CONTRIBUTION TO THE BOTANICAL SURVEY OF THE HURON RIVER VALLEY.

ALFRED DACHNOWSKI.

RAVINES IN THE VICINITY OF ANN ARBOR.

The following here presented is the outcome of study in the field carried on during the summer and autumn of 1904, and supplemented by further work of a more recent date at the suggestion of Dr. George P. Burns, to whom the writer desires to express his indebtedness for much helpful advice. As a preliminary note for an investigation of the casual relation existing between habitat and plants in this vicinity, the present paper includes the ravines situated along the bluff near the river east of Ann Arbor, in the wooded section known as School-girl glen, and the ravines in Cascade glen and near Foster, distances three and five miles (18 km. and 30 km.), respectively west of Ann Arbor. The objects of this study were to trace out the chief plant associations, and to correlate their distribution with the various ecological factors active in this region. Primarily these data are to be introductory to a more detailed and extended study, under measured conditions, of the varying activity of plants, as individuals and as associations, i. e., the attempt is made at field work in experimental physiology. In addition, though these floristic notes do not complete the needed investigations, it is expected that some light may be thrown on the probable succession of local vegetation. Hence, as a record for comparison of future changes, or an endeavor to indicate in a general way some of the conditions involved, a local study of this kind seemed desirable.

The soil of the Huron river valley is throughout of glacial origin. In this vicinity the numerous rounded morainal hills and similar depressions, the characteristic features of a drift area, betray the youthful topography; and an interesting display of dynamic phenomena is everywhere apparent. The river is bordered by banks 80 to 250 feet (24 m. to 76 m.) high, but seldom reaching more than 300 feet (90 m.). The slopes are more or less gradual. Details of general geography, the geology and topography of this region have been so well treated by several writers, that to avoid reiteration, reference is made to the work of Leverett (1), and the papers of Reed (2), Weld (3), and Brown (4).

Variations in climate are not very considerable. Here also referring, for a more detailed account, to a recent paper (5), the following are the chief climatic features for Ann Arbor (*): The winters, marked by a diminution of precipitation, are relatively mild as compared with other countries. Usually the freshets during March and April are less decided than during July and August, at which time the highest water occurs after the heavy rains; the temperature is at the highest also. This year (1905),

1 Leverett, F. The glacial formations and drainage features of the Erie and Ohio basins, Mon. 41, U. S. G. S.

2 Reed, Howard S. The Ecology of a glacial lake, Bot. Gaz., 34: 125-139, 1902.

3 Weld, Louis H. A peat bog and morainal lake, Bot. Gaz. 37: 36-52, 1904.

4 Brown, Forest, B. H. The Plant societies of the bayou at Ypsilanti, Michigan, Bot. Gaz. 40: 264-284, 1905.

5 Transeau, E. N.

* Comparative data taken from the Annual Summary of the Michigan section of the U. S. Weather Bureau Climate and Crop service.

however, the heaviest rainfall occurred in March. Low water is more frequent in November, gradually increasiing until the ground is frozen. The prevailing rains and winds are from the west and south-west, the winds averaging an hourly velocity of about ten miles (160 km.) for the year 1904, and a maximum velocity of 56 miles during July. The number of rainy days is considerably larger than the number of clear days.

Among the chief factors governing the distribution of plant associations the edaphic and physiographic agencies should be considered also; but here, as with certain climatic data, the importance of these features is best dealt with in the particular description of the localities studied. Neither is it necessary to discuss the early history or the varieties of ravines, since this is set forth in the excellent work of Cowles (6).

Of the ravines studied thus far in this locality, four have been chosen for a preliminary report, on account of the prominence of four phases in ravine processes. For convenience they may be treated under the following aspects: (1) a locally typical ravine; (2) a ravine influenced by man; (3) a ravine of arrested development due to captured territory; (4) a rejuvenated ravine. As illustrations of dynamics in botany no better examples around here could be cited. What additional phases may be present, the brief period of investigation has made impossible to show. Proceeding now to a more detailed account of the ravines and their vegetation, we may conveniently follow them in their natural order of succession.

