

THE POSSIBLE ROLE OF MICROCLIMATE¹

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Since the publication of Geiger's (1927) pioneer systematic treatment of microclimates, there have been important advances in this phase of climatology. Many of these studies are of more than passing significance to plant ecology, as a perusal of Geiger's (1950) second revision of his earlier work will reveal. Research during the past quarter-century has resulted, among other things, in giving *dimensions* to microclimates and microclimatic situations. It has changed the word *microclimate* from a philosophical term to one that refers to real, and to a greater extent than ever before, measureable conditions. The old term, by implication at least, was used to answer all questions, some of them unanswerable; the new concept raises more questions and answers fewer, but gives promise of more fruitful results in ecological investigations.

Over almost all landscapes, just above the substrate, there is a mosaic of varying weather regimes. The pattern may be simple, as over a level plain, or it may be exceedingly complex, as in mountainous country. A dozen strikingly dissimilar weather regimes have been described within a single small valley in the dissected

TABLE 1. *A Comparison of Certain Climatic Data Obtained in a Grotto and Frost Pocket, with nearby Weather Bureau Records. Data from a single year.*

	Grotto	Frost Pocket	Weather Bureau
Longest frost-free period in year....	276	124	160
Longest frost period in year (hrs.)..	373	246
Minimum temperature (year).....	+14	-25	-18
Maximum temperature (year).....	75	93	102
Date last spring frost.....	3/9	5/25	4/22
Date last fall frost.....	11/29	9/25	9/29
Rel. rate of evaporation (per season)	1	5
Precipitation (inches).....	00.0	41.0±	41.0

Appalachian Plateau (Wolfe, Wareham, and Scofield, 1949). Valley heads (coves), grottoes, variously-exposed slopes, ridges, crevices, valley bottoms, and other sites, all have differing weather regimes at all seasons. In table 1 certain data from two microclimatic situations in this valley, are compared with macroclimatic conditions.

Detailed analyses of microclimates have been published elsewhere (Geiger, 1950; Wolfe, Wareham, Scofield, 1949) and are beyond the scope of this paper. However, two or three aspects of the data in table 1 may be mentioned to illustrate the role that microclimates might play in the interpretation of floristic phenomena.

The data indicate that the longest frost free period in the plateau occurs in grottoes under present climatic conditions; moreover, extreme minimum temperatures are nearly 40 degrees higher than the lowest temperatures elsewhere. Even though it is assumed that glaciation had pronounced effects on periglacial macroclimate, extremes in these sites might well have been within the ecological amplitude of many boreal, as well as southern species. Not only is the frostless season longer in grottoes than elsewhere, but also the frost season, a condition favorable to many species of higher latitudes that require periods of varying duration to cold before breaking dormancy. It is these kinds of phenomena that make up the warp and

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the weft of our point of view with regard to the role of microclimates in the interpretation of periglacial conditions in the Ohio region.

Whatever the source, and whatever the nature of biota forced into the Ohio region during the Pleistocene, some extraneous species of both plants and animals have persisted in certain of these microclimates since the last glacial retreat. Presently the question as to just where these relicts were during the various maximum advances of the ice will be considered.

VARIATIONS IN MACRO-PERIGLACIAL CONDITIONS

Because of fundamental differences in general physiography and macroclimate, microclimatic, pedologic, and biotic phenomena and conditions along the ice border must have varied considerably from Long Island to the Rocky Mountain front during any single ice advance and from stage to stage during the Pleistocene. In the Ohio-West Virginia-Kentucky region, for example, the first ice advance (pre-Illinoian?) blocked the great Teays drainage system forming a vast proglacial lake, fingers of which extended far southward into tributary valleys in Kentucky and West Virginia (Transeau, 1941; Wolfe, 1940). This phenomenon must have had marked effects on climate and soils and consequently biota. Moreover these conditions would be greatly different from periglacial conditions elsewhere, *i.e.* on the coastal plain, in the Appalachian mountains, and the central lowlands. The discussion immediately hereafter is based on evidences collected in the Appalachian Plateau region.

ARRIVAL OF RELICT BIOTA IN THE PERIGLACIAL REGION

The borders of ice sheets in the Ohio area lie wholly in a Deciduous Forest climate. Within the area, however, are numerous relict communities and disjunctive species as well as species from other formations at the edge of their range.

During the 60 million years preceding the Pleistocene, the vast Teays drainage system developed. With headwaters in the southern Appalachians, and with its confluence with lake or river somewhere in the upper Mississippi Valley, its valley walls and bluffs and its flood plains formed continuous habitats, which along with the tremendous propagule-carrying potential of the system itself, resulted in an exchange of biota, north to south and south to north.

