THE DIFFERENTIALS EFFECTIVE IN THE DISTRIBUTION OF PLANTS IN THE COASTAL PLAIN[1]

MATHEMATICIANS use the noun differential as expressive of infinitesimal differences between two values of a variable quantity. The student of plant geography finds likewise that he can speak of the differentials effective in the distribution of plants, for frequently slight unrecognizable changes in the character of the environment may have marked influence on the associations of plants which are found in two adjacent, but different habitats. Dr. Gregor Kraus has a remarkable book which sets forth these differences in small areas published as "Boden und Klima auf Kleinstem Raum."[2] What is presented in the following discussion will be drawn from the speaker's research study of the geography, geology, physiography and vegetation of the Atlantic Coastal plain from Nantucket in the north to Key West in the south.

Nantucket, Martha's Vineyard, Block Island and Long Island lie within the glaciated region and their soils and topography have been influenced consequently by glacial action. The rounded hills of Nantucket, with the exception of parts of the south shore of the island, are composed of loosely assorted sands and gravels with erratic boulders imbedded. This elevated land being wind-swept is covered with heath vegetation, the plants of which in the course of time have formed a raw humus. Here grow *Quercus nana, Quercus prinoides, Comptonia asplenifolia, Myrica carolinensis, Corema Conradii, Gaylussacia baccata, Vaccinium vacillans, Vaccinium pennsylvanicum, Arctostaphylos uva-ursi, Gaultheria procumbens, Hudsonia ericoides, Epigaea repens, Tephrosia virginiana, Baptisia tinctoria, Chrysopsis falcata, Sericocarpus asteroides.*[3] In earlier times, as evidenced by the remains, deciduous woodlands existed in the valleys, or hollows, where the trees were protected from the winds. As in other glaciated regions, kettle holes abound, and these basin-like depressions are filled either with water, forming lakes and ponds, or by bogs with the usual bog species. Instead of a uniform aquatic and bog flora for all the kettle holes, each depression has a flora of its own, for example, one pond will be covered with water lilies (*Nymphaea odorata*), another will be invaded with the swamp loosestrife (*Decodon verticillatus*). The margin of one pond will have an association of *Hypericum adpressum*, another a thicket of button bush (*Cephalanthus occidentalis*). The former embayments of the south shore of Nantucket, which at one time communicated with the sea, have been closed by sand bars on the ocean side, and their water is fresh, or after storms, when the waves break over the barrier beach, decidedly brackish. Where the currents have cut away the hills, high bluffs have been formed, as, for example, Sankaty Head, and these bluffs have been tenanted by characteristic species which thrive on the steep slopes where there is a constant down-slipping of the sand and gravel, of which they are composed.

Martha's Vineyard is a larger island than Nantucket and its topography necessarily more varied. Consequently we do not find the same effect of the wind, as Martha's Vineyard is covered more completely with forest. Besides it is nearer the mainland and less exposed. In the physiognomy of its flora, it is more like the adjacent part of New England. Block Island is a small island well out at sea. In the almost complete absence of trees it resembles Nantucket. There is a remnant of a deciduous woods in a well-protected depression or valley. Early in the history of Nantucket similar depressions were so filled. Kettle hole ponds are present, and, where not used by the farmers to water their stock, are filled with aquatic and bog plants, such as bog bean (*Menyanthes trifoliata*), the cotton grass (*Eriophorum*) and the floating heart (*Limnanthemum*).

Long Island has two parallel moraines which form its backbone and which represent the great terminal continental moraine along the axis of which the four islands here described are placed. The central part of Long Island from Great Peconic Bay westward through two thirds of the island is characterized by a series of hills representing the Ronkonkoma Moraine from the large kettle hole occupied by Lake Ronkonkoma in the middle of the island. These hills of loose, porous sands and gravels, which retain the water poorly, are covered with the pine barrens where the prevailing tree is the pitch-pine (*Pinus rigida*) and associated species adapted to grow in a barren soil which dries out quickly. Harbor Hill Moraine, which is best seen from Port Jefferson westward, is broken into by deep, finger-like fjords or bays, and where the moraine hills have been undermined by the waters of Long Island Sound, steep bluffs on which the plants have a precarious hold, have been formed. This north shore is characterized by a deciduous forest, for the rain water which falls on the hills breaks out to the surface along the lower slopes, and these conditions are conducive to the growth of broad-leaved trees. In the lower parts of the north shore

[1] Paper read at symposium of the Ecological Society of America on "The plant and animal distribution of the coastal plain," held in Washington, December, 1924, at the meetings of the American Association for the Advancement of Science.

[2] Jena, 1911. Verlag von Gustav Fischer.

