

PROGRESSIVE AND RETROGRESSIVE CHANGES IN THE PLANT ASSOCIATIONS OF THE DELAWARE COAST

LAETITIA M. SNOW

(WITH SIX FIGURES)

During July and August 1901, certain observations were made on the plant associations of the Delaware coast, from Cape Henlopen southward, for about six miles.¹ Ten years later, in July 1911, the same region was again visited in order to ascertain the changes which had occurred during the interim.

Considering the extreme instability of dune topography, surprisingly little change was noted, thus indicating the slowness with which plant associations, in general, change their character. Certain observations, however, seem of value, as indicating the direction of change in various associations, and are therefore recorded.

As in the previous study, on account of the lack of flowers and fruit, the identity of many forms was difficult—at times impossible—to determine. For regions which showed practically no change, no lists are presented. Where changes were noted, only dominant forms are given, in order that an idea of the direction of change may be obtained. The nomenclature of GRAY'S *Manual* (7th edition) is used, with the BRITTON synonyms in parentheses.

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I. Geography and physiography

As a general discussion of the position, topography, soil, and climate of the region was presented in the former paper, a consideration of these points will be omitted.

II. Plant formations

A. TREELESS OPEN

1. *Beach formation*.—(a) *Lower beach*.—The contour of the lower beach varied exceedingly during July 1911, thus indicating

¹ SNOW, L. M., Some notes on the ecology of the Delaware coast. BOT. GAZ. 34:284-306. map and figs. 1-10. 1902.

an unstable condition. This instability is further evidenced by the fact that, during the 20–25 years which have elapsed since some of the summer residents first visited the region, the beach and the sea-cliff, along which Surf Avenue extends, have receded many feet. After great storms, especially during the winter, the beach is said to be several feet lower, exposing at such times ledges of peaty material. During the period of this study one small ledge nearly in front of Hotel Henlopen, Rehoboth, was twice exposed,

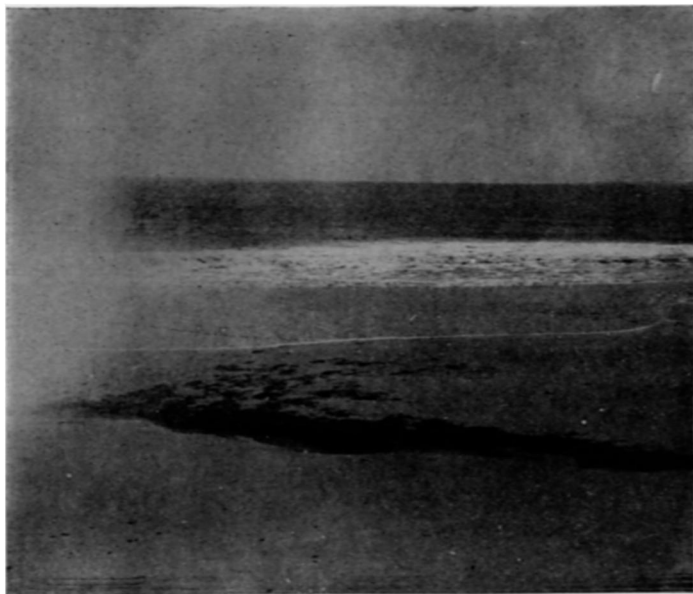


FIG. 1.—Ledge of peat in the beach near Henlopen Hotel, Rehoboth, Del.

appearing somewhat as in fig. 1. It is said to underlie the coast from Rehoboth to the Henlopen Life Saving Station. One fisherman reported that in winter a ridge of “turf with stumps in it” is exposed in the beach opposite Delaware Avenue. Reference to similar beach-buried peat is made in the report of the Intercollegiate Geological Excursion, 1911.²

b) Middle and upper beaches.—As was noted in the former paper, no upper beach can be distinguished. This year there is

² The Intercollegiate Geological Excursion. *Science* N.S. 34:611–614. 1911.

practically no middle beach, the summer storm-tides usually reaching the bases of the frontal dunes. The succulents characteristic of this zone appear, therefore, around the bases and on the slopes of these dunes.

