1905 were 22 red, 1 pinkish, and 9 yellow. *Hippiscus tuberculatus* and *Psinidia fenestralis*, normally red-winged in Illinois, are yellow-winged in the West. The only species variable in wing color and common in both the Illinois sand regions and on the humid prairie are *Hippiscus rugosus* and *Arphia xanthoptera*, but I have not at present a sufficient number of these from each locality for comparison.

The facts at hand warrant the conclusion that while the species of a given locality, and even the individuals of a species, may differ greatly among themselves in regard to wing coloration, the general tendency of arid climates to replace red with yellow and, under certain circumstances, yellow with blue, is too evident to be questioned.

A very similar effect upon tibial coloration is even more evident, and I have taken especial pains to collect evidence on this point. A notable series showing a direct influence of the blow-sand environment—virtually equivalent to climatic influence—upon species within a short distance of each other, is afforded in the genus *Melanoplus* by nearly every active sand-dune examined by us. In the first place, on the least sandy areas in the nearest level cultivated ground, the dominant *Melanoplus* is *femur-rubrum*, always with bright coral-red hind tibiæ. Secondly, on the drier and more sandy grassy ground of the base or lower slope of the dune we find it replaced by *M. atlanis* and *M. minor*. *Atlanis* is here unusually variable in tibial color. Most frequently it is red, as in *femur-rubrum*; sometimes paler,

even pinkish, with bluish at base; or else bluish green, apically yellowish or pinkish, the bluish green varying slightly towards blue or green; or even yellowish. The difference between red or salmon-pink, on the one hand, and the bluish to yellowish tints on the other, is generally well marked. Of 70 specimens of this species quite indiscriminately collected in the sand region, 46 had reddish tibiæ, and 24 were of the blue-green or yellow type—about one third of all, therefore, not being red. The 46 red ones were 23 males and 23 females; the 24 blue-green ones, 11 males and 13 females,—indicating that in this species at least the sexes are evenly divided in this particular. Twenty specimens of *minor* taken, had the tibiæ either greenish blue or coral-red, without intergrades, 12 of these bluish and 8 red. Only five of these were males, all with bluish tibiæ.

Thirdly, on the upper parts of the dunes, where loose sand and tufted growths begin (Pl. XVIII., Fig. 1), these species are replaced by swarms of *M. angustipennis*. This has clear blue tibiæ, rarely coral-red. A continuous search for examples with red tibiæ in this situation yielded only two specimens, both undoubted *angustipennis*, one of each sex. The number of this species taken was 125. Lastly, as one approaches and enters the wind-excavated hollows of the apex, *M. flavidus* becomes most abundant. This invariably has tibiæ of a brilliant and beautiful blue, approaching the shade of cobalt-blue.

In the dense black-jack oak brush which irregularly covers large areas of these sands (Pl. XXI., Fig. 1), four more species of *Melanoplus* are found: *luridus*, *impudicus*, *fasciatus*, and *scudderi*. In comparison with the four open-ground species previously discussed, these four sheltered species confirm the general deductions, as they all invariably had red hind tibiæ. This is true of these species elsewhere, excepting *fasciatus*, of which individuals with pale green tibiæ have been recorded.

In the above comparisons of species from open ground I refer to the colors of local examples from the sand regions only, and an examination of records of the same species for the humid prairie and the sand region of the foot of Lake Michigan,

with its moister atmosphere, at the eastward, and for the more arid western regions, will be of interest.

Femur-rubrum and *atlanis* are common on the humid prairie of Illinois. The tibiæ of the former are always red there, as in the sand region; those of the latter, as shown by a large number of specimens, are about ninety percent red—the rest being green—instead of only two thirds red as in the sand region. Blatchley ('03) says of *angustipennis* in the Lake Michigan sand region, that at least one third had red tibiæ, the rest blue. In a series of 64 specimens, 33 males and 31 females, taken by me near Waukegan, exactly one half have red tibiæ. This is very significant, since red tibiæ were seen in only two out of 125 of the same species in our western Illinois sand regions. The tibiæ of *minor*, according to Blatchley, are usually pale blue, pinkish at tip, sometimes red or dull yellow.

Of these four species in regions to the westward I have found the following records. McNeill ('99) found one female *femur-rubrum* in October in southwest Arkansas with green hind tibiæ. In Texas I have recorded ('06) two such occurrences among only a few specimens seen in the early part of the winter. Scudder ('97) says the hind tibiæ are normally red, occasionally more or less tinged with yellowish, very rarely pale green with a yellowish tinge. Examples with greenish tibiæ are recorded by him from the alpine region of the White Mountains, and from Massachusetts, Utah, Texas, and Mexico. The Massachusetts localities appear to be sandy districts. Gillette ('04) notes that the uniform fuscous-brown of this species in the East becomes in Colorado variably yellow-brown or with bluish tints, in the latter case the tibiæ also often bluish.

As to *atlanis*, Scudder ('97) says the tibiæ are normally rather bright red, not infrequently pale red, green, or yellow, or even dark blue. According to him, examples from the arid West are decidedly paler and more ashy, also those from sandy localities such as the seashore. He records green tibiæ in New Hampshire and Massachusetts at the East, and in Montana, Wyoming, Dakota, Colorado, Nebraska, and Missouri at the West; also blue tibiæ in Iowa, Colorado, Utah, and Texas; but

thinks the red are always in the majority. McNeill ('99) records from Arkansas 39 *atlanis* with red tibiæ and 42 with green. Caudell ('03) found the tibiæ of this species in Colorado to be bright red, yellow, or blue. Cockerell ('89) calls the blue-legged form *cæruleipes*.

Scudder says the hind tibiæ of *minor* are generally nearly uniform in color, usually pale red or glaucous, sometimes plumbeous or yellowish. Dodge ('78) noted "a red-legged variety" in Nebraska, of which he had taken many, but, as in our collections, all were females. As in the previous comparison concerning this species, the evidence is not full enough to be of value here.

Scudder ('97) records only six specimens of *angustipennis*, all from Montana and Nebraska, describing the hind tibiæ as glaucous, feebly lutescent apically; but he has described *M. coccineipes*, with bright red hind tibiæ, from 59 specimens from Utah, Colorado, Nebraska, and Kansas, which is now generally regarded as merely the red-legged form of *angustipennis*. If such it be, then the usual rule seems reversed in this case, and it may possibly be that, after all, the two are not the same species. Gillette ('04) records for Colorado a single male of *angustipennis* and moderate numbers of *coccineipes*, but remarks on the probable specific identity of the two.

The only record of variation in *flavidus* which I have seen, is that of a single otherwise abnormal, doubtful example from Colorado with pale red tibiæ (Scudder, '97).

Melanoplus packardii, a very variable species of wide range west of the Mississippi, has the tibiæ either glaucous or uniform red, according to Scudder ('97). He had 176 specimens. These showed that in this species red tibiæ prevail, perhaps exclusively, at the northward, occurring from British Columbia to Montana, and thence to New Mexico and Kansas. Both red and blue tibiæ are seen in examples from Montana, Utah, Colorado, and Nebraska, and blue only in the specimens from Wyoming, Iowa, and Texas. Bruner ('85) received quite a number of examples of *packardii* from Oregon and vicinity, all of which had the hind tibiæ red, instead of bluish—the usual color

in Nebraska specimens. Gillette states ('04) that the species occurs both on hills and on level ground in Colorado, and of his specimens 69 had red and 58 blue tibiæ. McNeill ('99) found the tibiæ green in southwest Arkansas, red and green in Newton Co., and purplish red in Marion Co. The records of this species indicate that the cooler northern climate has the same effect as a humid climate in favoring the development of red tibiæ.

The Rocky Mountain locust, *M. spretus*, has red tibiæ, and its normal range is from the Saskatchewan towards Colorado and Utah. Examples with pale blue tibiæ (*M. spretus cæruleipes* Ckll.) are recorded from Nebraska by Dodge ('78).

Finally, Scudder has separated *M. bivittatus*, having yellow tibiæ, from *femoratus*, having red tibiæ, but these are almost certainly varieties of one species. *Femoratus* ranges from Nova Scotia and Maine to British Columbia and California, and south to Colorado, Nebraska, Missouri, Illinois, Indiana, Maryland, and North Carolina. It is much the commoner of the two in Illinois, all but 4 out of 133 taken by us in this state being of this variety. *Bivittatus* abounds on the Great Plains, ranging principally from Texas to Utah and Nebraska and, in lesser numbers, from Texas to Ohio, and northward into Canada between Manitoba and the Pacific. The range of these two species accords with that of the two tibial color-varieties of species previously mentioned, indicating that variation in tibial color, which is the only constant difference noted between *bivittatus* and *femoratus*, is not a sufficient basis for specific separation.

Briefly, then, some species of *Melanoplus* have bluish tibiæ only, some red only, regardless of locality, but in other species we find individuals with both kinds of tibial coloration in varying proportions, red on the one hand, and various combinations of blue, green, and yellow on the other, the proportion of the two differing greatly according to species and also according to locality, in all species but possibly one the blue tibiæ increasing with the increase in aridity or in sandiness, except in higher latitudes, and being most numerous east of the Rocky Mountains, from Texas to Nebraska, and least so east of the Mississippi and towards the extreme north.

The details previously given are collated in the following table, in which the figures, when standing alone, represent percentages of individuals of the variety with bluish to yellowish tibiæ, instead of red. Estimated percentages are queried, and dashes indicate lack of data or non-occurrence of species. In the absence of precise data the proportion is expressed by words. or, if unknown, is indicated by the plus mark (+).

DISTRIBUTION AND PROPORTION OF MELANOPLUS HAVING BLUISH TO YELLOWISH HIND TIBLÆ.

Species	Extreme N.W.U. S.	Col.	Tex.	Neb.	Ark.	Ill. Sand	Ill. Prairie	Ind. Sand	East. Sand(?)
femur-rubrum	0	+	2 spms	—	1 spm	0	0	—	+
atlanis	0	+	+	+	52	34	10	—	+ (N.H. &Mass.)
minor	—	—	—	+	—	60	—	usually	—
angustipennis and coccineipes	—	1?	—	9 (Gr't Pl'ns)	—	{ W.,98 E., 50	—	66	—
flavidus	—	100?	100	100	—	100	—	—	—
packardii	0?	46	100	+	50?	—	—	—	—
spretus	0	0	—	1?	—	—	—	—	—
femoratus and bivittatus	+	99?	100	95?	—	—	3	"some"	0

The variation in tibial color has no marked relation to sex. In the small series of *M. minor* at hand the tibiæ are bluish, or in the female sometimes red; in *M. angustipennis* from Waukegan two of every three males have red tibiæ (21 of 33), and two of every three females have them bluish (20 of 31).

This tibial variation belongs to what Bateson calls discontinuous variation, the transition from red to bluish in a series of specimens being more or less sudden. Specimens at the point of change show one color basally and the other apically. This variation is attributed by Cockerell ('89) to an influence promoting or arresting a metabolism of pigment. The order of

the change seems to be, as in the spectrum, from red to yellow, then green, then blue, the intermediate steps between red and green or red and blue being usually absent.

Local Distribution of Species in the Sand Areas. The Insect Associations.

A careful study of the life of a region soon enables one to separate it into biological groups or associations, although in the ultimate analysis nearly every species requires a shelf of its own in the biological classification. It does not seem desirable in this connection to attempt more than a sketch of the insect life of each of the various general types of environment in the sand region. The observations here recorded are given also in the annotated list which follows.

One would not at first sight expect to see much life on the areas of bare sand or with very scanty vegetation, (Pl. X., XIII.–XVI.,) but, in fact, all except the larger entirely barren areas are busy scenes of insect activity, and there seems to be no great change in relative numbers from year to year. The exposed species of the blow-sand may receive attention first. These are largely predaceous. *Cicindela formosa generosa* and *C. scutellaris lecontei* are common everywhere (Pl. XIV., Fig. 1; XV., XVI.), and the light-colored and wary *C. lepida* flits on the bare sand in blowouts (Pl. XIV., Fig. 1, 2). The vertical burrows of their larvæ may be seen opening here and there, and the beetles themselves may be dug out of such burrows in wet weather. *Stachyocnemis apicalis* likes to run over the sand among thin vegetation (Pl. XVI.), and is sometimes seen in excessive abundance. Returning to a locality where it had been thus abundant the day before, rainy weather having set in meanwhile, I could find only one or two anywhere in the vicinity where they had just before been most numerous, and these were hiding under dried horse-dung. Some were once noted apparently feeding on a bit of fresh bird-dropping. *Lepidoptera* are not much in evidence here, except *Eubaphe* and *Crambus haytiellus*, which are not infrequent. In the blowouts (Pl. XIV., Fig. 1) *Microbembex monodonta* and *Laphystia 6-fasciata*

are seen resting on the bare sand and occasionally making a short quick flight. *Bembex spinolæ* is occasional. The *Bembecidæ* oviposit in burrows in the sand and provision them with flies. The red female *Mutillidæ* are conspicuous as they walk hurriedly along, presumably in search of insects with which to stock their nests, often followed by the black, winged males. (Pl. XIV., Fig. 1; XV., XVI.) Predaceous flies, *Anthrax* and *Asilidæ*, the latter including *Laphystia*, are common, resting on the sand or flying about. (Pl. XIV., Fig. 2; XVI.) Those alert personifications of incessant activity, the *Ceropalidæ*, flit rapidly along near the ground amongst the vegetation, (Pl. XVI.,) searching for spiders for their nests, and if the spider *Phidippus insolens* did not look so much like a female mutillid it might not be able to assume the manner which gives it its specific name. Of course the grasshoppers are a conspicuous feature of the blow-sand, *Melanoplus flavidus* and *M. angustipennis* and the bright-winged *Œdipodinæ*—such as *Spharagemon wyomingianum*, *Hippiscus*, *Psinidia fenestralis*, and others—jumping about or flying here and there over the bare sand. (Pl. XIV., Fig. 1; XV., etc.)

Logs, boards, dried dung, and other shelters are not very common on the sand prairie, but underneath them we find a second and very interesting group of insect associations. At the Devil's Neck we have found *Gryllus personatus*, *Nothopus zabroides*, *Ceuthophilus* sp., *Geopinus incrassatus*, *Cratacanthus dubius*, *Harpalus caliginosus*, *Anisodactylus rusticus*, *Termes flavipes*, and others, the *Carabidæ* all quite abundant. In June many *Nothopus* were found here, but all were dead. Under bark and sticks on sand under trees (Pl. XX., Fig. 2) were *Ischnoptera inæqualis*, *Udeopsylla robusta*, and some curious cydnid nymphs. Beneath boards on very sandy pasture land were *Lacon rectangulus* and *Opatrinus notus* in abundance, also *Harpalus testaceus* and *H. erraticus*, the latter commonest. Under the remnants of a dead animal in a blowout were *Trox scabrosus* and *Canthon nigricornis*.

A third group are the burrowers in bare sand, among which are the tiger-beetles and their larvæ and various *Hymenoptera*.

The ant-lions made their obconic pits wherever they could secure protection from rain, and waited at the bottom for an unwary insect to walk into the trap. A tiny surface-burrow in open sand, like that of a mole, was made by a small carabid larva. The most curious work seen, was that of a small active microlepidopterous larva, which webs together a tube of sand, usually beginning at the base of a plant, and extending it long distances (two or three feet), up to the tops of the stems. We have found these web tubes on *Onagra* and several other herbaceous plants. The adult was reared by Mr. J. J. Davis, and named by the Bureau of Entomology *Olethreutes dimidiana*. Discrepancies in the biology of that species and ours lead us to think that an error has crept in somewhere. The web closely resembles that of *Prionapteryx nebulifera*, described and figured by Daecke ('05), which he found on huckleberry and sand myrtle growing on white sand in New Jersey; but Mr. Daecke has seen our larva, and says it is not the same as his.

Turning now to the tufted and moderately dense vegetation of the neighboring areas of open waste land, too sandy for cultivation or even for pasturage (Pl. XVIII., Fig. 1), there is found an apparently inexhaustible variety of insect life. Grasshoppers swarm everywhere here. *Melanoplus angustipennis* is as numerous here as *M. femur-rubrum* on the prairie pastures. *Ageneottetix scudderi*, *Psinidia*, and *Trachyrhachis*, as well as the more familiar *Dissosteira* and *Hippiscus rugosus*, are seen in fall, and *Hippiscus phœnicopterus* and *H. haldemanii* in June. About the Devil's Neck, *Amphitornus bicolor*, a species of the Great Plains, was now and then taken in such ground. In short growths of coarse grass at the Moline Sand Hill were large numbers of *Orphulella speciosa*. Upon the vegetation of the waste areas mentioned were *Œcanthus 4-punctatus*, *Bacunculus blatchleyi*, and *Conocephalus robustus*,—the latter, head down, simulating a grass leaf,—also *Campylacantha*, *Neottiglossa sulcifrons*, and a host of others. The *Campylacantha* was not confined here to *Ambrosia bidentata*, upon which we uniformly found it in southern Illinois. Here ant-lion adults fluttered

weakly about. The song of *Cicada marginata*, resembling that of the periodical cicada, was heard; and in the twilight came the penetrating shrilling of *Conocephalus robustus*, and the rattling note of the male of *Heliocheilus paradoxus*, as moths of the latter species danced in groups here and there.