I. A LOCALLY TYPICAL RAVINE.

The crest outline of the ravine in School-girl glen is approximately that of the 860 feet (260 m.) contour line, (above sea-level) (*), leading into the Huron river by a north north-eastern direction; 1100 feet (330 m.) can be regarded as the length of it, while near the mouth the greatest width is about 300 feet (90 m.), and the depth 110 feet (33 m.). Surrounding the ravine on the east, south and west side and sloping into it, is a peach orchard several acres in extent. The soil consists of a heterogeneous sandy loam inclining in places to a clay structure, and occasionally with a large per cent of gravel. The ravine has been cleared somewhat about twenty years ago, and the consequent changes doubtless have led to a marked modification in vegetation. But the undisturbed trees and the characteristic physical conditions have been effective in the restoration of the original flora, and today the ravine presents a fairly advanced stage in the process. The water entering it is derived chiefly from drainage during seasons of maximum precipitation and, by an underground channel, from a spring near the head of the ravine. Bordering the east and west side occur (†) Corylus americana, Cratægus spp., Rhus hirta, R. glabra, Rubus nigrobaccus, R. canadensis, Helianthus divaricatus. A dense growth of Solanum dulcamara, Vitis vulpina, Sambucus canadensis, Micrampelis lobata, Hystrix hystrix

1 Cowles, H. C. The physiographic Ecology of Chicago and vicinity. Bot. Gaz. 31: 73-81.

* A topographic map, known as the "Ann Arbor Quadrangle," has been recently completed and published by the U. S. G. S. in cooperation with the Geol. survey of the State of Michigan.

† The nomenclature is that of Britton's Manual of the Flora of the Northern States and Canada, 1901.

with Typha latifolia, Carex retrorsa, C. hystricina, C. rosea, Scirpus atrovirens occupies the area between. The more hydrophytic of these plants owe their presence to the spring near by.

As the ravine widens and deepens a variety of trees become dominant. The vegetation as a whole is that of the "Bluff society," but the series of changes taking place downward is so rapid that definite societies cannot be distinguished except in the more extreme conditions, i.-e., where the vertical succession begins with a bluff society and culminates in a flood-plain society. The most characteristic trees of this bluff society are Quercus velutina, Q. alba, Hicoria minima, H. glabra, H. ovata, Juglans nigra, with an occasional elm (Ulmus americana), some ash (Fraxinus nigra), and poplar (Populus tremuloides, P. grandidentata.) The dominant shrub is Corylus americana; several others occur, the chief of which are Viburnum lentago, Ribes cynobasti, R. floridum, Celastrus scandens, Cornus stolonifera, C. alternifolia, Dioscorea villosa, Rhus radicans, making up an association characteristically mixed and densely vine-clad. Dependent upon the protection and the shade of the trees and shrubs are Collinsonia canadensis, Phryma leptostachya, Scrophularia marylandica, Helianthus decapetalus, Caulophyllum thalictroides, Geum canadense, Geranium maculatum, and the usual vernal forms such as Thalictrum dioicum, Sanguinaria canadensis, Trillium erectum, Podophyllum, Anemone, Viola, etc.; also various mosses and liverworts.

A striking difference from this condition is found in places where lateral erosion is greater. These sections may be compared to a denuded locality whose plant covering has been recently laid bare, i. e., during the early spring rains. The soil, a sandy clay, contains approximately 2 % to 3% of water more than the adjoining upland, but about 4% less than the shaded sections within the ravine. Subject to more exposed conditions, especially with reference to climatic factors, and differing also as to water content and soil temperature, the sections are particularly adapted to the study of invasion, consequent competition, and succession. The vegetation near the crest consists of Rhus sirta, Rubus canadensis, Solidago canadensis; further down Solanum dulcamara, Sambucus canadensis, Vitis vulpina, Verbena urticifolia, Mentha canadensis, Potentilla canadensis, Alsine media, Nepeta cataria, Dioscorea villosa, Cornus stolonifera. Where the soil is more sandy and contains a larger per cent of gravel, the flora is that of the adjoining hill; the plants just mentioned are replaced by Onagra biennis, Apocynum androsæmifolium, Linaria linaria, and various thistles, weeds and grasses. Marked differences are seen from year to year as the action of erosion or the influence of the invaders becomes more effective.