2. *Dunes*.—*Outer series*.—This series is practically fixed from the Henlopen Life Saving Station to a similar station at Dewey Beach, a distance of five miles. The dunes are held chiefly by *Ammophila arenaria*, with a sprinkling of *Cenchrus tribuloides* and succulents.

Between these dunes are many passages leading into hollows or lakes which are flooded in times of storm. As the beach is narrowing, the flooding of these regions occurs more frequently than formerly, thus causing a retrogression toward more hydrophytic conditions.³ The best example of this is the "flooded area" north of Rehoboth, called in the previous paper "desert waste," because a large portion of it was at that time bare, damp soil. It is reported to be at times "dry with a shining crust," but in July 1911, although the month was a rather dry one, the whole area appeared to be under water, thus indicating a greater inflow from the sea. At the south edge of this region are to be found isolated plants of *Mollugo verticillata*, *Sesuvium maritimum*, and *Spergularia marina* (*Tissa marina*). A second example of flooding by the sea is presented by Silver Lake, south of Rehoboth. The presence of numbers of crabs in this lake indicates frequent additions of salt water. This inflow of the sea takes place at a point near the south end of the lake where the margin closely approaches the tide line. Similar retrogressive movements have been described by HARSHBERGER as occurring in northern New Jersey.⁴

As was formerly noted, a region of great activity extends from a short distance south of the Henlopen Life Saving Station to the Henlopen Lighthouse. The large dunes, forming three amphitheaters opening seaward, have moved many feet inland during the last ten years. In passing back over alternating pine ridges and swamps, they have exposed "pine graveyards" and left in

³ COWLES, H. C., The causes of vegetative cycles. BOT. GAZ. 51:161-183. 1911.

⁴ HARSHBERGER, J. W., The vegetation of salt marshes, and of salt and fresh-water ponds of Northern Coastal New Jersey. Proc. Acad. Nat. Sci. Phila. 1909:373-400. figs. 1-6.

their seaward hollows swamps and ponds, which are at times flooded by the tide. In the third of these amphitheatres (fig. 2) many slabs of peat may be seen, which have probably been washed inland from the ledge below tide line.

Across the cape extends the long dune upon which stands the Henlopen Light. This is the largest dune in the region, estimated ten years ago to be 80-90 ft., when the crest was at the lighthouse. By 1911 the summit had moved about 300 ft. to the southwest, and



FIG. 2.—View from the crest of the lighthouse dune, looking south over the third amphitheater; flooded area in the distance.

appeared to be several feet higher than the base of the lighthouse. This advance has not changed the general appearance of the region, as photographs taken from the same points on both visits are very nearly identical. In spite of the fact that this is an active dune, a small clump of *Ammophila* has managed to gain a foothold on the crest (fig. 4).

The appearance of the cape after ten years is apparently unchanged. A low beach extends around the point, bordered on the inner side by low dunes, which inclose a complex of dunes and

swamps. A few shrubs appear on the dunes and a low ridge bearing small trees nearly crosses the cape, as may be seen in fig. 5.

South of Rehoboth the edge of the frontal ridge of dunes passes into a rolling plain called "a heath," and, although the growth of the shrubs and stunted trees gives the region a more thicket-like appearance, the flora has apparently not materially changed.

3. *Hudsonia complex*.—North of Rehoboth may still be found the region called a "*Hudsonia complex*," a jumble of small dunes,



FIG. 3.—Eroded face of the lighthouse dune; view taken from the northeast slope.

held principally by *Hudsonia tomentosa*, with swamps occupying the depressions between them. The flora of these dunes exhibits a more heathlike character than it showed ten years ago. South of Rehoboth the drying of the *Hudsonia complex* has progressed still farther. Swamps are rather rare, remnants showing in places, where *Scirpus americanus*(?) and *Juncus* sp. give evidence of former swampy conditions.