The abundant wild flowers were visited by large numbers of bees, wasps, and other aculeate *Hymenoptera*, many of which were species rarely or never seen on the prairie,—*Dielis plumipes*, for example,—probably associated with the unusual flora. Families which nest in sand were well represented, such as the *Larridæ*, which capture young *Orthoptera* to provision their nests, the *Bembecidæ*, which use flies for this purpose, and the bee family *Colletidæ*. In fact, this kind of region seems particularly favorable to the development of these insects in great numbers and variety because of the undisturbed ground and vegetation in addition to the character of the soil. Hoppner ('01) shows that similar conditions prevail in a tract of dune sands along the Weser valley in Germany, finding there six characteristic local species of bees, and three others more abundant there than elsewhere, the total list including two thirds of all the bees found in northwest Germany. To develop this subject for our district would require vastly more time than was available.

The insects associated with some of the more common plants of the sand region may next be grouped under their respective plants.

Mesadenia atriplicifolia.—This may well head the list of host plants, with its interesting insect guests. On the flowers of scattered clumps of these plants were two far western species, a large tenebrionid (*Epitragus acutus*) and a long-legged reduviid (*Zelus socius*), also *Lygæus bicrucis*, and, upon the stems, *Languria bicolor*, the larvæ of which burrow in the stems.

Opuntia humifusa.—This cactus was usually abundant, and sometimes supported flourishing colonies of *Pentatoma juniperina*. It was also responsible for the presence of the bright-yellow-striped chunky little syrphid fly, *Volucella fasciata*, seen

feeding in the flowers of various plants, as its larva lives in the cactus flesh. *Collops tricolor*, *Acmæodera tubulus*, and *Strigoderma arboricola* were noted within the flowers.

Onagra biennis.—In addition to the larva of the web tube previously mentioned, this was fed upon by *Attelabus bipustulatus*, *Haltica fuscoænea*, *Tyloderma foveolatum*, and *Chalcodermus collaris*, and often harbored a number of adult *Metachroma parallelum*.

Monarda punctata.—This abundant plant of the sand regions about Havana was seen at different times to have its stems dotted with *Corimelæna ciliata* and *Sehirus cinctus*. The *Corimelæna*, usually considered quite a rare species, was also extremely abundant in nearly bare sand about the bases of little grass tufts, every turn of the finger in the sand bringing several to the surface. Honey-bees were common upon the flowers of the *Monarda*.

Commelina virginica.—The leaves of this plant were white-streaked by the feeding of adults of *Lema cornuta*, the larva of which bores in the stems.

Rhus aromatica.—This dense, bushy sumac (Pl. XIX.) supported *Blepharida rhois* and its sticky larvæ, *Perillus circumcinctus*, and *Resthenia insitiva*. *Catorhintha mendica* and *Zelus socius* also occurred on it.

Euphorbia corollata.—*Chariesterus antennator* was once noted very common on flowers of this species.

Cassia chamæcrista.—This common flowering plant of the waste sand land was well populated. *Bombus*, *Apis*, *Plesia* (*Myzine*), *Polistes*, etc., were busy on its flowers, and *Phormia terræ-novæ* was numerous about it. *Bruchus cruentatus* was swept from it in numbers, probably breeding in the seeds.

Cracca virginiana.—A group of these plants was infested with *Macrobasis unicolor*.

Callirhoe triangulata.—This formed a sprangling tuft of stems and long-petioled radical leaves, and at their extreme bases, within the tuft, were often large enveloping masses of "frog-spittle", containing bulky blackish larval *Cercopidæ*, prob-

ably *Lepyronia sordida*, the adult of which was taken on this plant.

Euthamia sp. (*Solidago*).—In a small patch of this plant the phytophilous *Hesperotettix pratensis* was quite abundant.

Along the railroad track near Forest City, *Phacepholis candida* was abundant on some undetermined low weeds.

For the concluding group of inhabitants of the open waste sandy land I may appropriately mention our herpetological observations in this region, which cover all the characteristic vertebrates noted. There were four of these: the box-turtle (*Cistudo carolina*, Pl. XII., Fig. 2), the striped lizard (*Cnemidophorus sexlineatus*), the hog-nose snake (*Heterodon simus*), and a small *Hyla*, or tree-toad. Ten years ago the box-turtles were quite common at the Devil's Hole, but I have seen very few of late years. The striped lizard ranges throughout the valley, and is not rare here. The hog-nose is quite common, especially along roadsides and sandy shores.

The general arid aspect of the sandy regions is relieved by the moist growth at the bottoms of deep wind-excavations in the sand, and here a very different fauna obtains. Adults of aquatic neuropteroids, such as *Hexagenia* and various dragonflies, rest on plants here or fly about; *Locustidæ* and their nymphs suddenly come into prominence,—for example, *Xiphidium*, *Scudderia*, and *Amblycorypha uhleri*; and moisture-loving grasshoppers, such as *Dichromorpha viridis* and *Orphulella pelidna*, replace those of the dry sand. A variety of rare and interesting *Hemiptera* occurred on this vegetation; for example, *Homæmus æneifrons*. Long grass on the sides of hollows of this kind was well populated with elongate tryxaline grasshoppers, *Mermiria bivittata* and *neomexicana* and *Syrbula admirabilis*, the latter in the drier and sparser portions.

The sandy roadways have some fairly definite insect associations. Here *Aphodius rubeolus*, *Canthon lævis*, *Onthophagus hecate*, and *O. pennsylvanicus* are found at the usual occupations of these genera; *Anthrax*, *Erax*, and *Cicindela formosa generosa* and *scutellaris lecontei* fly along the bare wheel-track lines; *Ammophila* is common, and *Megachile latimanus* and *Epeolus lunatus*

bunch up in cool or rainy weather on the dead weed stems; while the border of dandelions and sweet clover is visited by numbers of *Volucella fasciatus*, *Dielis plumipes*, *Agapostemon splendens*, etc. In the level and least sandy roads are found *Melanoplus femur-rubrum* and *Cicindela punctulata*, and, under boards, along the fence lines, *Gryllus pennsylvanicus*, *Carabus sylvosus*, etc.

Culture of various kinds accounts for the presence here of the potato-beetle, box-elder bug, chinch-bug, potato stalk-borer, and house-fly, and of the male of *Blatta orientalis* at an electric light. In a street at Forest City, adults of *Lucanus placidus* were coming to the surface at the base of shade trees along the walks.

Taking up now the forested ground, a situation claiming especial attention is the very sandy black-jack land, with its matted scrubby growth (Pl. XXI., Fig. 1), whose contribution to our list of sand insects was by no means small. The characteristic grasshoppers here were *Melanoplus luridus*, *impudicus*, *scudderi*, and *fasciatus*, and *Chloealtis conspersa*. Along the roads were *Hippiscus phœnicopterus* and *Schistocerca alutacea*, (Pl. XVIII., Fig. 1,) which latter liked to fly up into the oak brush when disturbed. *Calopteron terminale* and *C. reticulatum* were common. The stalks of *Scrophularia nodosa* were loaded with *Cosmopepla carnifex* in June, and small oak sprouts had at that time a great many small click-beetles (*Limonius quercinus*) on leaves and stems.

The marginal sand ridge, with leaf-mold and a better developed forest (Pl. XXI.,Fig. 2), had about the usual central Illinois fauna for forest situations.

Finally, the long stretch of moist sandy shore (Pl. XXIII.) extending from Quiver Lake to Riverside Park, a distance of about three miles, added new elements to the sand fauna, partly due to the presence of the river and partly to the sand, and seeming but doubtfully eligible to a place in these studies. The river-shore-sand grasshopper, *Trimerotropis citrina*, whose habitat extends in a slender strip along the southern seashore and up each shore of our larger rivers, is here in evidence, as usual.

Along the narrow strip of wave-washed beach at the foot of the sand bluff were great numbers of tiger-beetles, *Cicindela cuprascens* and *C. hirticollis*, also *Paratettix cucullatus*. *Bembidium* was found along the water margins. Under the driftwood were *Chlænius sericeus*, *Patrobus longicornis*, *Platynus octopunctatus*, and other *Carabidæ*, also *Gryllus pennsylvanicus*. In the drier sand higher up we have noted *Tetragonoderus fasciatus* and *Blapstinus interruptus*. Under and about dead fish, turtles, etc., are found *Saprinus*, *Hister*, *Silpha*, and *Cercyon*, often in great numbers. *Anthrax* and *Bembex* are also common, flying about on the dry sand. Among the insects on plants along the sandy beach in June, and conspicuous by reason of their great abundance, were the daddy-long-legs (*Liobunum*) on mulleins and other plants, and *Metachroma angustulum*, *M. parallelum*, and *Melasoma lapponica* on willow. Even on straggling willows and poplars among the sand hills inland (Pl. XX., Fig. 1), both species of *Metachroma* were very numerous, and *M. parallelum* abounded also on a variety of plants. There is no previous record of their occurrence this side of Kansas except that of *parallelum* by Brendel ('87) in this same region. *Disonycha 5-vittata*, very variable in markings, was also taken on willow among the sand-hills.

Annotated List of Species.

The following list includes all species taken within the limits of the western Illinois sand regions. No attempt to restrict it has been made, since few faunal lists have as yet been published for Illinois. The determinations are my own except as otherwise stated, and much time and pains have been taken to make them accurate.

I am under obligations for help in securing determinations to Dr. L. O. Howard, Professor Herbert Osborn, Mr. W. S. Blatchley, Mr. A. L. Melander, Mr. E. S. G. Titus, and Mr. Frederick Knab, and their cordial coöperation is gratefully acknowledged. My friend and collaborator, Mr. Gleason, has helped me with the plant names. Mr. J. J. Davis and Mr. R. O. Johnson, of the University of Illinois, who accompanied me on the field

trip of June, 1905, have very generously permitted the free use of their collections and notes in this connection. The fulness of the records for Meredosia and the Moline Sand Hill are due in no small degree to the keen discrimination and enterprising activity of my field assistant, Mr. Frank Shobe. The extensive collections and excellent library of the State Laboratory of Natural History, and the Bolter Collection of Insects at the University of Illinois have been especially useful to me. The entire series of specimens collected has been turned over to the State Laboratory.

For each species the sand region localities and dates are given, so far as known, and usually, in parenthesis, the number of specimens taken, if more than one, followed by biological notes or other items of interest. The systematic notes (unless very brief), including descriptions of new species, appear under a separate heading at the end of the list, and are referred to by number. Finally, the distribution of the species in Illinois outside the sand regions is given, data being derived from the State Laboratory collections, the Bolter Collection, and published lists, supplemented by my own observations. The source is cited only in case of the Bolter Collection and published lists. The exact known distribution of the rarer species is given in full; the more common ones are followed simply by "Ill.", or, if known to be of general occurrence throughout the state, by "All Ill." The most important of the published lists referred to are those of Mr. Charles Robertson for Carlinville, of Dr. Brendel ('87) for Peoria, of the Chicago group of entomologists (see Kwiat, '05), of McNeill ('91—Illinois *Orthoptera*), of Melander ('03—*Mutillidæ*), of Wolcott ('95–'00—central Illinois *Coleoptera*), and of H. Garman ('92—*Amphibia* and *Reptilia*. The distribution outside of Illinois of species of restricted range has already been given under "Geographical Distribution".

The main Illinois Valley sand region (see map) extends from our southernmost locality, Meredosia, which is about eighty-five miles north and a little west of St. Louis, to near Peoria, about an equal distance northeast of Meredosia. Our northernmost locality is the Moline Sand Hill, in the Rock River

valley, northern Illinois, about eighty miles northwest of Peoria. Collections in the Illinois River area are cited from Teheran, at the eastern border of this area, fifteen miles east of Havana, from Pekin, ten miles below Peoria, from Matanzas Lake, eight miles below Havana, and from the sand beach of Thompson Lake, in Fulton county, opposite Havana; but especially from six principal regions in the vicinity of Havana, designated by numerals. Those who care for topographical rather than geographical detail may note that H.1, 2, and 3 are the three principal blow-sand areas, counting from north to south and in order of sandiness; that H.3 has a large admixture of areas of black-jack growth; that H.4 and 5 represent forest on sand; 4, the newer growth (black-jack), with some open ground; and 5, the older and more varied forest, approaching ordinary Illinois forest conditions with a little open sandy ground; and that H.6 is the immediate sandy river beach and lake beach along the western margin of the sand plain. For convenient reference, the principal details with regard to these various localities are summarized as follows:

H.1 = the Devil's Neck, ten miles north of Havana, open land, a large area of barren sands and blowouts, approached by sandy roads. (See p. 197, and Pl. XII., Fig. 1; XIV., Fig. 1; XX., Fig. 1.)

H.2 = the Devil's Hole, two miles east of Havana, similar to H.1 but smaller. (See Pl. XIII.; XIX., Fig. 1; XX., Fig. 2.)

H.3 = a large area of rolling sand-hills with occasional blowouts, considerable waste sandy open land, and areas of scrubby black-jack forest, lying south and southeast of Havana. (See Pl. VIII.–XI., XV.–XVII.)

H.4 = the east margin of the sandy postglacial island northeast of Havana near the center of which is the Devil's Neck. This margin is mostly covered with black-jack. (See Pl. XXI., Fig. 1.)

H.5 = the marginal sand ridge just above Havana, mostly covered by comparatively well-developed forest growth. (See p. 198, and Pl. XXI., Fig. 2.)

H.6 = the sandy beach, moist near the water level, extending for a mile or two along the river and lakes just above and below Havana. (See p. 198, and Pl. XXIII.)

H.m. = miscellaneous situations about Havana.

Mer. = a very sandy small area, with blowouts, some blackjack, sand-pit, and adjacent sandy river bank, just south of Meredosia, Ill. (See p. 198.)

Mol. = the Moline Sand Hill, on the left bank of the Rock River near Moline, with a small summit area of waste sand land, and blowouts, adjoining a close-cropped sandy pasture. (See p. 198.)

For the sake of brevity, Je., Au., and S. are used respectively for June, August, and September.

ARACHNIDA.

Phidippus insolens Hentz (Banks, det.). H.1, 4, Mer.; Je. 6, 7, Au. 20, 22, 29. (8) Blow-sand and dune tops. Mimics female *Mutillidæ*.

Acrosoma rugosa Emerton (Banks, det.). H.5, Au. 12.

Wala mitratus Hentz (Banks, det.) H.2, Au. 18.

Tetragnatha laboriosa Hentz (Banks, det.). H 2, Au. 18.

Xysticus gulosus Keys (Banks, det.). H.2, 4; Je. 6 (immature), Au. 18. (5)

Liobunum vittatum Say (Banks, det.). H.2, 6; Je. 9, Au. 12, 18, 19. (11) Abundant on mullein along river bank All Ill.

Trombidium locustarum Riley. H.2, Au. 19. (2) On *Melanoplus angustipennis*.

PLATYPTERA.

Termes flavipes Kollar. H.2, 5; Au. 17, 19. (8) Common on the under part of sticks and logs on sand. Observed swarming from a house in Havana. Ill., especially southward.

ORTHOPTERA.

Ischnoptera inæqualis Sauss.-Zehntn. H. 1,2, 4, 6, H.m.; Je. 7, 8, 9, 12, Au. 18, 19, 20, 22. (11) All Ill., common; Iowa.

Blatta orientalis Linn. H.m., Je. 18, 25. (2) Ill.

Bacunculus blatchleyi Caud. H.1, Au. 22. (2) On dry prairie vegetation. All Ill., not rare; L. Geneva, Wis. (Note 1)

Tettix arenosus Burm. H.6, H.m.; Apr. 13, May 6, Je. 8, 9. (6) All Ill.

Paratettix cucullatus Burm. H.6, Mer.; Je. 9, Au. 29. Nymphs, Je. 8, 9. (9) Moist shores. All Ill.

Mermiria neomexicana Thom. H 2, 4, Teheran; Au. 18, 19, 20, S. 2. Nymph, Au. 17. (38) With the next species among long bunch-grass (*Panicum virgatum*) in old blowout between dunes. No other Illinois records.

Mermiria bivittata Serv. H.1, 2, 3, 4, Mer.; Au. 12, 13, 14, 18, 22, 30, S. 2. (31) With the preceding; also in patch of *Cracca.* Tamaroa (S. Ill.), long grass on summit of Mississippi R. bluff at Chautauqua, Ill., near Grafton, July 20.

Syrbula admirabilis Uhl. H.2, 3, 4, Teheran, Mol.; Au. 12, 17, 18, S. 8. Nymphs, Au. 19, 20. (17) All Ill., dry grassy ground.