Where the slopes become better covered with humus, and the shade of trees is dense, protection from rapid changes in temperature and moisture is more pronounced, and the vegetation also is more luxuriant. But though topography and soil-water content, as determined by the underlying compact till, are two of the necessary and dominant factors for the development of a mesophytic vegetation, the changes in vegetation and the actual grouping of the plants into minor associations depend upon various factors—both physical and biological. It may be of interest to point out the chief species occurring in areas of very similar conditions of soil and topography. For example, the notes of a cross-section taken from a station about 700 feet (212 m.) from the head of the ravine contain among others the following species on the east side: Meibomia grandiflora, M. marylandica, Aster lateriflorus, A. lævis, A. macrophyllus, Rudbeckia laciniata, Ratibida pinnata,

Heliopsis scabra, H. helianthoides, Helianthus decapetalus, H. divaricatus, Monarda fistulosa, Leptandra virginica, Hystrix hystrix, Coreopsis tripteris, Asclepias exaltata. No trees are found here. A few feet farther down several oaks, (Quercus velutina) occupy aposition about midway between the upper and lower margin of the slope. On this cross-section the vegetation above and around the oaks is distinctly xerophytic and light-loving in character; the plants within the shadow cast by the oaks, and toward the lower edge of the ravine are Leptandra virginica, Coreopsis tripteris, Hamamelis virginiana, Vagnera racemosa, Dioscorea villosa, Vitis vulpina, Aster lævis, A. prenanthoides, Collinsonia canadensis, Mitella dyphilla, Asplenium filix-fœmina, Osmunda cinnamomea, Adiantum pedatum, and various mosses, such as Hypnum and Mnium. A similar section on the west side, under more exposed conditions, contained among others Rhus hirta, Pteris aquilina, Euphorbia corollata and Apocynum cannabinum dominant, while toward the more shaded environment were seen Smilax hispida, Corylus americana, Pteris aquilina, Heliopsis scabra, Dasystoma lævigata, Euphorbia corallata, Verbena urticifolia, Solidago canadensis, Onagra biennis, Hystrix hystrix, and at the base Salomonia commutata, averaging a height of 6 to 7 feet. The differences in temperature between the upland and the base of the ravine vary from 2½°–9°C. on sunny days; on cloudy or windy days the differences are less. Occasionally when the direction of the wind is from the north the reverse holds true, i. e., the temperature within the ravine is from 1½°–3° higher than that of the adjoining fields. The soil contains from 12% to 14% organic matter and a physical water content averaging 3% to 5% higher as compared with the upland. It is inadequate to express these changes in vegetation in terms of water content merely, since various factors are involved, and the results arise from the united action of these (7-8). Conditions obtain whose water-content and characteristic distribution of plants is largely determined by light; the development of plants as well as their structure and density change in accordance with the varying light intensity. The *reactions* of the plants are equally great and profound—the habitat in turn undergoing marked changes also. For instance, the increasing diffuseness of light in some places, due to luxuriant growth, precludes nearly all undergrowth, increases the humidity of the air, thus lessening again aeration, transpiration, and absorption of soil-water—reactions through which light, humidity, temperature and soil-water content are most distinctly modified. In other places the plants produce seeds and seedlings with difficulty. The decomposed remains of an earlier vegetation lead to mechanical and chemical changes in the soil. But though increasing the soil in nutrition content and water-content, in their extent these changes are more effective toward breaking up the flora into a heterogeneous formation, accompanied with a frequent changing of one dominant group by another. In other and dryer situations the more mesophytic of these plants differ in appearance, but especially in the extent and branching of the root system. The same physiological adjustments, though in a converse sense, hold true for the more xerophytic plants in the moister regions of the ravine. However, it is not the purpose of this paper to indicate in detail the extensive physiological reactions both functional and structural occurring here. On comparing the composition of these societies with that of others, it is clearly seen that the mutual interaction of plants and environment leads

7 Warming, E. Lehrbuch der ökologischen Pflanzengeographie, 1896, p. 105-106.
8. Schimper, A. F. W. Pflanzen-Geographie auf Physiologischer Grundlage, 1898, p. 204-205.

to grouping, which otherwise would be limited to and depending upon soil water factor alone, and hence would have been either very limited or else wholly absent.

