THE DIVERSITY OF ECOLOGIC CONDITIONS AND ITS INFLUENCE ON THE RICHNESS OF FLORAS.

BY JOHN W. HARSHBERGER, PH.D.

The ecologic conditions of vegetation are those which are connected with the influence of the environment on the plants. The factors which influence the growth and the distribution of species may be divided into Climatic, Edaphic, Physiographic, Biotic, and Chronologic (Geologic-Historic). The climatic factors include the influence of temperature, moisture, light and wind. The edaphic factors are connected with the conditions of the soil. The physiographic factors are concerned with the physical structure of the geosphere (land surface) and the hydrosphere (water surface) of our planet. The biotic factors are those in which plants and animals (including man) are influential. The chronologic factors deal with the past geologic and paleontologic conditions of the earth, while the historic data are concerned chiefly with the past distribution of plants and their probable successional history. The diversity of ecologic conditions is the diverse character of the climate, soil, physiography, life and chronology of any region.

The richness of a flora may be considered from a number of different points of view. We may consider it numerically, that is the actual number of species; or we may consider its richness in generic types, in endemic types, in introduced plants, in common plants, in rare plants, in relict species, in biologic forms (such as xerophytes, hydrophytes) and in growth forms (trees, shrubs, lianes) or in the types suggested first by Raunkiaer, namely, the phanerophytes, the chamæphytes, the hemicryptophytes, the helophytes and the geophytes. If we use the system of Raunkiaer and arrange the above types by percentages, then we would have a climatic spectrum which would enable us to make a comparison with the floras of other lands and climes similarly arranged. An attempt will be made to study the diversity of ecologic conditions and its influence on the richness of the floras of a number of different phytogeographic regions of North America. Those regions will be chosen with which the writer is more or less familiar, and regions which have been studied carefully by other botanists and their floras catalogued.

The regions of little physiographic diversity are the following: Point Pelee, Ontario, jutting into Lake Erie, comprises that part of Essex County at the western end of the lake, and in the enumeration of its plants those found on Pelee Island are included. Point Pelee is a triangular piece of land with its acute angle running about 9 miles south into Lake Erie. About nine-tenths of this tract is mostly a very wet marsh between the east and west beaches. Within this marsh limit are several ponds and small lakes, while on the east and west sides are narrow low, sandy beaches, the western one backed by sand dunes. Outside the marsh the land is sandy. No geographic configuration could be much more simple. C. K. Dodge[1] has found 466 genera and 623 species of ferns and seed plants on Point Pelee. The generic coefficient, which is the proportion of genera to species in a flora, is for the Point flora 74.7 per cent.

The pine-barren region of New Jersey is a country of slight relief. The soil is sandy, underlaid by gravel. The streams which flow into the Atlantic Ocean have nowhere a rapid current, and their mouths are influenced by tide water. The hills are low, the steeper ones having gradual slopes. Natural lakes are small and widely scattered. The lower drainage levels are occupied by marshes and swamps. With this simple topography we find a numerically poor flora of 250 genera and 555 species of native plants, so that the generic coefficient is 45 per cent.

Hartsville, South Carolina, the flora of which has been investigated by Coker,[2] is found on the inner drier part of the Atlantic coastal plain. Just north of the town proper is a rapid descent of about 50 feet into the valley of Black Creek. This valley with certain irregularities extends approximately one-half mile and is terminated on its northern edge by sand hills, which rise in gentle undulations. The general surface configuration of the country south of Black Creek Valley is that of a level plain with slight elevations and depressions, some of the latter cut by the streams. The nature of the vegetation on the level plain is determined very largely by the position of the water surface in the soil. The flora, as enumerated by Coker, includes 344 genera and 628 species of plants, which gives us a rather higher generic coefficient of 54.6 per cent.

The Altamaha Grit Region of Georgia, whose flora has been investigated by Harper, has fairly uniform environmental conditions.

---

[1] Dodge, C. K.: Annotated List of Flowering Plants and Ferns of Point Pelee, Ont., and Neighboring Districts, 1914.