Eritettix virgatus Scudd. H.4, Je. 6. (Note 2)

Amphitornus bicolor Thom. H.1, 4; Au. 20, 22. Nymph, Je. 7, 23. (8) Grassy dune summits near middle of postglacial island. No other Illinois record.

Orphulella speciosa Scudd. H.4, Mol.; Au. 20, S. 8. (61) Common in short dense grass on sand at Moline Sand Hill; rare in Havana region. All Ill., especially on dry soils; taken at lights.

Orphulella pelidna Burm. Mer., Au. 30. Moist bottom of sand-pit. Swales between sand ridges, Waukegan.

Dichromorpha viridis Scudd. H.1, 2, 5; Au. 12, 17, 18, 22. (7) Moist grassy bottoms of old blowouts; old forest. All Ill.

Chloealtis conspersa Harr. H.3, 4; Au. 14, 17, 20. (5) C. Ill. and northward.

Ageneotettix scudderi Brun. H.1, 2, 3, 4, Mol., Mer.; Au. 12, 13, 17, 18, 22, 29, 30, S. 2, 8. Nymphs, Je. 5, 7. (91) Abundant in all blow-sand areas. "Near Moline, where it seems to be confined to a few sandy hilltops along the Mississippi R." (McNeill). Waukegan, sandy ridges near L. Michigan. (Note 3)

Mecostethus lineatus Scudd. Matanzas L., July 6. At margin of sand plain, probably in bottom-land. In bog, Lake Co., Ill., Au. 13.

Mecostethus platypterus Scudd. Teheran, Je. 22. Low ground on glacial flood-plain. Champaign, July 31, dense grass in wet ground. Ill. (Coll. O. S. Westcott). Hitherto known only from New England, but these are typical examples of the species as characterized and figured by Morse ('96) and McNeill.

Arphia sulphurea Fabr. H.1, 4, 6; Je. 6, 7, 9, 23. (10) Open woods, all Ill., early summer.

Arphia xanthoptera Germ. H.1, 4, Mer.; Au. 20, 22, 30. (5) Roadsides, in black-jack. Dry woods, all Ill.

Encoptolophus sordidus Burm. Mol., S. 8. Ill., especially northward, on dry open ground.

Hippiscus tuberculatus Palis. H.4, Je. 6. C. Ill. and northward; infrequent.

Hippiscus phœnicopterus Germ. H.1, 4; Je 5, 6, 7, 23. (43) Common on grassy dunes and along roadsides in black-jack in early summer, with the next species. S. Ill., in dry open woods on hillsides.

Hippiscus haldemanii Scudd. H.1, 2, 4; Je. 6, 7, 8, 23. (21) Common in the sand region, associated with the preceding species. On Rock Island (McNeill, *tuberculatus*, *fide* Scudder). The intercalary vein in *Hippiscus*, especially in this species and *phœnicopterus*, is quite prominent and bears a row of minute tubercles, as in *Mecostethus*; and the upper carina of the internal face of the hind femur is rubbed against it, causing a distinct rasping stridulation. The sound may be easily produced in this way in freshly killed individuals. In all the *Œdipodinæ* of this list the same structure of the intercalary vein occurs, and presumably also the same habit of stridulation by means of it when not flying. Regan ('03) has described and figured (Pl. I., Fig. 3) this method of stridulation in *Psophus*. Morse ('96) has noted the general occurrence of this structure in the *Œdipodinæ*, and has seen and heard the stridulation in *Circotettix verruculatus* and *Encoptolophus sordidus*.

Hippiscus suturalis Scudd. Mol. (McNeill, *rugosus*).

Hippiscus rugosus Scudd. H.1, 2, 3, Teheran, H.m.; Au. 13, 17, 18, 22. Nymph, Au. 18. (16) Lower slopes of dunes. All Ill.

Dissosteira carolina Linn. H.2, 4; Au. 12, 18. Nymph, Au. 20. (3) Roadsides. All Ill., bare ground of roads, etc.

Spharagemon bolli Scudd. H.1, 2, 3, 4, Mer.; Au. 13, 17, 20, 22, 30. (7) In older dry forest, occasional in black-jack. All Ill.

Spharagemon wyomingianum Thom. H.1, 2, 3, 4, 5, Mol., Mer.; Je. 23, Au. 12, 13, 14, 17, 18, 19, 20, 29, 30, S. 2, 8. Nymph,

Au. 20. (76) Abundant everywhere on sand in open ground. Waukegan, sandy ridges near L. Michigan.

Mestobregma thomasi Caud. H.1, 2, 3, 5, Mol.; Au. 17, 18, 19, 22, S. 2, 8. (13) Common on the dunes. Throughout S. Ill., on dry barren ground. (*Trachyrhachis thomasi* in text.)

Psinidia fenestralis Serv. H.1, 2, 3, 4, 5, Mol., Mer.; Au. 12, 13, 14, 15, 17, 18, 19, 20, 22, 29, 30, S. 2, 8. Nymph, Au. 18. (85) Abundant everywhere on the blow-sand; wings rose-red. Waukegan, sandy ridges near L. Michigan. (Note 4)

Trimerotropis citrina Scudd. H.2, 6, Mer.; Au. 12, 29, S. 5. (12) Sandy shores of Ohio, Mississippi, and Illinois rivers in Illinois: one taken at Devil's Hole. "N. Ill." (Note 5)

Schistocerca americana Drury. H.m. Seen with *Locustida* in soft grass in moist bottom of old blowout. C. and S. Ill.

Schistocerca alutacea Harr. H.2, 3, 4, Mol., Mer.; Au. 14, 15, 17, 18, 20, 29, 30, S. 2, 8. Nymph, Au. 20. (69) Common along the margins of black-jack forest and about thickets and bunch-grass; roadsides. Dry soils of the Illinoian glaciation in S. Ill., and a few restricted localities in N. Ill.; swales between sand ridges, Waukegan.

Campylacantha acutipennis Scudd. H.4, Mer.; Au. 20, 30. (2) Found associated with the next species, but in much fewer numbers. Perhaps only a dark grayish variety of it. Clay Co.

Campylacantha olivacea Scudd. H.1, 2, 4, Mer.; Au. 18, 20, 21, 22, 29, 30, S. 2. Nymph, Au. 18. (19) On the grassy dunes, moderately common. Abundant on *Ambrosia bidentata* on the dry soils of the Illinoian glaciation across southern Illinois.

Hesperotettix pratensis Scudd. H.3, Au. 18. (17) On a patch of *Euthamia* (*Solidago*) in a basin among sand-hills. Taken in southern Illinois along the I. C. R. R.; swales among sand ridges, Waukegan; long grass on summit of Mississippi R. bluff at Chautauqua, Ill., near Grafton, July 20.

Hesperotettix speciosus Scudd. H.1, 2, 3; Au. 18, 22, S. 2. Nymph, Au. 22. (4) Occasional with *Campylacantha olivacea*. Taken on the dry soil of the Illinoian glaciation in southern Illinois.

Melanoplus flavidus Scudd. H.1, 2, 3, 4, 5, Mol., Mer.; Au. 12, 13, 14, 18, 19, 20, 22, 29, 30, S. 2, 8. Nymphs, Au. 17, 18, 19, 20. (51) Common everywhere in blowouts and on very sandy ground. Not taken elsewhere in Illinois. Associated by McNeill with the sand-bur (*Cenchrus*), but it is apparently an

accidental relation, and not invariable. Mr. J. D. Hood has shown me examples taken near Lone Rock, S. W. Wis.

Melanoplus atlanis Riley. H.1, 2, 3, 4, 5, Teheran, Mol.; Je. 6, 7, 8, Au. 12, 14, 17, 18, 19, 20, 22, S. 5, 8. (72) Moderately sandy ground. Dry sandy or gravelly places in N. and C. Ill.; general and abundant in S. Ill.

Melanoplus impudicus Scudd. H.3, 4; Au. 14, 17, 20. (4) Occasional in black-jack. Common on high rocky slopes of Ozark Ridge in S. Ill.

Melanoplus scudderi Uhl. H.1, 3, 4, Mer.; Au. 17, 20, 22, 30. (6) Roadsides in black-jack, and occasional elsewhere on sand. All Ill.

Melanoplus fasciatus Barnst. H.4, Au. 20. (11) On dry floor of fallen leaves in black-jack. Also in similar localities in eastern and southern Illinois.

Melanoplus femur-rubrum DeG. H.1, 2, 3, 4, Teheran; Au. 15, 17, 18, 20, 22, S. 2. (32) On the level areas with coating of soil. All Ill., least common in southern part.

Melanoplus angustipennis Dodge. H.1, 2, 3, 4, Mol., Mer.; Je. 23, Au. 12, 13, 14, 15, 17, 18, 19, 20, 22, 29, 30, S. 2, 8. Nymph, Au. 19. (122) Very abundant everywhere on waste sandy land. Commoner than *flavidus*, even at the Moline Sand Hill, but not recognized by McNeill as distinct from his *cenchri* (*flavidus*). Waukegan, sandy ridges near L. Michigan.

Melanoplus macneilli, n. sp. Mol., S. 8. (19) With *angustipennis* and *flavidus* at edge of large blowout at east end of the sand hill. (Note 6)

Melanoplus minor Scudd. H.1, Je. 7. (20) In sandy corner of close-cropped grassy pasture in early summer. No other Illinois record.

Melanoplus luridus Dodge. H.2, 3, 4, Mer; Au. 14, 17, 18, 20, 30. (31) Common in black jack. Also on dry, barren, high, wooded hilltops in Illinois, and, at Waukegan, on sandy ridges near L. Michigan.

Melanoplus differentialis Uhl. H.2, 3; Au. 15. Nymph, Au. 18. (2) Roadside, level ground. All Ill.

Melanoplus bivittatus femoratus Burm. H.1, 2, Teheran; Au. 13, 17, 18, 22. (6) Low ground, roadsides. All Ill.

Phœtaliotes nebrascensis Thom. H.4, Au. 20, nymphs and adults. (7) Rock Island region (McNeill, '91, *Pezotettix autumnalis*).

Dry sandy ground; also along swales between sand ridges near Waukegan.

Scudderia texensis Sauss.-Pict. H.2, 3, 4; Au. 14, 17, 18, 20. (6) Lower slopes of dunes, not uncommon. All Ill.

Scudderia furcata Brunn. H.3, 4; Au. 18. Nymph, Au. 20. (2) All Ill.

Amblycorypha uhleri Stål. Mer., Au. 30, in damp sand-pit. S. Ill.

Conocephalus robustus Scudd. H.2, 4, 5; Au. 11, 12, 18, 20. (4) Waste sandy land. Observed resting, head downward, on a grass stem, closely resembling a grass leaf. Its long-continued, penetrating shrill call is heard on all sides at dusk. Dry places in C. and S. Ill.

Xiphidium strictum Scudd. H.2, 4, Mol.; Au. 18, 20, S. 8. (7) One of the two from the Moline Sand Hill was long-winged. Common in damp grassy bottoms of old blowouts. Ill.

Xiphidium brevipenne Scudd.? Nymph, H.4, Au. 20. Ill.

Orchelimum, sp. Nymph, H.4, Au. 20.

Ceuthophilus, sp. H.1, Je. 7. Injured specimen; taken under fallen tree in blowout.

Udeopsylla robusta Hald. H.2, 5; May 17, Je. 8. (2) Under logs. No other Illinois records. (Note 7)

Nemobius fasciatus vittatus Harr. H.1, 4, Mol., Mer.; Au. 20, 22, 30, S. 8. (9) On sandy ground and elsewhere. All Ill. (Note 8)

Nemobius carolinus Scudd. Thompson L., S. 1. (6) On moist sandy beach under sticks among trees. All Ill., in damp woods.

Gryllus abbreviatus Serv. H.6, S. 5. (15) Under driftwood on dry sandy shore. Ill., in fall.

Gryllus pennsylvanicus Burm. Short-winged form, H.1, 2, 4,; Je. 6, 7, 8, 9, Au. 20. (13) Long-winged form, H.2, H.m.; Je. 7, 8. (6) Under sticks, boards and leaves on sand, and at electric light. Ill., mostly in summer.

Gryllus personatus Uhl. (Blatchley, det.). H.1, 2; Au. 19, 22. (3) Under logs in blowouts. Nymphs only, but mature enough for determination. No other Illinois records.

Œcanthus niveus DeG. H.4, nymph, Je. 23. Ill.

Œcanthus pini Beut. H.6, S. 4. (2) Ill.

Œcanthus 4-punctatus Beut. Mol., S. 8. (4) On vegetation. Ill. in fall.

HEMIPTERA.

Cicada dorsata Say. H.4, Au. 20. (2) Flying on open grassy summit of sand ridge. Tamaroa and Urbana.

Cicada marginata Say. Mol., S. 8. S. Ill., common.

Cicada tibicen Linn. H.m., Au. 17. Ill.

Tettigia hieroglyphica Say. H.1, H.m.; Je. 23, July 2. (2) Entered car window while train was passing through sand region. No other Illinois record.

Chlorochara conica Say. H.2, 4; Au. 19, 20. (2) Ill.

Scolops grossus Uhl. H.2, Au. 12, 18. (4) Ill.

Philænus lineatus Linn. H.4, Je. 6. (3) On vegetation of waste open sandy land. No other Illinois record.

Lepyronia gibbosa Ball. H.1, 4; Je. 6, 23, Au. 20. (7) On *Callirhoe triangulata*, etc. Also from Dayton (N. Ill.). A sand-hill species in Nebraska.

Cercopidæ, sp., immature. H.1, 4, 6; Je. 6, 9, 23. (11) Numerous on bases of radical leaves and stems of *Callirhoe triangulata*, each in mass of froth. Perhaps young of preceding species.

Deltocephalus melsheimeri Fitch. H.4, Je. 6. (2) Ill.

Agallia sanguinolenta Prov. H.4, Je. 6. (2) Ill.

Ceresa bubalus Fabr. H.5, Teheran; Au. 17. (2) Ill.

Stictocephala lutea Walk. H.4, Je. 6. Ill.

Ophiderma salamandra Fairm. H.4, Je. 6. Ill.

Campylenchia curvata Fabr. H.5, 6; Je. 9, Au. 17. (2) Ill.

Lecanium, sp., immature. H.2, Au. 19. (6) Common on stems of *Cycloloma atriplicifolium* in road.

Diommatus congrex Uhl. (Osborn, det.). H.6, Je. 8.

Tinicephalus simplex Uhl. Teheran, Au. 17. Vegetation along railroad. Ill.

Malacocoris irroratus Say. Teheran, Au. 17. (2) With the preceding species. Ill.

Lygus pratensis Linn. H.2, Au. 19. Ill.

Phytocoris colon Say. (Osborn, det.). H.4, Je. 5. (3) On plants by roadside.

Resthenia insitiva Say. H.1, 2, 4; Je. 6, 8, 23. (5) On *Rhus aromatica*. Ill.

Nabis ferus Linn. H.4, Au. 18, 19. (2) Ill.

Nabis elongatus, n. sp. H.6, Je. 9. (Note 9)

Sinea confusa Caud. Mol., S. 8. (2) Possibly *S. diadema*, as the males of these two species are not readily separable, and

no females were taken. The abdominal margin is nearly entire, scarcely undulate.

Acholla multispinosa DeG. H.2, Au. 18, 19. (2) Ill.

Zelus socius Uhl. H.1, 2, 3, 4, 6; Je. 8, 9, Au. 12, 15, 18, 19, 20, 22. (32) Common on *Rhus aromatica* in June and on *Mesadenia atriplicifolia* flowers in August. Seen eating *Phormia terræ-novæ*. No other Illinois records.

Zelus renardi Kol. H.4, Je. 6. In black-jack. N. Ill. (Bolter Coll.).

Zelus luridus Stål. H.6, Je. 9. Ill.

Melanolestes picipes H.-Schf. Teheran, Au. 17, nymph. Under board by railroad. Ill.

Aradus acutus Say. H.1, Je. 7. Also from Cobden and Villa Ridge (S. Ill.)

Phymata fasciata Gray (*wolffi* Stål). H.2, Au. 13, 18. (10) Occasional on sand plants. Ill.

Emblethis griseus Wolff. H.2, 3; Au. 14, 19. (2) Ill.

Sphragisticus nebulosus Fall. Mol., S. 8. (2) Ill.

Ligyrocoris constrictus Say. H.1, Je. 7. Ill.

Ligyrocoris sylvestris Stål. Mol., S. 8. Ill.

Phlegyas annulicrus Stål. (Osborn, det.). H.4, Je. 5.

Blissus leucopterus Say. Teheran, Je. 22. Serious injury to corn on very sandy land. Ill.

Nysius angustatus Uhl. H.m. Ill.

Lygæus bicrucis Say. H.2, Au. 12, 13, 18. (18) Common on flowers of *Mesadenia atriplicifolia*. Ill. On *Mesadenia reniformis* at Carlinville (Rob.).