Just as striking is the character of the vegetation in a smaller ravine which enters into this one from the west a few feet farther down. Here as elsewhere the behavior and arrangement of plants varies because of several factors; principally on account of modified relations between humidity and insolation due to the condition of the plants themselves, the reaction of plants in preventing erosion, in binding and enriching the soil. The accumulation of humus in one place, the destruction of it by fire in another; the no less important condition of habitat as determined by the trough-like or the talus-like character of the slopes, north and south exposure, prevailing westerly direction of rains; characteristic seed dissemination and germination, and the physiological condition of the invading plants—these, and more, make it obvious that the analytic treatment, or the explanation on the basis of one or few factors is not sufficient. Not only is it unsatisfactory to study the habitat as such, i. e., as it presents itself statically at the time of investigation; not even the standpoint of physiographic change and the consequent movement of a dependent fauna or flora is adequate to account for the changes and distribution of life in this region. A knowledge of the reactions of plants upon their environment—the functioning between organisms and environment—is equally essential for an interpretation of the habitat if dynamically considered. This will not be surprising to any one who approaches the problem from the physiologist's(9) point of view, and recognizes that a fuller account of physiological activities and reactions would clearly include an answer to a more satisfactory understanding of such terms as "habitat," "dynamic," "process." However, quantitative study, as well as careful and definite analysis of the conditions must be continued for some time in order that the various changes and phases may be correlated with the factors in question, and the extent of modification due to them may be recognized.

Worthy of note is the flora occurring at ground water level. This point is about 250 feet (76 m.) from the margin, and about 30 feet (9 m.) above the level of the river. During the months of July, August and the early part of September (1904) temperature readings, taken about three o'clock in the afternoon both at ground water level and at a point 65 feet (19 m.) directly above on the upland of the eastern slope, showed an average difference of 5° and 6.5° C., for air and soil temperature respectively. The physical water content of the soil averages slightly more than that last mentioned. The more alluvial character of the soil, together with increased humidity and the continual presence of flowing water favor a dense luxuriant flood-plain region. The following are a few forms to be found here and in the direction toward the river margin: Juglans nigra, J. cinerea, Tilia americana, Ulums fulva, U. americana with Carpinus caroliniana, Malus coronaria, Salix discolor, S. lucida, S. nigra, as a tension line nearer the water, and Prunus americana, Acer saccharum, Cornus candidissima, C. alternifolia, Hamamelis virginiana higher up. The most common associated herbaceous species are: Geum strictum, G. canadense, Sanicula marylandica, Equisetum hyemale, Galium triflorum, Smilax herbacea, Rudbeckia laciniata, Urticastrum divaricatum, Solidago flexicaulis, Deringa canadensis, Collinsonia canadensis, Campanula americana, Washingtonia claytoni, Parthenocissus

9. Clements, F. E., Research Methods in Ecology, 1905.

quinquefolia, Nabalus altissimus, Cassia marylandica, Physalis heterophylla, Uvularia perfoliata, Falcata comosa, Phryma leptostachya, Oxalis stricta, Micrampelis lobata, Prunella vulgaris, Lobelia syphilitica, Impatiens fulva, Bidens, Mitella, Viola, and others. Interesting also is the large number of sterile plants to be found here.

The ravine has not escaped human influence. The repeated burning of the slopes near the mouth has strengthened the xerophytic flora. On areas in which denudation of that character has affected the surface, the clearing societies consist of Helianthus divaricatus, Aster lævis, Salix humilis, S. tristis, Solidago canadensis, S. rigida, Lespedeza frutescens, L. violacea, Lacinaria scariosa, Rhus glabra, Euphorbia corollata, Viburnum acerfolium on the east side, and of Rhus hirta, Pteris aquilina, Vaccinium vacillans, Apocynum cannabinum, Monarda fistulosa, Vagnera racemosa, Pimpinella integerrima, Agropyron repens, Andropogon furcatus and others on the west side. This society is maintained until the seedlings of trees with deeper shade are capable of supporting themselves. Usually Rhus hirta and R. glabra get the ascendency, associated in some places with Corylus americana and Pteris aquilina. The latter develops best on slopes in such condition, though luxuriant also when near or under the shade of young oak and hickory saplings. As the shrubs and grasses add their share of vegetable debris to the soil, making it slowly richer in organic compounds, and the capacity to hold water, heat and oxygen increase, the flora at the lower margin creeps up again. Oaks (Quercus velutina being the most common) and hickories soon become dominant, to be followed in arrangement by poplar, basswood, elm, maple, and the associated shrubs and herbal undergrowth. Such signs of repeated invasion of mesophytic plant societies are frequent. Even though the changes induced by fires are considerable, as a rule they seem rather to assist in the direction of the original mesophytic association, and to prepare the ground for seeding.