With the advance of Pleistocene ice, a northern biota invaded the area. Whether or not it invaded and passed on, returning later, or whether it simply invaded, will be considered shortly. At any rate, certain of these northern species, along with southern species, occur today in special microclimates within a few miles of the glacial border. For example, in a small re-entrant (grotto) in the cliffs at Old Man's Cave in Hocking County, Ohio, is *Sullivantia sullivanii*, separated by 600 miles from its nearest relative northward in the Dells of the Wisconsin River. With it is *Silene rotundifolia*, a southern Appalachian species at the northern edge of its range. Irrelevant to the present thesis, but none-the-less interesting, is the presence in the same grotto of *Dodocatheon meadia*, of the Prairie.

Briefly, two basic points have been made:

1. There is a multiplicity of climatic regimes today in the plateau region near the glacial border.

2. Growing together in these microclimates at the present time are both species with northern affinities and species with southern affinities, along with various others of no importance in the present discussion.

With the advance of ice at any time during the Pleistocene, migrations of these two floras were limited to the following:

1. Southern species at the northern edge of their range either retreated to the south, returning in post-Pleistocene time to the habitats they occupy today; or, they remained in the periglacial area (not necessarily in the same location) through the ice age.

2. Northern species either became established in the periglacial region during the ice age, or migrated on southward, returning to their present sites at some post-glacial time.

SULLIVANTIA AND SILENE

Many species of plants of the southern Appalachians are at the northern edge of their range in southern Ohio and likewise, an even greater number of species of the Hemlock-Hardwood Formation are at the southern edge of their range or disjunctive in southern Ohio, facts recognized early in the century by Griggs (1913). The two species used to illustrate this discussion were chosen because they occur in special microclimates from which more data have been obtained than from many others just as distinctive.



FIGURE 1. Distribution of *Silene rotundifolia* Nutt.

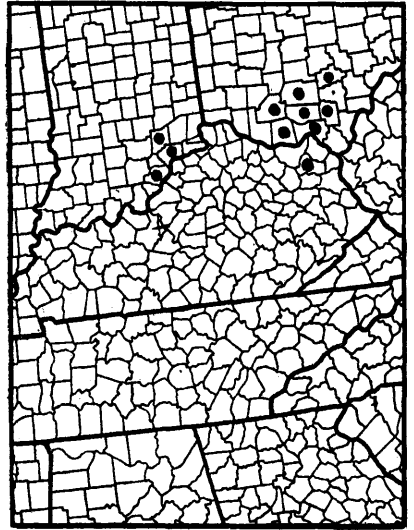


FIGURE 2. Distribution of *Sullivantia sullivantii* (T. & G.) Britt.

Sullivantia is known only from southern Ohio, southern Indiana, and northern Kentucky (fig. 2). It is confined to limestone and sandstone cliff faces, usually on ledges or in grottoes that are moist, yet relatively well-lighted. It produces abundant seed, but at present nothing is known by this writer of its viability.

Silene occurs locally through the southern Appalachians (and rarely to the west of the plateau), reaching its northern limit in several stations in southern Ohio (fig. 1). It too is confined to grottoes, crevices, and ledges that develop in vertical limestone and sandstone cliffs. Superficially its habitat may appear drier than that of *Sullivantia*, but its roots are often long (more than 6 feet) and are always in contact with abundant moisture. It also produces abundant seed from July until November in the Ohio area (Heaslip, 1950), which is almost 100 percent viable.

Both of these species then, are confined to the peculiar grotto-crevice-ledge environment, certain data from which are given in table 1. It is not implied that these measured factors are the ones responsible for the persistence of these species in these situations. Other factors, unmeasured or unmeasurable, may be more important. It can be said that they are confined to a microclimatic complex of which the measured factors are a part, at least.

PERIGLACIAL MICROCLIMATES

With the ice at a stage of maximum advance, the periglacial microclimatic mosaic was altered. Certain complexes were perhaps eliminated, others expanded or contracted, with new ones being added. Indeed, the mosaic of microclimates might well have been simplified, for near the ice border, glacial winds were meeting the Gulf air masses and cloudy, rainy weather must have been a conspicuous feature of the growing season.