Lygæus turcicus Fabr. H.2, Au. 13. Ill.

Lygæus kalmii Stål. H.1, 2, 3, 5, 6, Teheran; Apr. 14, Je. 7, 8, Au. 13, 15, 17, 18. (17) On *Asclepias cornuti*. Ill.

Jalysus spinosus Say. H.m., July 12. Ill.

Serinetha trivittata Say. H.m., Je. 23, Au. 12. (12) On box-elder tree. Ill.

Stachyocnemis apicalis Dall. H.1, 2, 3, 5, Mol., Mer.; Je. 7, 8, 23, Au. 12, 14, 18, 22, 30. (69) In blowouts and on nearly bare sand. Excessively abundant at Devil's Hole one sunny day, but the next day, which was rainy, only one was found—under a cow-chip. Examples were seen apparently feeding on some bird droppings. No other Illinois records.

Alydus pilosulus H.-Schf. H.1, 2, Mol., Mer.; Je. 7, Au. 18, 30, S. 8. Nymphs, Au. 18. (21) Sandy ground among plants. On dry ground elsewhere in Illinois. The immature forms resemble ants.

Alydus conspersus Mont. Mol., S. 8. With the preceding species. Urbana.

Alydus eurinus Say. H.3, 4, 6, Mol.; Je. 5, 6, Au. 18, S. 8. Supposed nymph, Je. 6, 9. (7) With *A. pilosulus*. Ill.

Megalotomus 5-spinosus Say. H.1, 3, 4; Je. 6, 23, Au. 17, 20. (6) Ill.

Catorhintha mendica Stål (Osborn, det.). H.2, 3, 4, 5, 6; Je. 6, 8, 9, 12, 24, July 22, Au. 18. (26) Common on *Rhus aromatica*, *Allionia nyctaginea*, and a variety of other plants, especially along roadsides. Also from Camp Point (Adams Co.), Dixon, and Galena.

Chariesterus antennator Fabr. H.2, 3; Au. 12, 15. (3) On *Euphorbia corollata*. Tamaroa, Villa Ridge and Anna (S. Ill.).

Podisus maculiventris Say. H.5, Au. 17. Ill.

Perillus circumcinctus Stål. H.1, 2, 4; Je. 6, 8. Nymphs, Je. 5, 8, 23. (21) On *Rhus aromatica*, not uncommon. Makanda (S. Ill), and "N. Ill."

Thyanta custator Fabr. H.2, Au. 18, 19. (2) Ill.

Cosmopepla carnifex Fabr. H.4, Je. 6. (33) On *Scrophularia nodosa* and other plants in black-jack, clustered along stems. Ill.

Neottiglossa sulcifrons Stål. H. 4, Je. 6. (2) On vegetation of grassy open dunes. Dry hillsides in S. Ill.

Hymenarcys nervosa Say. H.4, Je. 6. Ill.

Cœnus delius Say. H.4, Je. 6. (3) Ill.

Euschistus fissilis Uhl. H.4, Je. 6. Ill.

Euschistus variolarius Pal. Beauv. H.2, 3, Mol.; Au. 14, 18, S. 8. (7) Ill. (Note 10)

Mormidea lugens Fabr. H.4, 5; Je. 5, 6, Au. 17. (4) Ill.

Pentatoma juniperina Linn. H.1, 2, 3, 4; Je. 6, Au. 13, 14, 18, 22. Nymphs, Je. 8 and in August. (35) Common on *Opuntia humifusa*, puncturing the tip of the fruit. Eureka and Mascoutah; Waukegan, on dwarf cedar (*Juniperus sabina*) along sand ridges near L. Michigan.

Peribalus limbolarius Stål. H.4, H.m.; Au. 20. (3) Ill.

Brochymena 4-pustulata Fabr. H.2, Je. 8. On trunks of elm along roadsides. Ill.

Sehirus cinctus Pal. Beauv. H.2, on *Monarda punctata*. Savanna and Galena (N. Ill.), on *Stachys* and sweet clover.

Pangæus bilineatus Say. H.2, Je. 8. Ill.

Cydnus obliquus Uhl. H.1, Au. 22. "N. Ill."

Cydnus, sp. (*Æthus*). H.2, Au. 19. (9) Nymphs under sticks in sandy hollow at lee of dune, under tree.

Homæmus æneifrons Say. H.4, Je. 6, Au. 20. (5) Swept from long grass on sand near black-jack. N. Ill. (Bolter Coll.); Lake Co., Ill., Au. 3. (Note 11)

Corimelæna ciliata Uhl. H.1, 2, 3; Je. 7, Au.12, 18. Very abundant in blow-sand about grass roots in June; also on plant stems in August. No other Illinois records.

Neuroptera.

Chrysopa plorabunda Fitch. H.2, Au. 18, 19. (3) Ill.

Chrysopa oculata Say. H.2, Au. 12, 13. (3) Ill.

Cryptoleon conspersum Ramb. H.4, Je. 5, 6. (4) Sand ridges near L. Michigan, Waukegan, Ill., Au. 22.

Cryptoleon signatum Hag. (Currie, det.). H.1, 2, 3, 4, H.m.; Je. 6, 7, 8, Au. 18, 19, 21, 22. (12) No other Illinois records.

Brachynemurus abdominalis Say (Adams, det.). H.m., August. Not rare in September. Ill.

Brachynemurus irregularis Currie (Currie, det.). H.m., Au. 21. No other Illinois record.

Myrmeleon immaculatus occidentalis Currie (Currie, det.). H.4, H.m.; Au. 20, 21. (4) No other Illinois records.

Coleoptera.

Cicindela scutellaris lecontei Hald. H.1, 3, 4, 6, H.m., Mol., Mer.; April, Je. 6, 23, Au. 18, 20, 22, 30, S. 4, 5, 6, 8. (58) Common on bare sand, especially in blowouts and roadways. Chicago; "N. Ill"; Peoria (Brendel); Fort Sheridan (Kwiat, '05); Waukegan.

Cicindela purpurea limbalis Klug. Mol., S. 8. Rock Island; "N. Ill."

Cicindela formosa generosa Dej. H.1, 2, 3, 4, 5, Mol., Mer., H.m.; Apr. 13, Je. 6, 7, 19, 23, 24, Au. 12, 13, 14, 17, 18, 20, 22, 29, 30, S. 4, 8. (45) Common with *C. scutellaris lecontei*. "N. Ill."; Peoria (Brendel).

Cicindela vulgaris Say. Mol., Mer.; Au. 30, S. 8. (3) Ill.

Cicindela repanda Dej. H.6, Mol., Mer., Thompson L.; Je. 8, 9, Au. 14, 29, S. 8. (68) Moist sandy shores; one example in blowout at Moline Sand Hill. Ill.

Cicindela 12-guttata Dej. Mol., S. 8. One example, taken in blowout at the Sand Hill. Ill.

Cicindela hirticollis Say. H.6, Je. 19. (2) Mud banks; sandy beach of L. Michigan, Waukegan. Ill.

Cicindela punctulata Fabr. H.1, 2, Matanzas L.; Je. 23, Au. 18, 22, 23. (6) Roadways and fields, if not very sandy; frequent Au. 24 on beach of L. Michigan at Waukegan, cast up by waves. Ill.

Cicindela cuprascens Lec. H.6, Mer.; Au. 10, 29. (4) Moist sandy margins of Illinois, Ohio, and Mississippi rivers, and L. Michigan, in Ill.

Cicindela lepida Dej. H.2, 3, Au. 14. In blowouts; not common. Savanna, on sandy island in Mississippi R.; N. Ill. (Bolter Coll).

Carabus sylvosus Say. H.2, Je. 8. (3) Under boards along lane in level ground. N. Ill. (Bolter Coll.); C. Ill.; Peoria (Brendel).

Calosoma externum Say. H.2, Je. 8. Ill.

Calosoma scrutator Fabr. H.m. (2) Ill.

Elaphrus ruscarius Say. H.6, Je. 8, 9. (2) Ill.

Pasimachus elongatus Lec. H.1, H.m., Teheran; Je. 7, Au. 17. (4) Ill.

Bembidium lævigatum Say. H.6, Je. 9. (3) Ill.

Patrobus longicornis Say. H.6, Mer.; Je. 8, 9, Au. 29, S. 5. (10) Ill.

Pterostichus sayi Brullé H.6, Je. 8. (3) Ill.

Pterostichus lucublandus Say. H.2, Je. 8. Ill.

Pterostichus caudicalis Say. H.6, H.m.; May 6, 15. (3) Ill.

Pterostichus erythropus Dej. H.6, Je. 9. Ill.

Amara cupreolata Putz. H.m., Apr. 13. Ill.

Loxandrus brevicollis Lec. H.6, May 6. "Ill."

Diplochila impressicollis Dej. H.m., April. Ill.

Platynus extensicollis Say. H.6, Je. 9. Ill.

Platynus decorus Say. H.6, Thompson L.; Feb. 26, May 6, S. 1. (4) Ill.

Platynus octopunctatus Fabr. H.6, Je. 8. (5) Ill.

Platynus placidus Say. H.6, Je. 12. Ill.

Zuphium longicolle Lec. H.m.

Tetragonoderus fasciatus Hald. H.5, 6; Je. 12, 22, July 22. (3) Dry sand of river banks. Grafton, Quincy, Savanna; Peoria (Brendel).

Lebia scapularis Dej. Matanzas L., Au. 23. Ill.

Callida purpurea Say. Teheran, Je. 22. Peoria (Brendel).

Chlænius erythropus Germ. H.6, H.m.; May 6, 21. (3) Ill.

Chlænius sericeus Forst. H.6, Thompson L.; May 6, Je. 8, 9, S. 1. (11) Moist shores, under driftwood. Ill.

Chlænius prasinus Dej. H.6, Matanzas L., Thompson L.; Je. 9, Au. 23, S. 1. (8) Ill.

Chlænius pennsylvanicus Say. H.6, H.m., Matanzas L., Thompson L.; Feb. 26, April, May 6, Au. 23, S. 1. (6) Ill.

Chlænius impunctifrons Say. H.6, May 6. Ill.

Anomoglossus emarginatus Say. H.6, S. 5. (2) Ill.

Oodes cuprœus Chaud. H.6, Matanzas L., Thompson L.; Au. 6, 23, S. 21, 24. (10) Pekin and Carmi.

Geopinus incrassatus Dej. H.1, 6, H.m.; Apr. 13, Je. 7, 8, Au. 22. (10) Under sticks in blowout, and at electric lights. Ill. Seems to prefer sandy places.

Nothopus zabroides Lec. H.1, 2, 3, H.m.; Au. 14, 18, 19, 22, S. 16. (11) A common species under boards and logs on blow-sand and in blowouts. Many were seen in such situations at Devil's Neck June 7, but all were dead. Ill. (Bolter Coll.); C. Ill.; found also in the West on sandy stretches, *fide* Wickham (Wolcott).

Cratacanthus dubius Beauv. H.1, Au. 22. Common under sticks and boards in blowout at Devil's Neck. One found captured by a tiger-beetle, *Cicindela formosa generosa*. Ill.

Harpalus erraticus Say. Mol., S. 8. (11) Under sticks and cow-chips at edge of pasture on the Sand Hill, in company with another pallid species, *H. testaceus*. Illinois R. valley in La Salle Co.; Quincy. Inhabits sandy places.

Harpalus caliginosus Fabr. H.1, 3, 4, Mol.; Au. 14, 17, 20, 22. (12) Common under boards on sand. Ill.

Harpalus faunus Say. Mol., S. 8, Ill.

Harpalus herbivagus Say. H.1, Mol.; Je. 7, S. 8. (2) Ill.

Harpalus testaceus Lec. H.1, Mol.; Au. 22, S. 8. (2) Under boards

in blowout at Devil's Neck, also with *H. erraticus*. S. Ill. (Bolter Coll.); E. Cairo, Ky.; Quincy, September.

Stenolophus ochropezus Say. H. 6, Thompson L.; Apr. 14, Au. 14. (3) Ill.

Stenolophus dissimilis Dej. H.6, Feb. 26, S. 16. (4) Ill.

Anisodactylus rusticus Say. H.1, 2, Mol., H.m.; Apr. 13, Au. 18, 19, 20, S. 8. (17) Very common under boards and logs on sand, especially in blowout at Devil's Neck. Ill., generally distributed.

Anisodactylus carbonarius Say. H.4, Au. 20. Ill.

Anisodactylus discoideus Dej. H.6, Je. 8, 9. (11) A common river-shore species under driftwood on sand. Ill.

Anisodactylus baltimorensis Say. H.6, Je. 8. Ill.

Anisodactylus verticalis Lec. H.6, Je. 8. (2) Ill. (Bolter Coll.); Peoria (Brendel).

Anisodactylus piceus Lec. H.1, Au. 22. (6) Under boards in blowout at Devil's Neck. Ill.

Harpalini, n. sp. Mol., S. 8. With *Harpalus erraticus*. (Note 12)

Sphæridium scarabæoides Linn. Mol., S. 8. One specimen, with *Harpalus erraticus*. Introduced on Atlantic coast and spreading westward. Not previously reported west of the lake shore at Chicago. It was found there by me last spring also, Apr. 28, 1906, washed up by the waves in large numbers, about 80 specimens being taken. (See also Kwiat, '05.)

Cercyon analis Payk. H.6, Je. 7. Ill.

Silpha surinamensis Fabr. H.m., Je. 7. Ill.

Silpha inæqualis Fabr. H.6, Je. 8. (14) About carrion on sandy shore. Ill.

Silpha noveboracensis Forst. H.4, Je. 6. Ill.

Staphylinus maculosus Grav. H.6, Je. 8. Ill.

Staphylinus tomentosus Grav. H.6, May 6. Ill.

Bledius fumatus Lec. Mer., Au. 29. Ill., a common shore species.

Eustilbus apicalis Mels. H.6, Feb. 26. Ill.

Hippodamia glacialis Fabr. H.4, Au. 20. Ill.

Hippodamia convergens Guer. H.2, Au. 12. Ill.

Neoharmonia venusta Mels. H.6, July 8, on willow. Ill. (Bolter Coll.).

Coccinella 9-notata Hbst. H.2, 3, H.m.; Apr. 13, Au. 12, 18. (12) On sand plants. Ill.

Adalia bipunctata Linn. H.1, 6; Je. 8, 9, 23. (4) "Ill." (Bolter

Coll., one specimen); Jacksonville, from correspondent. Lately ('05, '06) seen occasionally about Urbana. Chicago ('06). No other Illinois records.

Hyperaspidius trimaculatus Linn. H.4, Je. 6. No other Illinois record. (Note 13)

Languria bicolor Fabr. H.2, Je. 8. (10) On stems of *Mesadenia atriplicifolia*, in which the larvæ burrow. Also found thus at Champaign. "Ill."; Normal; Peoria (Brendel).

Ischyrus 4-punctatus Oliv. H.5, Je. 8, Ill.

Attagenus piceus Oliv. H.m., Je. 8. Ill.

Cryptorhopalum, sp. H.4, Je. 6. (3)

Hister interruptus Beauv. H.6, Je. 8. (2) Ill.

Hister abbreviatus Fabr. H.m. Ill.

Saprinus ferrugineus Mars. H.4, Je. 6. No other Illinois record.

Saprinus fraternus Lec. H.6, Je. 8, 9. (15) Abundant, feeding on dead fish along sandy shore. Ill.

Saprinus patruelis Lec. H.1, Je. 7. "N. Ill."

Tenebrioides mauritanica Linn. Teheran, Au. 17. In food stuffs.

Ptilodactyla serricollis Say. H.1, Je. 7. Ill.

Lacon rectangularis Say. H.1, 4; Je. 5. (7) Common under boards in dry sandy pasture. Grand Tower and Pekin, under boards along banks of Mississippi and Illinois rivers respectively. Peoria (Brendel).

Cardiophorus convexus Say. H.2, 4; Je. 5, 6, 8. (3) Ill. (Bolter Coll.).

Monocrepidius vespertinus Fabr. H.5, Teheran; Je. 16, 22, July 22. (9) Anna and Grand Tower (S. Ill.); Peoria (Brendel).

Melanotus communis Gyll. H.6, May 6 (larva). Ill.

Melanotus infaustus Lec.? H.1, 2; Je. 7, 8. (4) Ill.

Limonius quercinus Say. H.2, 4; Je. 6, 8. (43) Abundant on oak sprouts in grove at foot of sand ridge. Ill. (Bolter Coll.).

Chrysobothris femorata Fabr. H.m. Ill.

Acmæodera tubulus Fabr. H.1, H.m; Je. 23. (3) In flowers of *Opuntia* and *Chrysopsis*. "N. Ill.", Galesburg, Hudson, Cobden, Villa Ridge; Apr. 28, May 29, September; Peoria (Brendel); Carlinville, on *Hypoxys erecta* (Rob.).