II. A RAVINE INFLUENCED BY MAN.

At a distance of about 120 rods (600 m.) to the west, another ravine is situated in this section. Its general direction is more to the north-west, with slopes averaging an incline of 30° to 35°. The conditions of the present association, briefly stated, seem to be these: The slopes, and most of the hill land adjoining the ravine are pasture. This pasture, though extensive, is not natural; it plainly shows that it has been the outcome of various agencies, of which the regular cropping and treading by cattle, and the repeated fires seem to have been the more active factors. Extensive thickets of Corylus americana and of various species of Cratægus, also of Rhus hirta and R. glabra occur here, no doubt the forerunner of an encroaching flora similar to the one in the neighboring ravine. The outposts of the new flora are rapidly advancing, running down the slopes of the ravine from the east. Beneath and about the invading shrubs, the grass-land takes on a somewhat different appearance. Extermination increases, as shrubs and dependent herbs, species similar to those of the ravine above mentioned, become more and more compact. Several trees (Quercus velutina, Juglans nigra, and Ulmus fulva, with an occasional willow) are standing isolated with dependent herbs checked in growth by the grazing cattle, or stunted and suppressed because of occasional cultivation. Interesting is the effect of artificial drainage on the habitat of some perennial grasses. The soil is slowly removed by the action of a spring near the upper margin of the ravine. The

plants check the numerous rills due to the downward flow of the water, causing deposition of part of the eroded soil. Accelerated growth, partly of the plant, partly on account of the fixation of soil, gives rise to the well-known hummocks of swamps. Building, enriching the soil, and occasional fires are represented by many and diverse changes. The repeated burnings do not injure so much the vegetation of the pasture, as the invading plants of the adjacent woods. However, it is necessary to investigate more definitely the various factors and stages determining the invasion between these two areas. This ravine and several others of a like type, excellently illustrate that the stage of a process in ravine life is more often due to biological than to physical causes, and that a description or an understanding of a life history of plant associations is inadequate, unless the human factor is taken into account. As an influence for introducing and eliminating many species, and complicating or interfering with the scene of action of ravine life, the human agency is certainly of increasing importance.

III. A RAVINE OF ARRESTED DEVELOPMENT DUE TO CAPTURED TERRITORY.

In Cascade Glen, as in the preceding section, and the one next to be described, woods occur some distance from the edge of the bluffs and down to the river margin. Throughout the whole area oaks and hickories are the dominant trees. The region is topographically very much like that of Schoolgirl Glen, except that the direction of the first and larger ravine is more parallel with the bluff, i. e., in a direction west to east-north-east. Springs and the effect of cultivation in adjoining fields have been the cause of the more rapid development, thus aiding in the capture of the neighboring territory, forcing a shifting of divides, and leading the increased drainage into the main ravine stream bed. This directed the formative forces into new channels, and resulted in the arrested development of neighboring ravines. The physiographic features are not so marked in the larger ravine as in some others of this vicinity. The vegetation is similar to that of the ravine first described, but noteworthy is the fact that the flora is increased in variety by a large number of herbaceous plants. The lowland of the ravine is damp, shady, and rich in humus. The shade of the trees is much greater on the south than on the north side; hence the flora of the former is much richer in species, especially of the early flowering kind, while the flora of the north side contains a high proportion of late flowering Compositæ. This difference is also observable in regard to ferns, mosses and liverworts. A few preliminary experiments show that the water content of the soil depends largely upon drainage, the firmness of the soil particles, and upon accumulated humus; it is the principal element in determining the character of the growth, while the ecological distribution of the vegetation is determined by conditions of water content of soil as modified by topographic environment, and plant reaction. Various other ecological factors such as the historic one, are of importance also, but the data on hand are so limited that at present a consideration of these and other questions can not be attempted.