At any rate, the grotto microclimatic complex must have occurred somewhere near the glacial border. Whether it was more widespread, or localized, as it is today, makes no difference. For if we accept the notion that the terrain south of the ice was tundra-like for miles (Deevey, 1949), we will have to assume that both *Silene* and *Sullivantia* were destroyed in the periglacial region. Expansion of the grotto type microclimate could well account for providing conditions favorable to migration southward and preservation in grotto refugia there. But any great migration—in terms of several hundred miles, not to mention a Floridian visit (Deevey, 1949)—“with the coming of the tundra”, raises two pertinent questions.

1. If these species retreated far into the southern Appalachians during Pleistocene, how, with their narrow ecological amplitude and lack of continuous migration routes, did they get back near the glacial border?

2. Having once arrived, why did *Sullivantia* not persist in some of the millions of grotto microclimates of the southern mountains?

The realization is clear that one swallow does not make a summer, nor a single catchfly a foundation for interpreting Pleistocene periglacial conditions. But along the glacial border in Ohio is a rather impressive group of southern Appalachian and southern species to which question 1 above, might be applied. Excluding *Polypodium polypooides*, the Gray Polypody, because of its windblown propagules, the list would include *Magnolia macrophylla*, Great-leaved Magnolia; *Pachistima canbyi*, Mountain-lover; *Rhododendron maximum*, Great Rhododendron; *Styrax grandifolia*, Large-leaved Storax; *Halesia carolina*, Silver-bell; *Azalea lutea*, Flame Azalea; *A. nudiflorum*, pink Azalea; and *Iris verna* var. *smalliana*, Dwarf Iris.

Likewise there are certain northern species occurring in southern Ohio which apparently were present during the ice age. Some of these occur far to the south along the Atlantic seaboard, but the edaphic factor provided the continuous habitat (*i.e.*, exposure of the seacoast with lowering of sea level during Pleistocene), and suitable continuous habitats must have been available in the mountains over which these reached the southern Appalachians.

MICROCLIMATES ON THE COASTAL PLAIN

With a great deal less evidence, one may suggest the possible occurrence of microclimates on the coastal plain proper, these being invaded by propagules of northern species in the time of flood or in some other manner. The existence of “cold pockets”, even as far south as New Orleans, is suggested by the data of McDonald (1940) and Dyke (1941). Variations in minimum temperatures as great as 25° are reported between New Orleans and a station six miles away. On 14 occasions in four years, differences greater than 20° were noted. A temporary establishment of northern species in such sites, if flood waters may be assumed to be an efficient propagule-carrying agency, is not altogether unreasonable. Earlier mention was made of the probability of abundant rainfall at the ice front when the cold glacial winds came in contact with the warmer Gulf air masses. Scott (1950) has described such conditions in front of the ice cap on the island of Kerguelen, pointing out that rain, sleet or snow falls during 300 to 320 days per year. No such frequency was probable in the plateau region during Pleistocene but considerably greater rainfall than is now recorded must have occurred regularly—especially during the growing seasons.

With increased rainfall at the ice front, plus meltwater from the vast snow and ice fields to the north, in addition to the regular precipitation in mountains to the southeast, tremendous floods must have been characteristic phenomena of the Ohio and Mississippi Valleys in glacial times. These floods were presumably more frequent, and in volume several times as great as the biggest flood of modern times, when a crest of 80 feet was reached at Cincinnati. The propagule-carrying potential of these floods might be exceedingly great, and the dispersal over the flood plains and lowlands of the southern plains relatively widespread.

One other phase of the ice age migrations might be scanned with the above mentioned pluvial conditions in mind, namely that of "the Pleistocene deposits of Louisiana [containing] tulip tree, sweet gum, tupelo, magnolia, along with northern conifers . . ." (Deevey, 1949).

Before agreeing that "the summers in Louisiana [were] cool enough for spruces while the winters were still warm enough for magnolias" (Deevey, 1949), another alternative is suggested. The same flood waters mentioned above, advancing as they must have, through various vegetation belts south of the ice, could well have carried a tremendous load of organic debris. Before interpreting this mixture of magnolia and fir in terms of forest associations, the notion of fossil flotsam might be investigated.

SUMMARY

The preceding discussion has dealt briefly with the possible role of microclimatic phenomena in the interpretation of periglacial biotic and climatic phenomena. To a large extent, the discussion is based solely on microclimatic evidences, and these would seem to support a concept that has glaciation exerting little influence on climate or biota very far beyond the ice front.

A more thorough knowledge of microclimatic phenomena is admittedly needed, as well as a more precise knowledge of floristic geography, before this relatively new discipline can contribute major evidences such as those presently being advanced by the pedologists, geologists, climatologists, and biologists.

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