Agrilus egenus Gory. H.1, Je. 7. (2) Ill.

Calopteron terminale Say. H.4, Au. 20. (4) With the next species. Ill. (Note 14)

Calopteron reticulatum Fabr. H.1, 2, 4, Mol.; Au. 19, 20, 22, S. 8. (20) Common on plants at sides of roadway through blackjack. Ill. (Note 14)

Lucidota atra Fabr. H.4, Je. 6. Ill.

Photuris pennsylvanica DeG. H.6, Je. 9. Ill.

Chauliognathus pennsylvanicus DeG. H.2, Au. 12. Ill.

Collops tricolor Say. H.1, 4, Je. 6, 23. (7) In *Opuntia* flowers. Peoria (Brendel).

Anthocomus erichsoni Lec. H.6, Je. 12. (2) Villa Ridge.

Anthocomus, sp. H.4, Je. 5.

Clerus thoracicus Oliv. H.4, Je. 6. Towanda, Villa Ridge, Peoria (Brendel).

Hydnocera subœnea Spin. H.4, Je. 6. Ill. (Bolter Coll.).

Hydnocera pallipennis Say. H.5, Au. 12. "N. Ill.", Pekin.

Lucanus placidus Say. H.1, 4, 6; Je. 6, 7, 9. (7) Coming out of ground at dusk beneath shade trees along street of Forest City. Chicago; Peoria (Brendel). (Note 15)

Canthon nigricornis Say. H.1, Teheran; Je. 22, Au. 22. (3) Under dry animal remains in blowout at Devil's Neck. Peoria (Brendel).

Canthon lœvis Drury. H.2, H.m.; Je. 7. (8) Common along roadways in level ground. Ill.

Copris carolina Linn. H.m. Ill.

Onthophagus hecate Panz. H.1, 4; Je. 6, 7. (2) Ill.

Onthophagus pennsylvanicus Harold. H.1, Je. 7. (9) Common about horse droppings in road near Devil's Neck. Ill.

Aphodius rubeolus Beauv. H.1, Je. 7. (2) With the preceding species. C. Ill.

Bolbocerus lazarus Fabr. H.m. Ill.

Trox scabrosus Beauv. H.1, Je. 7, Au. 22. With *Canthon nigricornis*. No other Illinois record.

Trox suberosus Fabr. H.m. Ill.

Lachnosterna prunina Lec. H.1, Je. 7. "N. Ill."; Peoria (Brendel).

Polyphylla hammondi Lec. H.5, Au. 17. Lying dead on bare blow-sand. No other Illinois record.

Anomala binotata Gyll. H.6, H.m.; Apr. 13, May 6, 21. (3) Ill.

Strigoderma arboricola Fabr. H.1, 2, 4; Je. 6, 7, 8, 23. (53) On flowers of clover, rose, *Opuntia humifusa*, and *Monarda punctata*. Ill.

Ligyrus gibbosus DeG. H.m., Apr. 13. Electric light. (2) Ill.
Ligyrus relictus Say. H.m., Je. 7. Electric light. Ill.
Euphoria sepulcralis Fabr. H.2, 3, Matanzas L.; Au. 14, 16, 18, 30. (7) In tops of various herbaceous plants. Common in southern Illinois.
Trichius piger Fabr. H.2, 4, 6; Je. 6, 8, 9. (3) On flowers of wild rose. Ill.
Parandra brunnea Fabr. H.2, H.m.; Au. 18. (3) Under log in grove at Devil's Hole. Ill., infesting the bases of fruit and shade trees.
Orthosoma brunneum Forst. H.m. Ill.
Physocnemum brevilineum Say. H.6, Je. 12. Ill.
Romaleum simplicicolle Hald. H.m. No other Illinois record.
Batyle suturalis Say. H.4, Au. 20. Ill.
Xylotrechus colonus Fabr. H.m. Ill.
Neoclytus erythrocephalus Fabr. H.4, Pekin; Je. 5, 6. (2) Ill.
Typocerus velutinus Oliv. H.6, Je. 9. On willow. Ill.
Typocerus sinuatus Newm. Teheran, Je. 22. Ill.
Mecas pergrata Say. H.1, 4; Je. 6, 23. (4) Dry soils of Illinoian glaciation in southern Illinois.
Oberea tripunctata Swed. H.2, Je. 8. Ill.
Tetraopes tetraophthalmus Forst. H.2, 4; Je. 6, 8, July 1. (3) On *Asclepias cornuti*. Ill.
Tetraopes femoratus Lec. H.3, Matanzas L., Mol.; Au. 15, 16, S. 9. (8) On *Asclepias*. Ill.
Lema cornuta Fabr. H.2, 3; Au. 18, 19. (11) On leaves of *Commelina virginica*, gnawing the surface and causing whitened streaks. Richardson ('92) describes a similar injury to this plant by *L. sayi*. He found its eggs placed singly in the folds of the central leaf about the flower stalk, and the larvæ,—which were white, with a black spot on the second segment,—eating down an inch or two into the soft stalk. Knaus ('01) found *L. cornuta* feeding on dock near sand-hills in Kansas. Sand-dunes of N. W. Ind. (Kwiat '05).
Cryptocephalus 4-maculatus Say. H.6, Je. 9. Ill.
Cryptocephalus mutabilis Mels. H.4, Au. 20. Ill.
Pachybrachys pubescens Oliv. Teheran, Je. 22. Ill.
Monachus ater Hald. H.4, Je. 6. (2) Ill.
Monachus saponatus Fabr. H.4, Je. 6. (3) Ill.
Graphops nebulosus Lec. H.4, Je. 6. (2) Ill.

Typophorus aterrimus Oliv. H.4, Je. 6. Ill.

Metachroma angustulum Cr. H.2, 4, 6; Je. 5, 6, 8, 9. (21) Abundant on Carolina poplar, willow, *Œnothera biennis*, and other plants, on sand-dunes and along the river shore. No other Illinois records.

Metachroma parallelum Horn. H.1, 2, 4, 6; Je. 6, 7, 8, 9. (30) Very abundant on willow, *Œnothera biennis*, and other plants, in company with the preceding species. Peoria (Brendel).

Leptinotarsa 10-lineata Say. H.2, Au. 19. Ill.

Zygogramma suturalis casta Rog. H.2, 4; Je. 5, Au. 18, 19. (4) Ill.

Chrysomela auripennis Say. H.1, H.m.; Je. 7, S. 29. (2) Normal, Galesburg, and Waterman, May, Je. 14, and August; "N. Ill."; Ill. (Bolter Coll.). Sand-dunes of N. W. Ind. (Kwiat '05).

Melasoma lapponica Linn. H.1, 6; May 21, Je. 7, 8, 9. (14) On willows in sand-dune hollows and along river shore. Ill.

Melasoma scripta Fabr. H.6, Je. 8, S. 4. (4) On willows along river shore. Ill.

Cerotoma trifurcata Forst. H.4, Je. 6. (4) Ill.

Diabrotica 12-punctata Oliv. H.2, Je. 8, Au. 12, 13, 18, 19. (5) Ill.

Diabrotica longicornis Say. H.2, Teheran; Au. 17, 18. (4) Ill.

Galerucella notulata Fabr. H.4, Je. 6, Au. 20. (3) Ill.

Blepharida rhois Forst. H.1, 2, 4; Je. 5, 6, 8, 23. (52) Larvæ, Je. 5. Common on *Rhus aromatica*, sometimes defoliating it. Ill.

Œdionychis vians Ill. H.6, Je. 9. Ill.

Œdionychis thyamoides Cr. H.4, Je. 6. (2) Ill.

Disonycha pennsylvanica Ill. H.1, 4, 6; May 6, Je. 6, 7, 8, 9. (6) On willow. Ill.

Disonycha 5-vittata Say. H.1, Je. 7, Au. 22. (3) On willow in dune hollows. Same situation, Waukegan, near L. Michigan. Ill.

Disonycha triangularis Say. H.6, Je. 8. Ill.

Haltica fuscoænea Mels. H.2, 4, 5; Je.6, 8, July 22, Au. 12. (14) On *Œnothera biennis*, its food plant. No other Illinois records.

Systena blanda Mels. H.4, Je. 6. (4) Ill.

Chalepus smithi H. Donck. (*Odontota horni*). H.4, Au. 20. No

other Illinois record. N. W. Ind., coll. by Wolcott (see Kwiat '05).

Chalepus dorsalis Thunb. (*Odontota*). H.1, Je. 7. (3) Ill.

Coptocycla clavata Fabr. H.1, Je. 7. Bloomington and Kappa, Mar. 8, July 14; N. Ill. (Bolter Coll.); Peoria (Brendel).

Bruchus cruentatus Horn. H.2, Au. 18. (8) On *Cassia chamæcrista*, probably breeding in the seeds. Ill.

Bruchus hibisci Oliv. H.4, Je. 6. (2) Camp Point and Normal, Ill.

Zabrotes, n. sp. H.2, Au. 18.

Epitragus acutus Lec. H.1, 2, 3, 4, 5, 6, H.m.; July 22, 30, Au. 3, 12, 14, 18, 19, 20, 22. (23) On flowers of *Mesadenia atriplicifolia*. No other Illinois records.

Scotobates calcaratus Fabr. H.1, Je. 7. Ill.

Xylopinus saperdioides Oliv. H.1, Je. 7. Ill.

Tenebrio molitor Linn. H.m. (2) Ill.

Opatrinus notus Say. H.1, Je. 7, 8, Au. 22. (21) Common under boards in dry sandy pasture in company with *Lacon rectangularis*. On sandy land in Texas (Hart, '06) the same association is conspicuous, except that *O. notus* is replaced by the allied species *aciculatus*. Ill.

Blapstinus interruptus Say. H.6, Je. 8, 9, 12. (4) In dry bare sand along upper slope of river bank. Ill. (Bolter Coll.). Collected by Wolcott in "Chicago Area" (Kwiat '05). On sand near Waukegan, Au. 18.

Hymenorus obscurus Say. H.1, Je. 7. Ill.

Nothus varians Lec. H.4, Je. 5. (3) Ill. (Lec.).

Mordella scutellaris Fabr. Teheran, Je. 22. Ill.

Mordella octopunctata Fabr. H.6, Je. 9. Ill.

Mordella marginata Mels. H.4, H.m.; Je. 5, 6, July 12. (5) Ill.

Mordellistena biplagiata Helm. H.2, 4; Je. 5, 8. (2) "N. Ill., June"; Carlinville (Rob.).

Stereopalpus mellyi Laf. H.1, Je. 7. (3) Rock Island; sand ridges near Waukegan, Au. 23.

Notoxus bifasciatus Lec. Teheran, Je. 22. Ill.

Macrobasis unicolor Kirby. H.1, 2, Mer.; Je. 8, 23, Au. 30. On *Cracca virginiana*. (18) Ill.

Epicauta pennsylvanica DeG. H.1, 2, 4; Je. 6, 7, 8. (7) Ill.

Rhipiphorus pectinatus Fabr. H.2, Au. 18, 19. (2) On plants on dune slopes. Ill.

Attelabus bipustulatus Fabr. H.2, Je. 8. On *Œnothera biennis* stems on sand-dunes. Villa Ridge, September; Peoria (Brendel).

Phacepholis candida Horn. H.1, 2, 4; Je. 6, 7, 8. (22) Abundant on stems of plants along the railroad in low ground near Forest City. Urbana. (Note 16)

Phytonomus comptus Say. H.6, Je. 8. (5) Ill.

Lixus concavus Say. H.2, Je. 8. Ill.

Magdalis armicollis Say. H.2, 6; Je. 8, 12. (3) On elm along roadside. Ill.

Rhyssematus lineaticollis Say. H.3, Au. 15. On *Asclepias cornuti*. Morris, July 19; "N. Ill."

Chalcodermus collaris Horn. H.2, Je. 8, Au. 12. (14) Common on *Œnothera biennis* on dune slopes. Knaus ('93) found "a fine lot" about Kansas sand-dunes, which he thought bred in the seed pods of the *Yucca* which was abundant along the sides of the blowouts. There is no wild *Yucca* in this valley. Chittenden thinks its habits are probably similar to those of *C. æneus*, which breeds in cow-peas. No other Illinois records.

Tyloderma foveolatum Say. H.6, Je. 8. On stems of *Œnothera biennis*, in which the larvæ breed. Ill.

Acanthoscelis acephalus Say. H.2, Je. 8. Ill. (Bolter Coll.); Peoria (Brendel). Occurs on *Œnothera biennis*.

Trichobaris trinotata Say. H.4, Je. 5. Ill.

Centrinus picumnus Hbst. H.4, Je. 6. Ill.

Rhodobænus 13-punctatus Ill. H.2, Je. 8. Ill., on cocklebur.

Lepidoptera.

Pyrameis huntera Fabr. H.2, Au. 12, roadside. Ill.

Apatura celtis Boisd. & Lec. H.2, Au. 18, roadside. Ill.

Apatura clyton proserpina Scudd. H.2, Au. 18, roadside. Ill.

Thecla melinus Hübn. H.2, Au. 13, roadside. Ill.

Chrysophanus hypophlæas Boisd. H.2, Au. 13, roadside. Ill.

Pieris protodice Boisd. & Lec. H.2, Au. 13, roadside. Ill.

Colias philodice Godt. H.3, Au. 18. Ill.

Terias lisa Boisd. H.2, 3; Au. 13, 14. (2) Ill.

Pamphila zabulon Boisd. & Lec. H.3, Au. 17. Ill.

Pamphila metacomet Harr. H.2, Au. 13. Ill.

Pyrgus tessellata Scudd. (Skinner, Ent. News, Vol. XVII., p. 277.) H.3, Au. 17. Common along roadways in sand region. Ill.

Eudamus tityrus Fabr. H.2, Au. 18, roadside. Ill.

Eubaphe aurantiaca brevicornis Walk. H.2, Je. 8. (2) Frequent on sand-dunes. Ill.

Estigmene acræa Drury. H.3, Au. 17. Ill.

Chloridea virescens Fabr. H.1, 6; Je. 8, Au. 11. Urbana; Ill. (Bolter Coll.).

Heliocheilus paradoxus Grote. H.2, 5; Je. 17. Au. 12, 13. (2+) These curious little noctuids dance up and down in stationary groups of usually two to four at twilight, in open sandy ground, near the level of the tops of plants. The subcostal and discal cells of the male fore wings are greatly enlarged, transversely ribbed, and usually denuded. While they are dancing, a continuous rapid series of sharp ticks is heard, exactly like that of a watchman's rattle, but of diminutive volume, yet easily heard fifty feet away. This is probably effected by the male's extending the fore legs and rasping the tibial spurs against the corrugated cell-membranes during flight. Urbana, Au. 28 and S. 29, in gravel-cut on railroad.

Schinia arcifera Guen. H.2, Au. 13. Ill.

Xanthoptera semiflava Guen. (Dyar, det.). H.3, Au. 17. Ill.

Acontia lactipennis Harvey. H.1, 4; Je. 6, 7. (2) This handsome Texan species is new to Illinois.

Ypsia undularis Drury. H.1, Je. 23. Ill.

Sesia tipuliformis Linn. (Dyar, det.). H.2, Au. 13. Ill.

Meroptera eviatella Dyar (Dyar, det.). H.4, Je. 5. Recently described (Proc. Ent. Soc. Wash., Vol. VII., p. 34) from Chicago, and named after the collector, Mr. A. Kwiat. This may be a sand-region species, common to the Lake Michigan and Illinois valley areas.

Crambus haytiellus Zinck. (Dyar, det.). H.2, Au. 12. Not infrequent about sand blowouts. Described from Hayti and listed from Texas. No other records found.

Olethreutes dimidiana Sodoff? (U. S. Bur. Ent., det.). H.1, 2; Je. 7, 8 (all immature). In these two localities many cylindrical tubes of webbed sand were found extending up the stems of *Onagra biennis*, *Cassia chamæcrista*, and *Ambrosia*(?), often as much as two feet long, and following most of the stems of a plant, reaching the top, where the new growth had been fed upon. In one case a short tube was formed on the surface of the bare sand. These tubes closely resemble those figured

by Daecke ('05) for *Prionapteryx nebulifera*, from sand areas in New Jersey. In these tubes were found small and very active tortriciform larvæ. Mr. J. J. Davis, of the University of Illinois, submitted an example to Mr. Daecke, who replied that it was not the same as his species. Mr. Davis was successful in securing an adult from these larvæ June 30, and the Bureau of Entomology at Washington has determined it for him as *Olethreutes dimidiana*, a European species, reported also from Missouri. The larva of this species, however, according to Treitschke, is quite differently marked from our specimens, feeds on birch and elder, and occurs in August instead of June, pupating in September and emerging the following May.

DIPTERA.

Tipula, sp. H.6, S. 4.

Spogostylum albofasciatum Macq. H.3, Au. 18. No other Illinois record.