As an example of arrested development due to captured territory, the ravine nearest the headwaters of the one just mentioned, is of more special interest. The ravine indicates various changes, all of which have an evident effect on the vegetation. The conditions of plant life are very distinct; the amount of water available is scanty, partly on account of the divide existing, partly because the vegetation carpet reduces instability of soil, and erosion is confined to side-wash. Where soil and vegetation are more com-

pact, even this side-wash is reduced, largely on account of the delayed downward flow of water, and the consequently greater absorption of it by the soil. Absence of vertical erosion and of meandering due to ravine rills and streams has increased the favorable conditions necessary for plant life, but the limited drainage is not advantageous to the formation of a mesophytic flora, either of vernal or estival forms. About midway the outcropping of an impervious and compact clay, which underlies the whole region, and appears elsewhere at the surface, is important, because of the relations existing between the upper and lower soil types and the associated plant societies. There is a slow but constant flow and percolation of water, and the distribution of plants as influenced by conditions of soil moisture gives rise to important differences. A profile was made, shown in Fig. —, and is added here through the courtesy of Dr. Burns.

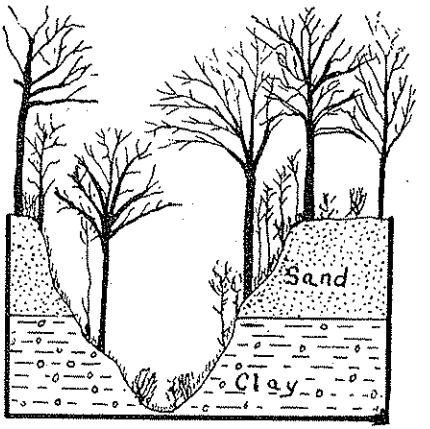

FIG. 1.

The moisture in the soil is retained for considerable depth. Tracts of low, wet ground occur at the mouth and such moisture-preferring plants as Impatiens fulva, Gentiana flavida, Solidago flexicaulis, Equisetum hyemale, Eupatorium ageratoides, Pedicularis lanceolata, Lobelia syphilitica, Aster lowrieanus are frequent. Mosses, liverworts and fungi are well represented. The intermediate zone is a dense profusion of ferns, such as Adiantum pedatum, Asplenium felix-fœmina, Onoclea sensibilis, O. struthiopteris, Osmunda regalis, O. claytoniana, O. cinnamomea, Dryopteris acrostichoides with Pteris aquilina and Phegopteris hexagonoptera higher up. The arrangement varies from place to place. Shrubs such as Corylus americana, may be thickly clustered; in other parts a loose growth of oak and hickory saplings, or of Cornus candidissima, with climbers such as Celastris scandens, Dioscorea villosa and Smilax herbacea, covers the ground. In passing upward the herbaceous vegetation includes Thalictrum dioicum, Vagnera racemosa, Eupatorium purpureum, Smilax hispida, Meibomia grandiflora, and nearer the divide are found Meibomia rigida, M. Michauxii, Lespedeza violacea, Vaccinium vacillans, Rosa humilis, Helianthus divaricatus, Salix humilis, Corylus americana, Rhus hirta, and several perennial grasses and composites, already indicated in the first ravine described.

IV. A REJUVENATED RAVINE.

Of greater interest from a dynamic point of view, is a ravine situated across the river, on the side opposite the city water works and near Foster. The surface of the region in that vicinity is typically morainal. The ground is undulating and hilly, the highest point running up to 300 feet (90 m.) above river level. The hills are rounded and at times occurring in parallels. The depressions are of like characteristic. Many of them are occupied by swamps or show deposits of peat several feet in thickness and now covered by soil of similar depth. Springs occur, but running water and streams are few, scarcely any outlets being visible except such as have been produced through ravine erosion.

The drainage from these hills finding its way into the main ravine channel is comparatively large. The soil is heterogeneous, consisting principally of sand and gravel and boulder clay underlying the whole region, with frequent pockets of fine sand or extensive beds of marl. Ground water level and water-content of soil vary accordingly. The seepage springs along the soil line plainly reveal the importance of soil water-content as an influence in the distribution of plants. The ravine has a length of about half a mile (3 km.), but only a part of this is wooded. At the mouth the width is nearly 450 feet (136 m.), the ravine fronting the river from a direction north to south. It seems that a phase of ravine life existed here similar to the one last described; and that at some not distant period a sudden increase of drainage area occurred, which, no doubt, was due to the tapping of the depressions and swamp areas north of the bluff. The effect of cultivation has been scarcely less significant.