[2] Coker, W. C.: The Plant Life of Hartsville, S. C., 1912.

Harper[3] finds that there are 404 genera and 797 species of plants, giving, therefore, a generic coefficient of 50 per cent.

Miami Florida, is situated on the oölitic limestone formation of south Florida.[4] The flat, featureless country is relieved by short streams which drain the Everglades (of simple topography) into the Atlantic Ocean. The sea beaches are of silicious sand. Small enumerates 466 genera and 796 species in his *Flora of Miami*, and the calculated generic coefficient is, therefore, 59 per cent.

The Florida Keys[5] are of even simpler configuration than the adjoining mainland. There are no running streams and the limestone soil is singularly porous. Besides, the islands are narrow and their shores are rocky, of calcareous sands, or mud-fringed. The entire number of genera is, according to Small, 346 and the number of species is 533, giving the exceptionally high coefficient of 65 per cent.

Selecting a number of other localities, we find that the vegetation of the upper Susquehanna[6] in New York and Pennsylvania is developed on a soil of glacial origin, in fact the whole region was glaciated. Here there is a relatively rich flora of 462 genera and 1105 species of seed plants and ferns. The generic coefficient of the upper Susquehanna flora, is, therefore, 41.8 per cent.

Lancaster County, Pennsylvania, is in a region of rich, agricultural development, which has been dependent on the limestone soils, suitable to the tobacco plant, which thrives upon such soils without depleting seriously the natural mineral fertilizers. The county is in the rolling Piedmont district where the hills are rounded, the streams quiet and the topography comparatively simple and unmountainous with broad, fertile valleys between the ranges of hills. The Susquehanna River runs along the western boundary for about forty miles and for over one-half of this distance it passes through a canyon with steep sides and a southern exposure where plants of a more southern distribution are at home. Sphagnum swamps among the hills have a more northern flora. Shale and sandstones border the northern part of the county, and south of the middle belt of limestone, schistic rocks occur with some outcrops of serpentine.

---

[3] Harper, Roland M.: *Ann. N. Y. Acad. Sci.*, 17 : 323.

[4] Harshberger, John W.: The Vegetation of South Florida south of 27° 30′ North, exclusive of the Florida Keys, *Transactions Wagner Free Institute of Science of Philadelphia*, VII, Part 3, October, 1914, p. 183.

[5] Small, John K.: Flora of Miami, 1913; Flora of the Florida Keys, 1913.

[6] Clute, Willard N.: The Flora of the Upper Susquehanna and its Tributaries, 1898.

Small[7] enumerates 617 genera and 1464 species of Lancaster County plants, so that we have a generic coefficient of 42.1 per cent.

As a general rule, the smaller the area of land, the more simple and uniform the configuration of that country. There are of course exceptions to this fact. Fortunately, we have two floras from which we can draw conclusions. Daniels[8] has studied the flora of Columbia, Missouri, and vicinity and Mackenzie[9] has enumerated the plants of Jackson County, the same State. Columbia is in the tension belt between forest and prairie. The prairie vegetation is that of Illinois and Iowa; the forest vegetation is that of the Ozark Plateau of Missouri and northern Arkansas. The bottoms of the Missouri River bring hither the alluvial flora and in the ponds and marshes occurs the hydrophytic flora of the eastern United States. Jackson County is bounded on the north by the Missouri River. There are river sand bars, high and rocky bluffs, and an uneven country threaded by small rivers. Prairie country lies between the streams. Barrens are found where the limestone rocks are covered by a thin soil, with a bog region found along the Missouri bluffs west of Sibley. Daniels lists 435 genera and 1058 species of plants about Columbia. The generic coefficient is 41.1 per cent. Mackenzie enumerates 500 genera and 1141 species in the flora of Jackson County with a calculated generic coefficient of 43.8 per cent.