Exoprosopa fasciata Macq. H.1, 2, 4, 5; Au. 12, 17, 18, 20, 22. (9) Ill.

Exoprosopa fascipennis Say. H.3, Teheran; Au. 14, 17. (2) Ill.

Anthrax lateralis Say. From a pupa apparently of the ordinary noctuid type, taken by Mr. Davis at the Devil's Hole June 8, an adult of this species emerged July 1. The species of this genus rest quietly—making occasional short flights—about roadways and bare sandy places. Ill.

Anthrax hypomelas Macq. H.6, S. 5. This species has been bred from cutworms (Ins. Life, Vol. II. p. 353). No other Illinois record.

Anthrax halcyon Say. H.6, S. 4. Savanna, July 22; Carlinville (Rob.).

Anthrax fulvohirta Wied. H.2, 3; Au. 12, 18. (2) Ill.

Anthrax sinuosa Wied. H.6, Je. 9. Matteson, July 8; Carlinville, on *Psoralea onobrychis* (Rob.).

Systœchus vulgaris Loew. H.1, 2, 3; Au. 18, 22. (5) On flowers. Ill.

Phthiria sulphurea Loew. H.2, 4; Au. 18, 20. (2) Roadside plants. Cockerell has noted it resting on composite flowers of the same color as itself. Ill.

Psilocephala pictipennis Wied. H.4, 6; Je. 6, 9. (2) No other Illinois records.

Psilocephala hæmorrhoidalis Macq. H.2, 4; Je. 6, Au. 18. (2) Resting on bare sand. Ill.

Laphystia 6-fasciata Say. H.2, 4; Je. 6, 7. (2) On the bottoms of deep blowouts in company with *Microbembex monodonta*, which it somewhat resembles, especially when in action. No other Illinois records. Common at the seashore. (Note 17)

Dasyllis grossa Fabr. H.4, July 1. No other Illinois record.

Proctacanthus brevipennis Wied. H.1, 2, 4; Je. 6, 7, 8, 23. (6) Flying about vegetation in sandy places, and alighting on or near the ground. No other Illinois records. These "robber-flies" prey on other insects.

Proctacanthus milbertii Macq. H.2, 3, 4; Au. 15, 18, 19, 20. (9) With the preceding species; said to prey upon honey-bees and grasshoppers. Sand ridges near L. Michigan, Waukegan. *Asilus agrion* Jaennicke, a doubtful synonym, is the only other record for Illinois.

Erax æstuans Linn. H.1, 4; Je. 6, 7. (8) Common along sandy roads near the Devil's Neck. La Salle Co., Mt. Carmel, Urbana, sand at Waukegan; Au. 16, 28, S. 25.

Promachus vertebratus Say. H.1, Au. 22. Ill. A common robber-fly.

Asilus angustifrons Will. (Coquillett, det.). H.6, Je. 9. No other Illinois record.

Rhadiurgus leucopogon Will. (Coquillett, det.). H.2, 3; Au. 12, 17, 18. (8) This robber-fly is common at Devil's Hole. No other Illinois records.

Mesogramma politus Say. H.2, Au. 19. Ill.

Mesogramma marginata Say. H.2, Au. 19. Ill.

Volucella fasciata Macq. H.1, 2, 3, 4; Je. 6, 8, 23, Au. 12, 13, 14, 17, 18, 19. (14) This odd little syrphid is one of the characteristic blow-sand species. The larvæ breed in the tissues of the cactus (*Opuntia humifusa*) which grows abundantly in this region (Smith, '91, Williston, '91). The adults are often seen flying about, and abound on roadside flowers, such as *Verbena*, dandelion, sweet clover, etc. No other Illinois records.

Conops sylvosus Will. H.3, Au. 14. No other Illinois record.

Conops xanthopareus Will. H.1, 2, 4; Je. 6, 7, Au. 18. (4) Ill.

Zodion obliquefasciatum Macq. (*leucostoma* Will.). H.2, 6, Pekin; Au. 12, 18. (3) Urbana and Sandwich; July 25 and 28. Carlinville (Rob.).

Cistogaster immaculata Macq. H.2, Je 8. Ill.

Ocyptera carolinæ Desv. H.2, 4; Je. 6, 8. (3) Ill.

Sturmia albifrons Walk. (Coquillett, det.). H.2, Au. 19. (2) Ill.

Phormia terrænovæ Desv. (Coquillett, det.). H.2, Au. 18, 19. (4) Very common on *Cassia chamæcrista* at Devil's Hole. A common species of house-fly.

Musca domestica Linn. H.2, Au. 18. Not infrequent at Devil's Hole. The common house-fly.

Anthomyia pratincola Panz. (Coquillett, det.). H.2, Au. 18. No other Illinois record.

Cœnosia lata Walk. (Coquillett, det.). H.2, Au. 19. No other Illinois record.

Rivellia viridulans Desv. H.4, Je. 6. (2) Ill.

Rivellia 4-fasciata Macq. H.2, 6; Je. 9, Au. 19. (3) Common on plants along the river shore. Ill.

HYMENOPTERA.

Tenthredo verticalis Say. H.4, Je. 6. Ill. (Bolter Coll.).

Dolerus arvensis Say. H.5, Apr. 14. Ill.

Monophadnoides rubi Harr. H.2, Je. 8 (larvæ). On raspberry by roadside. Ill.

Schizocerus, n. sp. (Ashmead, det.). H.3, Au. 14. Common on undetermined low plants at edge of blowout, associated with *Chelonus*, and closely imitated by it. (See *Chelonus texanus*, below.)

Iphiaulax eurygaster Brullé. H.4, Au. 20. Ill.

Cardiochiles apicalis Cress. (Ashmead, det.). H.2, Au. 18. (5) Ill.

Microdus sanctus Say (Ashmead, det.). H.4, Je. 6. (2) Ill.

Chelonus texanus Cress. (Ashmead, det.). H.3, Au. 14. Examples of *Chelonus* were very abundant in association with an undescribed *Schizocerus*, so closely resembling it when in action that the two were hard to distinguish. Two *Chelonus* were taken, and proved to be one each of this and the next species. No other Illinois record.

Chelonus angheri La Mun. (*Ascogaster*) (Ashmead, det.). H.3, Au. 14. (See the preceding species.) No other Illinois record.

Exochilum fuscipenne Nort. (Ashmead, det.). H.2, 5; Au. 12, 13. (2) Ill.

Nototrachys canadensis Prov. (Ashmead, det.). H.2, Au. 19. Ill.

Enicospilus purgatus Say. H.1, 6; Au. 22, S. 4. (5) Ill.

Lampronotus mellipes Prov.? ("*mellipes* Say"; Ashmead, det.). H.6, Je. 9. No other Illinois record known to me.

Amblyteles nubivagus Cress. H.5, 6; Je. 9. (2) Ill.

Ichneumon subcyaneus Cress. H.m., Au. 19. Ill.

Formica fusca Linn. H.2, Au. 19. Ill.

Formica pallidefulva schaufussi Mayr. H.2, Au. 18, 19. (5) Very few ants' nests were seen in the blow-sand. Ill.

Lasius niger americanus Linn. Mol., S. 8. Males and females swarming from a large nest in the coarse grass on the slope of the Sand Hill. Ill.

Lasius latipes Walsh. Mol., S. 8. (2) Examples under boards at edge of pasture on the Sand Hill, along with the pallid harpaline beetles. Rock Island (Walsh); Muncie.

Prenolepis fulva Mayr? H.5, Au. 17. (7) Nesting in sand in a thicket. Ill.

Camponotus herculaneus Linn. H.5, Au. 17. In same place as preceding species. Ill.

Myrmica rubra scabrinodis schencki Emery. H.5, Au. 17. (3) In thicket with the two preceding species. Ill.

Pheidole vinelandica Forel (Ashmead, det.). H.5. A sand-inhabiting species. No other Illinois record.

Monomorium minutum Mayr (Ashmead, det.). H.2, Au. 18. Ill.

Sphærophthalma, n. sp. (Melander, det.). Mol., S. 8. (2) Belongs to *simillima* group.

Sphærophthalma harmonia Fox (Melander, det.). H.2, 3; Au. 14, 18. (13) One of the commoner species of the Illinois valley blow-sand areas. Sand-dunes in N. W. Ind. (Melander, '03); Pine Hills, Union Co. (S. Ill.), Au. 11.

Sphærophthalma occidentalis Linn. H.2, 3, Mer., Pekin; Au. 12, 13, 14, 17, 29. (6) Occasional. The Mason Co. examples are all a golden ochre color. The Meredosia specimen is of the usual scarlet color of the species, as are also the State Laboratory specimens, which are all from southern Illinois. Mason Co. is near the northern limit of its range.

Sphærophthalma 4-guttata Say. H.2, 3, Mol.; Au. 12, 14, 18, S. 8. (7) Savanna, Normal, and Metropolis; July 25, 26, Au. 18, September.

Sphærophthalma ferrugata Fabr. (Melander, det.). H.1, 2, 3, 4, 5, Mol.; Au. 14, 17, 18, 20, 22, S. 8. (15) Another common species of our sand regions.

Sphærophthalma vesta Cress. (Melander, det.). H.4, Au. 20. No other Illinois record.

Sphærophthalma canella Blake (*rugulosa* Fox) (Melander, det.). Mol., S. 8. No other Illinois record.

Sphærophthalma chlamydata Mel. H.1, 2, 3, 4, 6, H.m., Mer.; Je. 23, Au. 12, 14, 15, 18, 29, S. 5. (80) H.3 (Melander, '03, *chlamydata*). The leading species of velvet ant in the Illinois-valley sand area. It will be noted that with the exception of a single *Methoca bicolor* no *Mutillidæ* whatever were seen during the early June visit to the Illinois valley region. (Note 18)

Sphærophthalma agenor Fox (Melander, det.). H.2, 4, Mol.; Au. 18, 20, S. 8. (7) Ill.

Sphærophthalma macra Cress. H.2, Au. 18. Ill. (Note 19)

Timulla hexagona Say. H.2, 6; Au. 18, S. 5. (3 males) Ill.

Timulla dubitata Smith. H.1, 3 (Melander, '03), 4; Au. 20, 22. (4 females) Ill. Probably female of *hexagona*.

Methoca bicolor Say (Ashmead, det.). H.6, Je. 9; the only mutillid taken in early June. Lake Co. Ill., in gravel-pit (Melander, '03).

Tiphia punctata Rob. H.2, 3; Au. 13, 14, 18. (9) Ill.

Dielis plumipes Drury. H 2, 4, 6, Pekin; Je. 6, 8, Au. 15. (54 males, 2 females) Abundant on dandelion and sweet clover flowers along roadsides at Forest City and the Devil's Hole in June. N. Ill. (Bolter Coll.); Rock Island, Savanna, Fox L.; July 26, 30. Carlinville (Rob.).

Trielis octomaculata Say. H.3, Au. 14. The thorax of this example is black except for three very small yellowish dots on the collar. No other Illinois record.

Discolia bicincta Fabr. H.5, Au. 17. Ill.

Plesia namea Fabr. (*Myzine*) (Ashmead, det.). H.2, Au. 18. (2) Common on flowers of *Mesadenia atriplicifolia*. Ill.

Plesia interrupta Say. H.2, 3, H.m., Teheran; Au. 12, 13, 14, 17, 18, S. 25. (10) Ill.

Plesia, sp. (Ashmead, det.). H.2, H.m.; July 1, Au. 18, S. 25. (4)

Plesia obscura Fabr. (Ashmead, det.). H.2, 3, 6, H.m.; July 29, Au. 12, 14, S. 10. (5)

Hedychrum obsoletum Say. H.1, 2; Au. 12, 22. (2) Ill.

Ancistrocerus campestris Sauss. H.4, Au. 20. Ill.

Odynerus pedestris Sauss. H.2, Au. 18. Ill.

Odynerus geminatus Cress. (Ashmead, det.). H.2, Au, 18. (2) No other Illinois record.

Odynerus dorsalis Fabr. H.2, Au. 13, 19. (2) Ill.

Polistes pallipes St. Farg. H.2, 4; Au. 12, 18, 20. (6) Common on *Cassia chamæcrista*.

Vespa cuneata Fabr. H.2, 4, Mer.; Je. 6, 8, Au 30. (11) On fresh watermelon rinds in sandy road. Abundant at Du Bois about cider-mill August 24; Normal, July 28; Aldridge, Au. 11; Carlinville, on *Aster ericoides villosus* (Rob.).

Vespa germanica Fabr. H.4, Je. 6, Au. 20. (8) Ill.

Ceropales fulvipes Cress. H.2, Au. 18. Ill.

Anoplius ingenuus Cress. (*Pompilus*). H.1, 4; Je. 7, Au. 20. (2) Ill.

Anoplius scelestus Cress. H.2, 4; Au. 12, 20. (2) Ill.

Anoplius atrox Dahlb. H.2, Au. 12. Ill.

Anoplius philadelphicus St. Farg. H.6, Au. 30. Ill.

Anoplius tropicus Linn. H.1, 2, 3; Je. 7, Au. 17, 18, 19. (5) Ill.

Anoplius fuscipennis St. Farg. H.2, 4; Au. 12, 20. (2) Ill.

Anoplius marginatus Say. H.2, Au. 12, 18. (3) Ill.

Anoplius cylindricus Cress. H.m. Ill.

Anoplius biguttatus Fabr. H.2, 6; May 20, Au. 12, 18. (2) Ill.

Anoplius, spp. (Ashmead, det. "*Ceropalidæ*; can not be determined at present"). H.1, 2, 3, 4; Au. 14, 18, 20, 22. (9) Four species.

Cryptocheilus nebulosus Dahlb. (*Priocnemis*). H.6, Au. 12.

Cryptocheilus, sp. H.2, Au. 13.

Ammophila vulgaris Cress. H.2, Au. 18. (5) Ill.

Ammophila argentata, n.sp. H.1, 2; Je. 7, Au. 18, 22. (3) (Note 20)

Ammophila procera Klug. H.2, 3, 4; Je. 6, 8, Au. 13, 14, 18, 19. (5) Ill.

Ammophila extremitata Cress. (*pictipennis* Walsh). H.2, Au. 13. Ill.

Priononyx bifoveolatus Tasch. (*thomæ* Fabr.). H.2, Au. 19. Ill.

Priononyx atratus St. Farg. H.2, Au. 18. Ill.

Sphex pennsylvanicus Linn. H.1, Au. 22. Ill.

Sphex ichneumoneus Linn. H.1, 2; Au. 18, 22. (2) Ill.

Anthophilus pulchellus Cress. H.2, Au. 18. (3)

Cerceris fumipennis Say (Ashmead, det.). H.4, Au. 20. Ill.

Cerceris venator Cress. (Ashmead, det.). H.2, Au. 12, 18. (2) Ill.

Tachysphex texanus Cress. (Ashmead, det.). H.2, Je. 8. No other Illinois record.

Tachytes obscurus Cress. H.2, Au. 13. Ill.

Stictia carolina Fabr. (*Monedula*). H.2, 5; Au. 12, 18. (2) N. Ill. (Bolter Coll.); Carlinville, on *Pycnanthemum muticum pilosum* (Rob.).

Microbembex monodonta Say. H.2, 3; Au. 12, 14, 18. (8) Resting on bare sand in blowouts, or flying about near the surface. Ill.

Bembex spinolæ St. Farg. H.3, 6, Mol.; Au. 14, 18, S. 8. (4) Common along the sandy shore above Havana. Ill.

Bembidula capnoptera Handl. H.2, Au. 13. No other Illinois record. (Note 21)

Bembidula 4-fasciata Say. H.4, Au. 20. Carlinville, on *Pycnanthemum linifolium* (Rob.).

Mimesa argentifrons Cress. Mol., S. 8. Ill.

Anacrabro ocellatus Pack. H.2, 4; Au. 18, 20. (3) Ill.

Notoglossa americana Rob. H.2, 4; Je. 6, Au. 18. (2) Ill.

Colletes americana Cress. H.2, 3; Au. 12, 14, 18. (5) Carlinville, on various flowers (Rob.).

Colletes latitarsis Rob. H.1, 3; Au. 12, 21. (3) Ill.

Chloralictus pilosus Smith. H.1, 2, 3; Au. 14, 18, 22. (4) Ill.

Lasioglossum coriaceum Smith. H.4, Au. 20. Ill.

Oxystoglossa confusa Rob. H.5, Au. 12. Ill.

Augochlora fervida Smith. H.2, Au. 12. Ill.

Augochlora humeralis Patton (Titus, det.). H.2, 3; Je. 8, Au. 14, 18, 19. (5) Ill.

Agapostemon texanus Cress. H.2, Au. 18. Ill.

Agapostemon splendens Lep. H.1, 2, 4, 6; Je. 6, 7, 8, 9, Au. 18. (7) On sweet clover.

Halictus tumulorum Linn. H.4, Je. 6. Ill.