That the earlier condition was but temporary is best seen in the changes now taking place. Increased drainage and the consequent entrenched meandering of the ravine stream—averaging in some places a depth of 5 to 6 feet—again are causing vertical banks, both in the old flood-plain of the ravine as well as in the adjoining slopes. In these, though of a tenacious blue clay, the eroded parts average a height of 15 to 25 feet. The size of the trees, moreover, is clearly indicative of former favorable conditions, while the activity of the erosion forces now present, is revealed by leaning and fallen trees.

At the mouth of the ravine occurs an extensive zone of sedges and willows. An interesting feature in the sedge zone is the relative abundance of Chara, the relation of which to local marl formation has been recently described by Davis (10). The plant gets its lime from the water and forms large patches of fine-grained marl deposits. Where the water comes with considerable calcareous matter from the neighboring marl-beds, incrustations develop around roots and mosses. Nearer the ravine stream Salix petiolaris, S. rostrata, S. lucida, Populus tremuloides, together with Cornus stolonifera, various species of Cratægus, Vitis vulpina and Celastrus scandens form a loose thicket. The ground is little shaded and such plants as Gentiana crinita, G. quinquefolia, Aster punicens, Prunella vulgaris, Euonymus obovatus, Parnassia Caroliniana, Impatiens fulva, Urticastrum divaricatum, Nabalus albus and Cystopteris fragilis are frequent. Here especially the relation of the impervious clay layer beneath to the distribution of these plants is evident. On the banks about the mouth Vaccinium vacillans and Gaylussacia resinosa are dominant.

10 Davis, C. A. "A Contribution to the natural history of Marl," Geol. Surv. of Mich. 8:65-90-1900-1903.

Passing northward, the characteristic vegetation found to prevail throughout the upper part of the ravine and the occasional tributary ravines, consist of Juglans cinera, J. nigra, Hicoria glabra, H. ovata, H. minima, Tilia americana, Quercus alba, Q. velutina, Q. rubra, Q. Alexandrii, Ulmus americana, U. fulva, U. racemosa, Acer saccharum, A. rubrum, A. nigrum, Populus deltoides, Fagus americana, together with Hamamelis virginiana, Sassafras sassafras, Carpinus caroliana, Ostrya virginiana, Prunus serotina, Opulaster opulifolia, Cornus florida, Benzoin benzoin, Corylus americana, and others. A conspicuous feature is the large number of saplings of red oak (Quercus rubra), maple (Acer saccharum, A. nigrum, A. rubrum), and beech (Fagus americana). As undergrowth, some of the early flowering forms are found. The character of the humus-flora is also noteworthy. Hepatica hepatica, Arisæma triphyllum, Asarum canadense, Actæa alba, are very common; relatively frequent is Monotropa uniflora. Where the physical nature of the slopes makes rapid weathering and erosion impossible the almost vertical clay bluffs, dripping with moisture, have principally mosses and liverworts, while Collinsonia canadensis, Cicuta maculata, Impatiens fulva, Viola and other moisture-preferring plants are found at the base.

The beds of marl occurring here, covered to some extent by a layer of humus have an herbal vegetation differing but little from other places around them. Of the ferns, Dryopteris acrostichoides is quite common, but mosses, such as Climacium, Hypnum and Mnium are more abundant. The water derived from springs near by, and from seepage, dissolves the almost pure limestone beds very rapidly. Considerable sections are thus undermined, producing instability and consequent settling of the beds, and leading finally to the formation of tributary ravines. The calcium carbonate is carried off to the river, but partly met with again in the form of incrustations mentioned above.

As has been stated, the present paper is preliminary to a more extended study of field work in physiology; hence more complete data will be included in another report. But even at this stage, the results obtained make it very obvious that the simplest condition in the life-history of these plant associations is the outcome of a chain of factors. Where no doubt exists concerning the more dominant ecological factor, in concrete cases no one of them can be cited as exclusively determining the character of the local flora. Many differences in kind and arrangement of vegetation are results of the united action of the various ecological factors working in concert, which, in turn reacted upon by the condition of the plants themselves, thus give rise to changes in habitat and consequent distribution of plants not to be attributed either to a changing topography alone, or ground-water level, character of soil, etc. Fully to understand these plant groups we must contemplate them as the result of an ever-changing process (as described and defined above on page —). And if we wish to compare records, the reason should be that we would know *how* the many active factors are involved and related in the process that is going on.

University of Michigan, Botanical Laboratory, April, 1905.