4. *Swamps and meadows*.—As the flora around Silver Lake was studied somewhat more in detail ten years ago than that of the

other meadows, it would have been interesting to have made careful comparisons this year. But unfortunately that region has been converted into a pasture, and is closely grazed. The few forms found in the fence corners, however, indicate an assemblage similar to that occupying this region ten years ago. As one passes northward the flora changes, many more heath forms appearing this year than at the time of the previous study. This seems to indicate that the higher land has become drier, while the land in lower



FIG. 4.—View from the top of the lighthouse looking southwest; this figure is a continuation to the right of fig. 2.

situations has maintained its swampy meadow character, due to the frequent additions of sea water to the lake.

North of Rehoboth, around Frazer's Lake, there extends a large swamp. Near the lake the cat-tail is apparently the dominant form, while to the east and north this association passes into a meadow which is a second pasture. This swampy meadow extends to the flooded area on the north and has a very uniform appearance. Only the southeastern extension, as it runs between the *Hudsonia* dunes, was studied. Many typical undrained swamp forms were

listed, among which may be noted *Spiranthes praecox*? (*Gyrostachys linearis*?), *Viola lanceolata*, *Juncus scirpoides*, *Osmunda regalis* (*O. spectabilis*), and *Aspidium Thelypteris* (*Dryopteris Thelypteris*).

In the *Hudsonia* complex, as previously noted, are many small swamps. The segregation of species in these swamps is most singular. Neighboring hollows may have almost totally different associations. One may be carpeted with cranberries, while in another, a few feet away, not a plant of this species is to be



FIG. 5.—View taken from the top of the lighthouse looking north across the cape; Delaware Bay to the left; the Atlantic Ocean to the right.

found. The hollows appear to be remnants of the south end of the swampy meadow around Frazer's Lake, and, with the lake, apparently are not affected by the tidal inflow, which seems to reach only the northern end of the meadow. The hollows and the lake, therefore, show progressive changes.

One easily identified pine swamp was rather carefully studied in 1901 and again in 1911, with the following result: *Osmunda regalis*, *Aspidium Thelypteris*, *Vaccinium macrocarpon* (*Oxycoccus macrocarpon*), *Xyris flexuosa*, *Rhexia virginica*, and *Smilax rotundi-*

folia have disappeared; while *Lyonia ligustrum* (*Xolisma ligustrum*), *Ascyrum hypericoides*, *Eupatorium hyssopifolium*, *Rubus* sp., *Vaccinium atrococcum*, *Gaylussacia baccata* (*G. resinosa*), *Baptisia tinctoria*, *Rhus Toxicodendron* (*R. radicans*), and *Quercus marylandica* have established themselves.

No sphagnum has been found, and none could be identified in the peat collected. The absence of typical peat bogs from the eastern shore of Maryland was noted by SHREVE,⁵ although sphagnum was found abundantly in the clay upland swamps.

Hibiscus Moscheutos has apparently disappeared from these hollows in the ten-year interval, but whether this is due to the stress of changing ecological conditions or to the assiduous gathering of the plants cannot be stated.

5. *Heath*.—This formation shows a progression toward the development of a forest by a greater growth of the shrubs and trees, without much change from a floristic standpoint.

B. WOODED REGION

The thicket and forest formations have received no detailed study at either time, but the collections made this year indicate that the pine stage, represented by *Pinus Taeda* and *P. rigida*, is being succeeded by the oak-hickory stage, represented by young plants of *Quercus marylandica*, *Q. alba*, *Q. velutina*, *Q. stellata* (*Q. minor*), *Q. falcata* (*Q. digitata*), *Carya glabra* (*Hicoria glabra*), and *C. alba* (*H. alba*). The list of associated forms is incomplete, but it is interesting to note that the species found are not those characteristic of similar situations in New Jersey or southward,⁶ but that many of the plants found in clay and sandy loam areas of the Talbot terrace of Maryland are present (SHREVE *loc. cit.*). According to the manuals, the northern limit of *Myrica cerifera*, a typical pine barren plant, is Maryland. It was found, however, at Rehoboth and is mentioned by STONE⁷ as occurring in the southern

⁵ SHREVE, F., The plant life of Maryland. Md. Weather Service, Spec. Publ. III. 1910.

⁶ HARPER, R. M., Science 25: 539-541. 1907.