Cœlioxys octodentata Say. H.2, 5; Je. 8, Au. 13, 17, 18, 19. (7) Ill.

Megachile mendica Cress. H.3, 4; Au. 15, 20. (3) Ill.

Megachile brevis Say. H.2, 3, 4; Au. 15, 18, 20. (6) Ill.

Megachile latimanus Say (Titus, det.). H.2, Au. 13, 19. (27) Found one cloudy morning (Aug. 13) resting in occasional large clusters on dead wild verbena stems along the road to Devil's Hole.

Nothosmia albiventris Cress. H.4, Je. 6. Ill.

Epeolus concolor Rob. H.2, 6; July 22, Au. 13, 19. All Ill.

Epeolus lunatus Say. H.1, 2, 4; Au. 13, 18, 19, 20, 22. (18) On the occasion referred to under *Megachile latimanus*, *E. lunatus* was frequently found singly, attached by its jaws to various plants. No other Illinois records.

Epeolus bifasciatus Cress. (*fumipennis*). H.1, Au. 22. Ill.

Epeolus pusillus Cress. H.2, Au. 18. Carlinville, on *Compositæ* (Rob.).

Melissodes obliqua Say (Titus, det.). H.2, Au. 13, 18, 19. (10) Ill.

Melissodes atripes Cress. (Ashmead, det.). H.2, 3; Au. 13, 14, 17, 18, 19. (38) On the occasion referred to under *Megachile latimanus* this species also was found in large numbers, clustered on dead weed stems by the roadside.

Melissodes agilis aurigenia Cress. H.1, Au. 22. Ill.

Tetralonia dilecta Cress. H.2, 4; Je. 6, 8. (2) Ill.

Bombus pennsylvanicus DeG. H.2, Au. 12, 18. (2)

Bombus vagans Smith. H.4, Matanzas L.; Je. 6, Au. 15. (3) Ill.

Bombus virginicus Oliv. H.2, 3; Au. 17, 18. (3) Ill.

Bombus separatus Cress. H.2, Au. 13. Ill.

Apis mellifera Linn. H.1, 2, 3; Je. 7, Au. 13, 14, 18. (6) Common on flowers of *Monarda punctata* and other plants in the sand region.

BATRACHIA.

Hyla squirella Bosc. H.1. Two seen on bushes on open sand-dune.

REPTILIA.

Heterodon simus Linn. Pekin (H. Garman, '92). The hog-nose snake is common in the Illinois valley sand region, particularly under boards along sandy roads at the Devil's Neck, and under stones and driftwood along the sandy shores.

Cnemidophorus sexlineatus Linn. H.1, Je. 7. Henry, in a dry sunny field on the banks of the Illinois River, not rare; Ottawa; lives in dry sandy regions (H. Garman, '92).

Terrapene carolina Linn. (*Cistudo*). About ten years ago I saw a number of these box-turtles traveling about the dunes of the Devil's Hole, but only one was seen by us during the field work for this article. The sinuous line at the edge of a moving dune, shown in Pl. XII., Fig. 2, was probably made by this box-turtle. Southern Illinois, dry woods (H. Garman, '92).

Mecostethus platypterus Scudd. (Page 231) While this article is going through the press I find Mr. E. D. Ball's list of Iowa *Orthoptera* ('97), supplementary to that of Osborn, in which he records this species from the extreme northwestern corner of that state. Otherwise it is known only from New England, and is only so listed by Scudder in his Catalogue ('00). Mr. Ball also records *Mermiria bivittata* from Iowa, which is a little north of its usual range.

Arphia xanthoptera Germ. (Page 232) On page 214, in discussing the differences of hind-wing coloration of certain *Orthoptera* in dry and humid environments, I mention the lack of sufficient material for a comparison of the two variably colored species which are common both in the sand region and on the humid prairie. An opportunity for such a comparison has since been afforded by the kindness of Mr. J. D. Hood, of the University of Illinois. Mr. Hood is making a very interesting study of a similar sand region in Wisconsin, and has secured a large series of *Arphia xanthoptera*, which may properly be compared with our series from the humid prairie, as the effect of aridity would be reduced rather than increased by the higher latitude of his locality. Blatchley says that in Indiana one third or more of the males have yellow wings and not over one sixth of the females, or an average of one fourth. Our collections show practically identical conditions, the usual color being a clear orange-red. On the other hand, Mr. Hood states that although in the Wisconsin sand region this species was very abundant, being seen by the hundreds every day, only a single orange-winged specimen was observed during five weeks' collecting, all the rest having yellow wings with at most a faint tinge of orange. Mr. Hood pertinently points out that the original color in all these species is probably that found in the more arid environment; not the reverse, as might be inferred from my wording.

Lepyronia gibbosa Ball? (immature). In the preceding list (page 236) I have mentioned immature *Cercopidæ*, probably *L. gibbosa*, occurring on the extreme bases of the stems in tufts of *Callirhoe triangulata*. Ball ('01) has found a western *Aphrophora* feeding on pine in the adult stage, but in the immature

stages inhabiting the stem bases of *Chrysopsis villosa* and *Lupinus* sp. after the manner of our species on *Callirhoe*. He regards this as a result of the arid environment, the enveloping froth with which the young surround themselves being more easily maintained here than on exposed twigs; and he assumes that the adults oviposit on these herbaceous food plants of their young. In the Illinois valley sand region there are no wild conifers.

Systematic Notes.

Note 1, p. 230.—*Bacunculus blatchleyi*. Walsh described his *Diapheromera velii* from Nebraska males and Illinois females. Scudder, in his Catalogue, credits *velii* to Nebraska only. The common prairie species of Illinois and Indiana, which we have been calling *velii*, was represented in our collections mostly by female specimens, but it was noted that the males indicated either that our *velii* was not a typical *Diapheromera* or that it was a *Bacunculus*. Mr. A. N. Caudell has received from Mr. W. S. Blatchley a pair of alcoholic specimens taken in Indiana, and described them as *Bacunculus blatchleyi*. Mr. Caudell has kindly sent me a typical male *velii* from Kansas, and I can now say with certainty that our specimens, and also those in Mr. Blatchley's cabinet, which I had previously examined, are all *Bacunculus blatchleyi*, to which species Walsh's females probably belonged. It is an inhabitant of rank prairie vegetation like *velii*, while *femorata* is a forest species. I have also taken *blatchleyi* at Lake Geneva, Wis., as stated in the list.

Note 2, p. 231.—*Eritettix virgatus*? This single female agrees with Scudder's description and McNeill's key except that the supplementary carinæ of the pronotum are almost entirely obsolete. It is possibly a new species.

Note 3, p. 231.—*Ageneotettix scudderi*. Hancock ('06) has collected examples of *Ageneotettix* near Chicago, which, after comparison with a type specimen of *A. scudderi*, he has described as a new species under the name *arenosus*, suggesting that the Minnesota, Illinois, and Indiana *scudderi* of Lugger, McNeill, and Blatchley respectively are probably also *arenosus*. According to him, *arenosus*, as compared with *scudderi*, is smaller and more slender, with the vertex right-angled, not acute-angled as in *scudderi*, the foveolæ deeper, the tegmina slightly shorter, etc. He has evidently overlooked Bruner's

"Some New Colorado Orthoptera" (Bruner, '04), in which a key to this genus appears and *A. occidentalis* is described from Colorado. This is said to differ from *scudderi* "in its somewhat slenderer form and smaller size," in its "somewhat abbreviated tegmina and wings," and "in the fewer (9) spines on the outer row of the hind tibiæ." *Scudderi* is characterized in Bruner's key as having 10 or 11 spines in the tibial outer row and the vertex right-angled or obtuse-angled in both sexes, while in the remaining species, *deorum*, it is slightly acute-angled. It will be noted that the broad-angled vertex is used by Bruner to distinguish *scudderi* from *deorum*; and, on the other hand, by Hancock, to distinguish *arenosus* from *scudderi*. Apparently *arenosus* is not sufficiently distinguished from *occidentalis*, or from *scudderi* as defined by Bruner, and it seems best for the present to retain the name *scudderi* for our Illinois examples. Individuals from all the Illinois localities herein cited, as well as some taken in Wisconsin by Mr. J. D. Hood, agree sufficiently with Hancock's description of *arenosus*, as well as with Bruner's characterization of *scudderi* just cited. The vertex is usually slightly obtuse-angled. An examination of the spines in the hind tibial outer row of 12 specimens from various localities gave the following result: spines, 9–9 (1 specimen), 9–10 (2), 10–10 (7), 10–11 (1), 11–11 (1).*

Note 4, p. 233.—*Psinidia fenestralis.* Five eastern specimens of *fenestralis* (New Jersey, etc.) in the State Laboratory collections show varietal differences from Illinois examples. Our specimens are smaller—female, 19–23 mm., male, 14–17 mm.—as compared with the eastern examples—female, 25 and 27 mm., male, 18–19 mm.; and in our examples the wing band is farther from the base. In the eastern specimens it crosses the wing centrally, or a trifle nearer the base; the first convex radiate vein—that crossing near the wing center—is at least half in the band; and there is a broad hyaline space beyond the band, the apex immaculate in the female. In our examples the band crosses nearer the apex than the base; the first convex radiate vein is about two fifths in the band; and the hyaline spot beyond is small, the apex in the female with evident darker spots at the vein tips and in the subcostal region. In all the males the apex is blackish.

Note 5, p. 233.—*Trimerotropis citrina.* Our examples of *T.*

* Rehn, in a paper received since the above was written (Proc. Acad. Nat. Sci. Phila., Vol. 58, p. 371), shows that both *scudderi* and *occidentalis* are probably synonyms of *deorum*.

maritima from New York and New Jersey have a very narrow wing-band, tapering out at the anal vein and falling far short of the anal angle; the tegmina are without definite indication of the two principal spots or bands; the dorsal hue is a dull pale sand-color; and the tibiæ are whitish yellow. Typical *citrina* (from Galveston, Tex., from Elizabethtown, Ill., on the Ohio River, from Meredosia and Havana on the Illinois, and from the Mississippi River shore from Grand Tower to Savanna) has a broad complete band approaching the anal angle; the tegmina have a pair of evident spots or bands; the general color is a speckled brownish; and the tibiæ are red to orange. In the State Laboratory collections are a number of examples labeled "N. Ill." which are intermediate between the two forms above described—the wing band narrow, but not interrupted except by the pale anal vein, a pair of inconspicuous small spots on the tegmina, the general color light, and the tibiæ pale lemon-yellow. One of this type, with yellow tibiæ, is from Henry, Ill., north of Peoria, on the Illinois River. This and a *citrina* from Bird's Point, Mo., were listed by McNeill in his "Orthoptera of Illinois" as *Circotettix verruculatus*. Collections of the lakeshore form of *maritima* were made by us along the beach of Lake Michigan at Waukegan in August, 1906, in time to include the results herein. These were closely like the somewhat intermediate form just mentioned as labeled "N. Ill."—probably, therefore, lakeshore collections also. The tibiæ were lemon-yellow, and identification as *maritima* seemed admissible. Mr. Shobe succeeded, however, in finding on the lake beach examples with well-marked orange tibiæ not otherwise differing from those with lemon-yellow tibiæ. This makes the line of division between the two species very indefinite.

Note 6, p. 234.—*Melanoplus macneilli*, n. sp. This was found only in a restricted area beside the blowouts on the Moline Sand Hill, associated with *M. davidus* and *angustipennis*, to the latter of which it is closely allied. It was at once recognized by my assistant, Mr. Frank Shobe, and myself, as a new form because of its different thoracic and femoral coloring. The male terminal structures are about as in *angustipennis*, except that the furcula is very short and strongly divergent, and the apex rather narrowly rounded. The hind tibiæ are light blue, apically greenish. The species is about the size and color of *angustipennis*, perhaps a trifle smaller, but with two noticeable color differences. The entire ventral margin of the hind femora is strongly sanguineous, while in *angustipennis*

it is dull greenish yellow; and the dorsum of the thorax, especially in fresh specimens, is a lighter gray than in *angustipennis*, contrasting much more with the black lateral stripe. The dorsal margin of the hind femur is more distinctly banded than in *angustipennis*. The prozona is slightly narrower behind than in *angustipennis* and the metazona shorter. Apparently these differences require the formation of a new species, which I dedicate to the pioneer in this interesting local field.

Note 7, p. 235.—*Udeopsylla robusta*. The common *Udeopsylla nigra* of eastern Illinois is uniform black or piceous, except for some faint rufous thoracic spots. Examples of *Udeopsylla robusta* from South Dakota are rufo-testaceous throughout, except for being darker in front of the sutures. The male and female taken near Havana are mahogany-brown, darker at the sutures; the face, legs, and ovipositor are rufo-testaceous, about as in the South Dakota specimens, but the outer faces of all the femora are indefinitely striped and mottled with the dark mahogany color, not uniformly pale as in typical *robusta*. The tibiæ and tarsi are just as in typical *robusta*, while those of *nigra* are no paler than the dorsum. The Havana pair are clearly not *nigra*, and for the present may be regarded as a variation of *robusta*. The eastward range of *robusta* is thus extended across the Mississippi. That of *nigra* reaches certainly about to the Indiana line, and probably far beyond it.

Note 8, p. 235.—*Nemobius fasciatus vittatus*. As I have elsewhere stated ('06), we may recognize three forms of wing development in *Nemobius* by adding an intermediate form to the usual macropterous and brachypterous types. In the intermediate form the wings are aborted as in the brachypterous form, but the tegmina are long, as in macropterous individuals, the dorsal field at apex ampliate and much exceeding the tip of the lateral field, not truncate. The specimen from the Devil's Neck is of this form.

Note 9, p. 236.—*Nabis elongatus*, n. sp. Length, 10 mm.; width, 2 mm. Elongate, with whitish pubescence, minute and sparse on upper surface, surface yellowish white above, a dusky stripe extending from between the antennæ to the tip of the scutellum, broader and darker posteriorly, especially on the scutellum; hemelytra attaining the base of genital segment, wings but slightly shorter, hemelytra whitish without fuscous dots, veins of membrane faintly bordered with fuscous on basal part, a dark spot at base of membrane on inner margin; tergum fuscous, darkest medially, becoming

yellowish laterally. Beneath, dull yellowish with broad lateral fuscous stripe, bordered on the metastethium by a whitish stripe edged within by a dark line.

Head nearly as long as the thorax medially, a little more than three times as long as the width between the eyes; first antennal joint about as long as the head, antennæ yellowish, apex of second joint and remaining joints feebly infuscated; pronotum about as wide at base as its length.

Legs pale dull yellowish, femora rather slender, the anterior and middle ones gently tapering towards apex, the posterior one subcylindrical, all dotted with fuscous spots, tibiæ with some fuscous points, apex of tarsi, and claws black; fore femora slightly longer than head and pronotum conjointly.

Abdomen about four times as long as broad, the genital segment parallel-sided, one half longer than broad, with dark median line on apical three fifths; male hamule about as figured by Reuter for *vicarius*, with a lobate extension of the margin in a lower plane, on the ventral side beneath the junction of the petiole and the semicircular lamella.

Taken along the sandy river margin in the lower part of Havana, Ill., June 9, 1906. Type in coll. Ill. State Lab. Nat. Hist.

This macropterous male is near *vicarius* Reut., which was described from Illinois, and is by some united with *propinquus* Reut.* Both were described from the brachypterous form. Professor Herbert Osborn thinks our specimen can not be *vicarius*, and I have decided to describe it as new.

†*Ligyrocoris constrictus.* (See page 237) The species thus listed by me is that commonly so identified in Illinois collections. All examples at hand, however, clearly lack the stridulatory vitta of *Ligyrocoris*. It is not *Perigenes fallax*, which resembles *Ligyrocoris* and also lacks this vitta, but is larger, broader, and otherwise different.

†*Phlegyas annulicrus.* (See page 237) This is our common *Peliopelta abbreviata*, now catalogued as a synonym of *annulicrus*. I have not verified the occurrence of *annulicrus* in the sand region if

Propinquus and *vicarius* were originally described on the same page, *propinquus* first. Reuter in a later article made *vicarius* a synonym of *propinquus*, but Lethierry and Severin list the species under the name *vicarius*, giving *propinquus* as a synonym.

†The two notes without serial number were added after the printing of the list.

it be a western species distinct from *abbreviata* as suggested by Van Duzee ('05).

Note 10, p. 238.—*Euschistus variolarius*. In a study of the genus *Euschistus*, I noted examples of an apparent variety of *variolarius* having the usual black terminal ventral dot of the male, but with small black dots at the sutural intersections of the abdominal margin as in *fissilis* and other species. The humeral spines are very prominent in these specimens, and the lateral edge just in front of the spines is concave or straight instead of being more or less convex. This variety is represented in *variolarius* from H.2 and 3.