[3] Harshberger, John W., "The vegetation of Nantucket," *Bull. Geogr. Soc. Phila.*, XII: 70–79, April, 1914.

valleys, where fine springs gush forth, moisture-demanding trees are found, such as the beech, tulip, black walnut and sycamore. West of the pine barrens the low hills which represent Hempstead Plain are treeless and covered with a natural prairie, vegetation first fully investigated by Dr. Roland M. Harper.[4] It seems that this natural prairie has existed always, and the speaker is inclined to go back to glacial times to account for its origin, for the soils represent the outwash materials of a glacial fan which on the retreat of the glacial ice were ready for occupancy by plants. The invasion of the prairie species probably took place at that time and by the formation of a dense and unbroken mat of roots and overground parts has prevented the invasion of tree species which surround the plain on all sides. The proof of this statement is that when the ground is broken for cultivation tree species will thrive.

The Hudson River and New York Bay were efficient barriers in the former spread of coastal plain plants from south to north, for Stone[5] has shown that the so-called pine barrens of Long Island are decidedly weak in the characteristic pine-barren plants. Of 62 species listed for this region, only 26 are included in Stone's list of typical New Jersey pine-barren plants. New Jersey and North Carolina pine barrens have more in common.

When we study the coastal plain of New Jersey we find, if we draw a line west to east, the following types of vegetation: In the Delaware River Valley there are fresh-water, tidal marshes with the upland and interstream areas covered with deciduous forest. This is sometimes called the transition area, and the trees characteristic of it are willow oak (*Quercus phellos*), sweet gum (*Liquidambar styraciflua*), holly (*Ilex opaca*) and scrub pine (*Pinus virginiana*). Beech and tulip trees occur, but they are not confined to the coastal plain in these parts. To the eastward lie the pine barrens, which are about 45 to 50 miles wide. Here the pitch pine (*Pinus rigida*) and its associates are supreme.[6] Before reaching the salt marshes we pass a narrow strip east of the pine barrens where deciduous trees are found. Here the characteristic trees are holly, willow oak and sweet gum, but the scrub pine is absent. Skunk cabbage (*Symplocarpus foetidus*) comes into the northern part of this strip. The salt marshes fringe the open bays which separate the sandy beaches and dunes with their vegetation from the mainland. The distribution of plants across the state, as we have described their occurrence, is due fundamentally to differences in the soil. I have shown elsewhere[7] that the water-holding capacity of the soils represented in the above section of the state is as follows:

Dune sands	33.33 per cent.
Pine-barren soils	45.87 " "
Upper plain soils	46.00 " "
Deciduous forest soils	56.16 " "

The New Jersey plains (Upper and Lower), or speaking phytogeographically, the *Coremal,* because of the abundance of the broom crowberry (*Corema Conradii*), are peculiar in being covered with a dwarf, elfin or pigmy forest of pitch pines, oaks, laurel and other shrubs with a herbaceous undergrowth. It would appear from extensive research, which I have made, that the dwarfed character of the pines, oaks and other plants of the Coremal is due primarily to the stiff impervious subsoil and the light, easily dried, sandy surface soil. The elevated character of the country facilitates rapid surface drainage and the influence of elevation coupled with strong winds has a dwarfing effect on the plants exposed to such conditions.

The coastal plain of the southern United States, from Maryland to Texas, presents some interesting differentials. W. J. McKee has distinguished the Lafayette and the Columbia formations. The Lafayette, the older of the two, is a deposit of sandy clay, reddish or yellowish in color, varying considerably in thickness, lying unconformably on the Mesozoic and the Cenozoic strata over a vast area of the coastal plain. It is supposed to have been deposited just before the Glacial Period during a submergence of the coastal plain estimated to have lasted 60,000 years. In general it extends from Maryland to Texas and up the Mississippi Valley to Illinois. The Columbia formation in the northern coastal plain consists almost entirely of sand. It was probably laid down during a much shorter period of submergence contemporaneous with or subsequent to the glacial period. It is always above the Lafayette where the two come into contact. The Columbia formation covers a large part of the coastal plain from Long Island to Mexico and up the Mississippi and Ohio rivers to Indiana. In the middle and South Atlantic states it covers the whole area near the coast. The relation of vegetation to these deposits is marked. *Taxodium imbricarium,* one of the deciduous cypresses, always grows over the Lafayette formation in undrained swamps, while *Taxodium distichum* grows on the Columbia deposits and on others in drained swamps, but not on the Lafayette formation.

[4] Harper, Roland M., "The Hempstead plain," *Bull.* Amer. Geogr. Soc. XLIII: 351–360, May, 1911; *Torreya,* 12: 277–286, December, 1912.

[5] Stone, Witmer: "Plants of Southern New Jersey," 1911, page 112.

[6] Harshberger, John W., "The Vegetation of the New Jersey Pine Barrens," 1916.