The Pacific coast flora also illustrates the same principle first enunciated by Jaccard,[10] that the generic coefficient is inversely proportional to the diversity of the ecologic conditions. Hall[11] has written one of the best local floras extant. The Yosemite National Park presents a great variety of conditions, but as compared with the central Rocky Mountain region or the entire Sierra Nevada chain its topography is less diversified. Here, however, we find springs, creeks, rivers, ponds, lakes and glaciers with rocky outcrops, gravelly ridges and steep precipices. The irregular topography gives rise to southward-facing slopes which receive the full effect of the sun's rays, as well as northward slopes, where it is moist and shady. The altitude ranges from 2500 feet to 13,090 feet along the crest of the Sierra Nevada. If an enumeration is made of the

[7] Small, John K.: Flora of Lancaster County, Pa., 1913.
[8] Daniels, Francis P.: The Flora of Columbia, Missouri, and Vicinity, 1907.
[9] Mackenzie, Kenneth: Manual of the Flora of Jackson County, Missouri, 1902.
[10] Jaccard, Paul: Nouvelles Recherches sur la Distribution Florale. *Bull. Soc. Vaud. des Sci. Nat.*, XLIV, 259, 1908.
[11] Hall, Harvey and Charlotte C.: A Yosemite Flora, 1912.

plants in Hall's *Yosemite Flora*, we get, omitting the grasses, sedges, rushes and varietal forms, a total of 741 species and 311 genera with a generic coefficient of 41.9 per cent. If the omissions are supplied, Hall estimates that there would be not less than 1200 species in the park area of 1124 square miles.

The selection of regions of greater physiographic diversity, than those which we have discussed, brings out some interesting facts. It shows that our study is a comparative one, as we have contrasted areas such as Point Pelee and the Florida Keys with regions of somewhat greater diversity, such as Jackson County, Missouri and the Yosemite National Park, California. A greater contrast is seen when we compare the Yosemite region of considerable diversification of topography with regions of even greater natural environmental conditions.

The flora of the State of Connecticut,[12] which has a great variety of soils, slope exposures, river systems and tidal estuaries, includes 621 genera and 1942 species, so that the generic coefficient is 31.9 per cent. As a close approximation to this coefficient yielded by a flora at about the same latitude and not far removed geographically, we have the flora of the vicinity of New York. In his monograph, Taylor[13] lists 830 genera and 2651 species of plants. The physiography of the New York region includes salt marshes, estuaries, sea beaches, large river systems, mountains, as the Catskills and the Poconos, sandy country, as the pine-barrens of New Jersey, and morainic deposits in Long Island and elsewhere. Hence we find the percentage 31.3 per cent. to be an expression of that diversity.

The flora of a great state like Pennsylvania,[14] with all kinds of soils, river systems, lakes, bogs, mountain systems and plateaus, might be expected to give a low generic coefficient, and we find on counting that there are 680 genera and 2275 species of ferns and seed plants, so that the coefficient is 29.8 per cent.

Consulting the *Flora of Tennessee*, by Gattinger, published in 1901, we find that for that state, with a high and ancient system of mountains in its eastern end, that there are 755 genera and 2218 species of plants, a considerable number less than in Pennsylvania, and that the generic coefficient of the Tennessee flora is 34 per cent.

The plant life of Alabama[15] as concerns the pteridophytes and

[12] Committee Conn. Bot. Soc. Catalogue of the Flowering Plants and Ferns of Connecticut, 1910.

[13] Taylor, Norman: Flora of the Vicinity of New York, 1915.

[14] Small, John K.: Flora of Pennsylvania, by Thomas C. Porter, 1903.

[15] Mohr, Charles: Plant Life of Alabama, 1901.

spermaphytes, in a region of great physiographic diversity comprises 822 genera and 2502 species, yielding a generic coefficient of 32.8 per cent.

However, if we use Coulter and Nelson's *New Manual of Botany of the Central Rocky Mountains* (1909), we find that 23.7 per cent. is the generic coefficient for that region where the diversity of land configuration is great and where the ecologic conditions present striking differences. There are listed in this manual 649 genera and 2733 species.