⁷ STONE, WITMER, The plants of southern New Jersey. Rep. N.J. State Museum. 1910.

part of New Jersey. I agree with STONE (*loc. cit.*), SHREVE (*loc. cit.*), HARPER,⁸ and WILLIAMSON⁹ that the flora of south-eastern Delaware has affinities, southward and northward, with districts much farther inland, rather than with the coastal regions.

C. THE CANAL DUNE

This dune, mentioned in the previous paper as having been formed, about a mile inland, from material excavated in making a canal, is at this time practically fixed. This is due (1) to the fact that the finer sand has been blown away, leaving the coarser material, and (2) to the binding power of plants. No *Ammophila* is to be found, but many of the plants characteristic of the *Hudsonia* complex and of the heath are present.

III. Problems connected with the region

Second series of dunes.—This series was omitted from the foregoing discussion, because of its possible relation to the problem concerning the change in direction of the coast line.

This ridge of dunes is best seen north of Rehoboth, extending to the northwest from the end of the board walk, thus making an angle with the coast. It was considered in the previous report (p. 286) to be a ridge of dunes blown from the coast in a south-westerly direction. The dunes lie on a hard, flat foundation of clay and sand impregnated with iron. This is continuous with the bluff along which Surf Avenue lies and with the clay-sand ledge south of the town, shown in fig. 6. A portion of this ledge was figured in the previous paper (p. 285) and erroneously called sandstone. At Dewey Beach there again appears a clay-sand ledge, crowned with dunes, which, taken in connection with the clay areas north of Silver Lake, may be a continuation of the same formation. In the absence of any geological information on the subject, the fact that these various outcroppings appear to be at the same level, together with their probable connection, suggests the possibility that this low bluff was the original sea-cliff, running from

⁸ HARPER, R. M., Car-window notes on the vegetation of the Delaware peninsula and southern Virginia. *Torreyia* 9: 217-226. 1909.

⁹ WILLIAMSON, C. S., Notes on the flora of central and southern Delaware. *Torreyia* 9: 160-166. 1909.

Dewey Beach to Rehoboth roughly parallel with the present coast, and north of Rehoboth extending in a northwesterly direction. There are many irregularities in this line, now occupied by lakes, streams, and marshes, which suggest erosion of the cliff.

The second interesting problem is connected with the plant remains, which in a thick peaty mass apparently underlie a large part of the present beach. This deposit was undoubtedly formed in a swamp, which would indicate that at one time the coast line



FIG. 6.—Clay-sand ledge south of Rehoboth, Del.; view from near the end of the board walk looking south; Dewey Beach in the distance.

was *farther out*. The following history seems reasonable and is suggested as a possible explanation. The sea-cliff stage was followed by the formation of a bar to seaward, inclosing a lagoon, which by progressive changes became a swamp. That the swamp stage must have continued for some time is suggested by the report of "stumps in the turf." Erosion of the seaward side of the bar followed, involving the driving backward of the dunes over the swamp and the formation of a hook at the north end of the bar,

thus extending the coast northward with the development of Cape Henlopen. This erosion stage is still in progress.

IV. Summary

1. Ten years is too brief a period in which to show any considerable change in plant associations, even in so active a region as that of the dunes.

2. Progressive changes were observed: (a) advancement of the *Hudsonia* complex toward the heath; (b) advancement of the heath toward the thicket; (c) drying of isolated swamps and lakes; (d) fixation of the "canal dune."

3. Retrogressive changes were noted: (a) recession of the coast, resulting in more frequent flooding of certain regions, thus continuing or increasing their hydrophytic character; (b) movement of active dunes over the forest.

4. The character and position of the sand-clay ledge suggests that it may have been an ancient sea-cliff.

5. The presence of a ledge of peat in the beach indicates the location of a former swamp.

6. This swamp was probably due to the presence of an ancient bar inclosing a lagoon.

7. The present erosion of the coast indicates that this bar with its dunes was moved inland over the swamp, while portions of the beach material were carried northward to form the hook.

8. This process of erosion is still in progress.

DEPARTMENT OF BOTANY
WELLESLEY COLLEGE