[7] Harshberger, John W., "The Vegetation of the New Jersey Pine Barrens," 1916.

I have outlined the differentials found in South Florida south of 27°30′ north in my book, "The Vegetation of South Florida" (1914). On the east coast of Florida are rolling sand plains and sand hills which extend from the north side of Indian River Inlet south to Hillsboro Inlet. It appears that these sand hills are ancient dunes formed by wind action, for the sand deposits have covered an older, flat land of limestone. These hills are covered with the sand-pine or spruce pine (*Pinus clausa*), with low oaks (*Quercus geminata, Q. minima, Q. myrtifolia*), the saw palmetto (*Serenoa serrulata*) and rosemary (*Ceratiola ericoides*) and other plants.

To the southward are exposures of oolithic limestone which are covered with slash-pine (*Pinus caribaea*) and an occasional silver thatch-palm (*Coccothrinax argentea*) and coontie (*Zamia integrifolia*). Around Princeton there are depressions in the limestone where broad-leaved hammock plants grow as islands in a sea of pines. Below Miami are everglade prairies which cut the slash-pine forest transversely. The delimitation of pineland and prairie is here very sharp. One can stand with one foot on the prairie and the other in the pine forest. The difference in elevation between pineland and prairie is only about a foot or eighteen inches. Back of the pineland occurs the fresh-water marsh, or fenland known as the Everglades. Here is a sea of saw-grass stretching unbrokenly to the horizon in every direction, the surface diversified by hammocks and groves of trees. The whole fen is threaded by channels which connect open lagoons filled with aquatic plants. Lake Okeechobee is a sufficiently large body of water to ameliorate the climatic of the south shore, for here we find a forest of custard apple (*Annona glabra*), a mile or two wide, bordering the south shore of the lake.

Stretching south and southwest from the extreme end of Florida there is an archipelago of approximately two hundred named islands known as the Florida Keys. First at the northeastern end of the chain are two sand islands, namely, Virginia Key and Key Biscayne, designated the Upper Sand Keys. Seven miles south of Key Biscayne is a second group of islands composed of coral rock extending from Soldier Key a distance of approximately one hundred and twenty miles to the West Summerland, or Spanish Harbor Keys. This section of the chain may be called the Upper Keys. Beginning with No Name Key and Little Pine Key is the third natural group extending in a western direction for thirty miles to Key West. The islands of this group are composed of Miami limestone and are known as Lower Keys. Westward of Key West reaching into the Gulf of Mexico lies the fourth section of the Florida Keys, composed of sand. These are the Lower Sand Keys. As one might expect these differences in the character of the materials composing the islands of the four groups of Florida Keys naturally influence the character of the vegetation. We find that to be the case, for the Upper Sand Keys maintain a sand-dune and hammock flora related to that of the coastal peninsula to the north. The Upper Keys are clothed with a dense hammock growth of tropical hardwood shrubs, trees and palms, resembling the vegetation of the Bahama Islands. The Lower Keys are more varied in their vegetation with large areas covered with pineland, palm groves and extensive hammocks.[8] Their vegetation suggests that of Cuba. The Lower Sand Keys are little more than bars of sand, shifting their position with the ocean currents and with the hurricanes that sometimes strike them so as to completely change their entire configuration. Dr. William R. Taylor informs me that a tropical hurricane may denude completely the coastal fauna and algal flora of these islands. The Lower Sand Keys support usually, like the ocean side of all the Florida Keys, the characteristic strand flora found on most of the West Indies.

The foregoing sketch indicates that from north to south, excluding the climate from consideration, the edaphic, geologic and physiographic differences are productive of differences in the flora, and if we consider the matter from the ecologic and phytogeographic aspects, these differentials are directly responsible for variations in the vegetation or ensemble of plant species as related to environment. Such a survey shows that there are many problems awaiting study, and the Atlantic coastal plain is favorably situated for such research, for many large cities are situated along its inner edge known as the "fall line" and the student can use these centers of population as providing the facilities for his investigation.

JOHN W. HARSHBERGER

BURT GREEN WILDER

DR. BURT GREEN WILDER, professor of neurology and vertebrate zoology, emeritus, in Cornell University, died at his home, 93 Waban Hill Road, Chestnut Hill, Mass., on January 20, 1925, in his eighty-fourth year.

Dr. Wilder was born in Boston on August 11, 1841, and traced his ancestry directly back to Thomas Wilder, one of the *Mayflower* passengers. His youth and early manhood were passed in the stimulating intellectual, moral and political atmosphere of New England; and he enjoyed the instruction and friendship of the great teachers Asa Gray, Oliver Wendell Holmes, Jeffries Wyman and Louis Agassiz. His well-known uprightness of character, his devotion to

[8] Small, John K., "Flora of the Florida Keys," New York, 1913.