The differences presented by the generic coefficients of different countries is illustrated by reference to the *Flora of the State of Washington*, by Charles V. Piper (1906), and by an enumeration of the genera and species given in Jepson's *Flora of Western Middle California* (1901). The first work gives 614 genera and 2279 species, as the richness of the Washington flora, while Jepson's book includes 421 genera and 1449 species. The generic coefficient for the flora of Washington was determined to be 26.9 per cent. and for that of western middle California 29 per cent.

In such regions as the Appalachian Mountains, which represent an ancient upheaval, and are covered with a deciduous forest, which has occupied the region since the Miocene, the chronologic factor must be considered as one of the factors influencing the numerical richness of the flora. This fact is also illustrated in California, where the diversity of the coast flora in endemic types, as contrasted with that of the Sierra Nevada Mountains, is linked intimately with the past geologic history of the country. Although possessing many species in common, the flora of the coast ranges of California is decidedly different from that of the Sierra Nevada. Jepson regards the flora of the California coast ranges as a decidedly endemic one, much older and more unique than that of the Sierra Nevada. An examination of a list of plants peculiar to the coast ranges and the Sierra Nevada will show that the coast ranges lack those northern genera which we may call boreal-alpine, while the list of genera found in the Sierra Nevada includes such boreal-alpine genera as *Bryanthus*, *Cassiope*, *Sibbaldia*. This difference at once emphasizes the fact, that to explain the floral diversity and the generic coefficient, we must emphasize not only present conditions of physiography as effective, but we must study the geologic history of the region as well, as the past distribution and past successional phases of the land and water plants.

Before summarizing, it is important to give a few additional

comparative figures. Small includes in his *Flora of the Southeastern United States* (1913), 6364 species and 1494 genera, giving a generic coefficient of 23 per cent. The total number of genera and species in Gray's *Manual*[16] is 821 genera and 3413 species, or 24 per cent., for the British flora 734 genera and 2964 species, or 24 per cent., and for Switzerland 659 genera and 2453 species, or 27 per cent.

If we place in sequence the numbers which we have given above, it becomes evident that we can arrange our regions so that we discover that no two places are alike with respect to the diversity of the physiographic conditions.

Region.	Species.	Genera.	Generic Coefficient.
Point Pelee, Ontario	623	466	74.7 per cent.
Florida Keys	533	346	65 "
Miami, Florida	796	466	59 "
Hartsville, South Carolina	628	344	54.6 "
Altamaha Grit Region, Georgia	797	404	50 "
Pine Barrens, New Jersey	555	250	45 "
Jackson County, Missouri	1141	500	43.8 "
Lancaster County, Pennsylvania	1464	617	42.1 "
Yosemite National Park (incomplete)	741	311	41.9 "
Upper Susquehanna	1105	462	41.8 "
Columbia, Missouri	1058	435	41.1 "
Tennessee	628	344	34 "
Alabama	2502	822	32.8 "
Connecticut	1942	621	31.9 "
New York and vicinity	2038	830	31.3 "
Pennsylvania	2275	680	29.8 "
Switzerland	2453	659	27 "
State of Washington	2219	614	26.9 "
Colorado	2912	702	24.1 "
Northeastern United States	3413	821	24 "
Great Britain (Druce)	2964	734	24 "
Central Rocky Mountains	2733	649	23.7 "
Southeastern United States	6364	1494	23 "

The figures of this table are a partial confirmation of Jaccard's law of plant distribution, applied for the first time to a statistic study of the American flora. It seems, therefore, "that the generic coefficient is inversely proportional to the diversity of ecologic conditions." Such regions as the central, northeastern and southeastern United States, central Rocky Mountains, Great Britain, and Switzerland have ecologic conditions of the greatest diversity, and hence low generic coefficients, while the Pelee region, the Miami region and that of the Florida Keys with fairly uniform physiography have relatively high generic coefficients.

[16] Robinson, B. L., and Fernald, M. L.: A Handbook of the Flowering Plants and Ferns of the Central and Northeastern United States and Adjacent Canada, 1908.