Note 11, p. 239.—*Homœmus æneifrons*. In this genus the general aspect of the punctuation varies to a remarkable degree. The surface pattern is formed by sudden changes in the density of the punctures, emphasized by contrasting shades of the ground color, which also varies excessively in distinctness, from sharp contrasts to their almost total obliteration; but its form is nevertheless very constant for each species. The differences in the median scutellar pattern may be tabulated as follows:

Median pale line of scutellum rather suddenly widening back of middle into a broad medio-apical stripe.
Medio-apical stripe parallel-sided, the dark adjacent color gradually shading off. Length, 7–8 mm. - - - - - *æneifrons* Say.
Medio-apical stripe usually narrowing posteriorly, margined by a dark line. Length, 4.5–6 mm. - - - - - *grammicus* Wolff.
Median pale line gradually widening into a narrow medio-apical stripe. *bijugis* Uhl.
Median pale line very narrow or interrupted at posterior third of scutellum, in front of and behind this usually very distinct, posteriorly spread out fanlike or broadly subtriangular and gradually darkening, to apex. *proteus* Stål.

Proteus is readily recognized also by the deep notch in the flap like anterior extension of the prosternum each side of the middle.

Note 12, p. 242.—*Harpalini*, n. sp. This interesting carabid appears to be generically and specifically new. It belongs to the tribe *Harpalini*, but as the single specimen obtained is a female, its systematic place is uncertain, and it does not seem advisable to do more at present than to call attention to its striking peculiarities.

It is about the size of *Harpalus testaceus*, but even paler than that species, yet apparently perfectly matured; the thorax has the

well-rounded angles and the form of that of *Harpalus herbivagus*. Unlike *Harpalus*, however, it has three dorsal series of elytral punctures, 4 or 5 in each row, located on the 3d, 5th, and 7th intervals. The tibial and tarsal angles are not prolonged; the fore tarsi are spinulose beneath, slightly dilated; the first joint of the hind tarsi is not elongate. The antenna has the proximal two joints glabrous; the eyes are rather small; the left mandible is chisel-shaped, slightly overlapping the right; the labial palpi are plurisetose in front, the last joint slightly shorter than the preceding one; the mentum is acutely toothed at middle, its epilobes are narrow, and it has a single setigerous puncture at each posterior angle.

Note 13, p. 243.—*Hyperaspidius trimaculatus*. In this specimen the two pale vittæ—lateral and sutural—of each elytron are at base slightly broader but not united, the three black intervals of equal width at base.

Note 14, pp. 243, 244.—*Calopteron*. I offer the following key to facilitate the separation of these two species.

Apical part of third vein of elytra within the black band raised on an elevated ridge like that of the second and fourth, ridge ending rather abruptly; no middle band in our specimens. - - - *terminale* Say.

Apical part of third vein within the black band not on a distinctly elevated ridge, the interval concave from the second to the fourth veins; middle band present or wanting. - - - - - - - *reticulatum* Fabr.

Note 15, p. 244.—*Lucanus placidus*. This species may readily be separated from *dama* as follows:

Mandibles of male rounded, ecarinate; of female strongly carinate on the inner side of the dorsal surface—especially over the subapical tooth—and usually a lower carina along its outer margin; top of head of female anteriorly rugosely punctate and very opaque; elytra and thorax shining. *dama* Thunb.

Mandibles of both sexes subtriangular in cross-section, their dorsal surface concave, with a strong carina along its outer margin only; the inner edge sharp, bidentate in the female and multidentate in the male; entire dorsal surface of insect with dull luster. - - - - - - *placidus* Say.

Note 16, p. 248.—*Phacepholis candida*. Dr. Horn described this from two specimens as "nearly white." It has, in fact, a color pattern similar to that of *obscura*, in pale brown and white. The thorax has a dorsal darker stripe divided by a fine median white line, and lateral and ventro-lateral darker stripes. The elytral scaling is very pale golden-brown, with two vague stripes and the

lower margins white. The scales beneath are nearly white, without evident pattern.

Note 17, p. 251.—*Laphystia 6-fasciata.*—Dr. Williston says (Trans. Am. Ent. Soc., Vol. 12, p. 53): "Specimens of this species from Montana differ appreciably from those from the Southern States that I have seen. In all the northern specimens the pollinose bands of the abdomen are all entire, while in the southern ones they are mostly interrupted; the femora, moreover, in the former are mostly yellow, while in the others they are chiefly black. These differences, if not sufficient to warrant specific separation, may be varietally indicated by the name *notata* Bigot for the southern form." In our specimens the femora are reddish and the fifth abdominal band is clearly interrupted.

Note 18, p. 254.—*Sphœrophthalma chlamydata.* Melander ('03) collected "several" specimens of a male mutillid in the sand region about Bath (designated in this list as H.3) which he determined as *bioculata*, and of a female, described by him as new under the name *chlamydata.* Ten of my 16 unassigned males are his *bioculata*, and 61 of the 83 unassigned females are his *chlamydata.* On one occasion one of these males was seen dancing in attendance upon a female *chlamydata*, both being then captured. Their occurrence is coincident, and they have close similarities in vestiture. It would seem proper to accept them as two sexes of one species. However, *bioculata* in the West has been connected by Cresson with quite a different female, which Fox conjectures may be the same as *creusa* Cresson. Since the females are more reliably separable than the males, it would seem best for the present to retain the name *chlamydata* for both sexes in our region.

Note 19, p. 254.—*Sphœrophthalma macra.* The single example which is assigned to this species has an evident coarse orange pubescence on the second segment, the dorsal reddish area of which does not seem to be two partly confluent spots as is the case in the more common types assigned to *ferrugata* and *agenor*, in which also the pubescence is yellowish and not evident when viewed vertically from above.

Note 20, p. 255.—*Ammophila argentata*, n. sp. The sides of the thorax are covered with a mat of uniform silvery pubescence, its dorsum is less conspicuously silvery pubescent; the face is silvery, the red or yellowish of the abdomen extends from near the base of the second joint to beyond the middle of the fourth, or even upon

the base of the fifth; the legs are wholly black; the thorax is rather sparsely punctate; the metanotum is finely and densely obliquely striate; the wings are yellowish hyaline. Length, 18–21 mm. One male, three females, Mason Co., Ill. Type in coll. Ill. State Lab. Nat. Hist.

Note 21, p. 256.—*Bembidula capnoptera*. The single example agrees with the description of this species except that the abdominal yellow bands are of good width, about equal to the intervals between them, and all rather narrowly interrupted at middle.

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VIII.

Eighty-acre field occupied by blow-sand and blowouts. Original bunch-grass prairie in the foreground: in the distance, black-jack forest.—A typical locality for the characteristic blow-sand fauna.

IX.

A large blowout in which a large cotton-wood tree has grown. Sand has filled two-thirds of the blowout, covering the cottonwood to its lower branches, and has been partially fixed. Upon the filled part, in the left foreground, the formation of a second blowout has begun.

A butternut-tree covered to its lower branches with sand removed from a blowout.

XI.

Front slope of an advancing dune covered with the tumbleweed, *Cycloloma*. On the crest, a dense clump of *Rhus aromatica*. The tree is an American elm.

FIG. 1. Blow-sand entirely without vegetation. A grove of walnuts (*Juglans nigra*) in the rear.

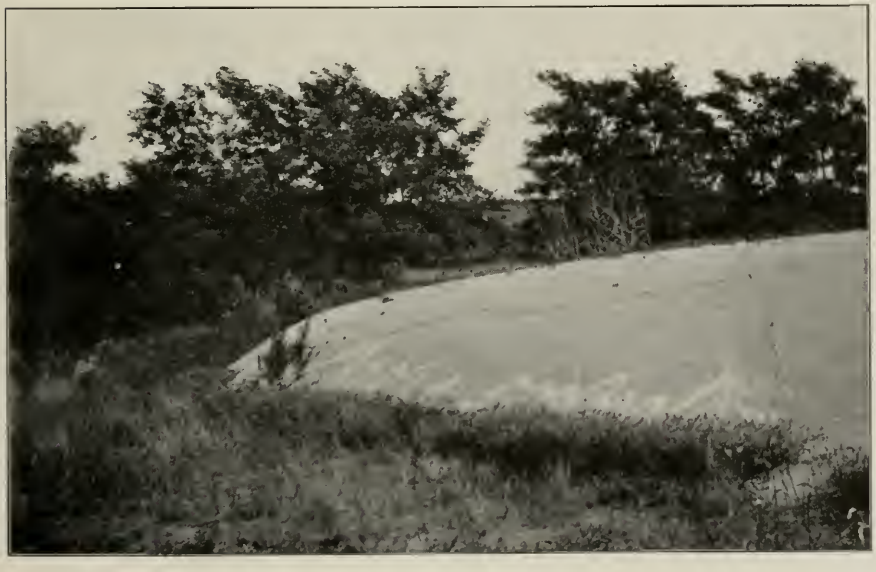


FIG. 2. Traveling dune formed of sand removed from a blowout. A small thicket of plum-trees has been partially buried and the trees killed. A dense zone of *Diodia teres* grows around the edge. *Robinia pseudacacia* cultivated in the background.—The zigzag line at the edge of the sand is the track of a box-turtle (*Cistudo carolina*).

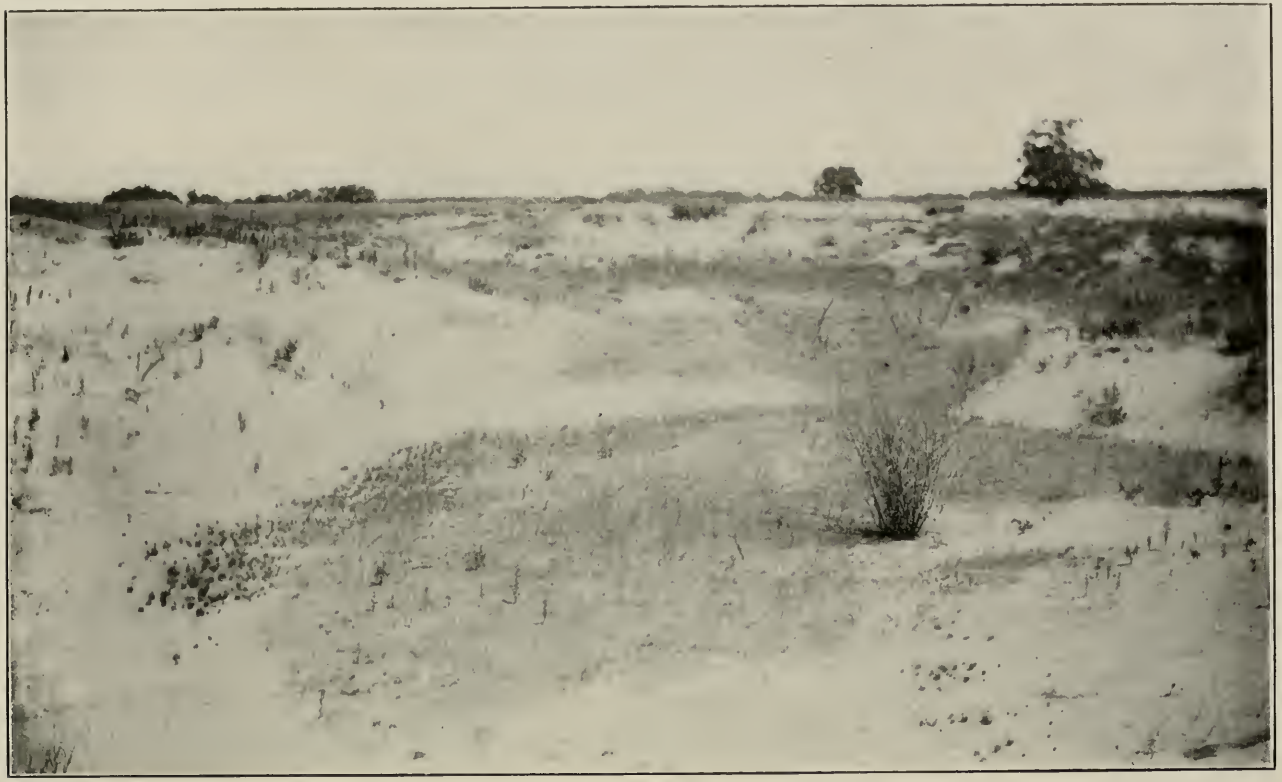
XIII.

Level tract of blow-sand, almost devoid of plants. Invasion of *Ambrosia*, *Cenchrus*, *Commelina*, and other species, from the margin.—*Corimelæna ciliata* abundant in sand about roots of grass tufts in foreground

FIG. 1. Large blowout, the slopes still bare, but with the typical blowout association on the flat bottom. The low vertical walls of sand are held in place by sand-binding grasses.—Most abundant on the bare sand are *Microbembiex, Laphystia, Cicindela lepida*, and *Melanoplus fluvidus;* and in the sparse growth various *Mutillidæ, Melanoplus angustipennis, Ageneotettix scudderi, Spharagemon wyomingianum, Anthrax, Cicindela formosa generosa*, and *C. scutellaris lecontei*.

FIG. 2. The steep wall of sand is held in place by the bunch-grasses at its top. They are being gradually undermined, as shown by the sliding plants on the slope.—A favorite place for *Cicindela, Microbembex, Mutillidæ*, and *Melanoplus fluvidus*.

XV.



Early stage of a blowout association. The floor of the blowout is covered with a carpet of *Stenophyllus capillaris*, and in its center is a large bunch of *Panicum virgatum*.—A fine field for sand insects such as *Cicindela, Mutillidæ, Melanoplus flavidus* and *M. angustipennis, Spharagemon wyomingianum, Agenceotettix scudderi, Psinidia fenestralis, Anthrax, Asilidæ, Pompilidæ*, etc.

XVI.

Bunch-grasses dislodged by wind-action, and drifting into a shallow blowout. The dense flattened bunches are an unidentified *Panicum*, the large bunch at the right is *Sorghastrum avenaceum*.—A typical locality for *Stachyocnemis apicalis*, *Cicindela*, *Mutillidæ*, *Anthrax*, etc.

XVII.

Final stage of the blowout succession, showing a typical black-soil prairie association. A small box elder has also appeared.—*Bacunculus blatchleyi*, *Mermiria neomexicana*, *M. bivittata*, and *Schistocerca alutacea* in the long grass.

FIG. 1. Bunch-grass association (*Stipa spartea*) on top of a hill, showing the open character of the vegetation. The trees in the background are not native.—*Melanoplus angustipennis*, *Ageneotettix scudderi*, *Mestobregma thomasi*, *Hippiscus rugosus*, and *Mutillidæ* are common, and in early summer *Hippiscus phœnicopterus* and *H. haldemanii*. *Conocephalus robustus* also occurs here.

FIG. 2. A single plant of *Sporobolus cryptandrus* growing on blow-sand has built up a conspicuous mound beneath it.

FIG. 1. A low mound of sand held in place by *Rhus aromatica*. Several other species grow in the protected sand on its lee side. The small plants in the left foreground are *Commelina virginica*.

FIG. 2. A dense thicket of the sand-binder *Rhus aromatica*. The tumbleweeds, *Cycloloma atriplicifolium*, are the only plants on the blow-sand in front. Upon the *Rhus* are *Blepharida rhois* and its larvae, *Perillus circumcinctus* and its nymphs, *Resthenia insitiva*, and the predaceous *Zelus socius*.

FIG. 1. *Populus Dilatata* spreading by suckers over the blow-sand into the blowout. *Cristatella Jamesii* grows in abundance in the right foreground.—Upon the *Populus* are *Metachroma parallelum* and *M. angustulum*.

FIG. 2. A dune has invaded a walnut grove. The ground cover on the moist shaded sand is mainly *Solanum nigrum* and *Sicyos angulatus*.—Under logs are *Ischnoptera inæqualis*, *Udeopsylla robusta*, *Pangæus*, etc.

FIG. 1. Interior of a black-jack forest.—On the ground are *Melanoplus fasciatus*, *M. luridus*, and *M. impudicus*, and under gatherings of dry leaves *Gryllus* is abundant. Along the forest margins are *Schistocerca alutacea* and *Hippiscus phœnicopterus*.

FIG. 2. Interior of a mesophytic forest of white oak and bur-oak on a sand ridge extending along the low marginal bluff of the sand plain bordering the Illinois River —On the ground are *Melanoplus scudderi* and *Spharagemon bolli*.

XXII.

Illinois River flood-plain at high water, as seen from the margin of the sand plain above Havana, Ill., looking westward. In the distance are the western upland bluffs, and at the left of these is the lower end of the valley of Spoon River.

Margin of sand plain just below Havana, Ill., here forming east bank of the Illinois River. Areas of mesophytic forest are near the margin.— On the sandy beach is *Trimerotropis citrina*; on its moist margin are *Cicindela cuprascens*, *C. hirticollis*, and *Paratettix cucullatus*; on the small willows at the water's edge are *Metachroma* and *Melasoma*; and under driftwood, *Chlænius*, *Patrobus*, and numerous other *Carabidæ*.