

GERMINATION AND GROWTH OF THE COTTON-
WOOD UPON THE SAND DUNES OF LAKE
MICHIGAN NEAR CHICAGO.

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EXTENT OF THE ASSOCIATION.

The first tree association to become established upon the sand dunes of Lake Michigan is one composed of the cottonwood *Populus deltoides* and a few shrubs, among which species of *Salix* and *Cornus* are conspicuous. Occasionally *Populus deltoides* is replaced by *P. balsamifera*; its ecological equivalent. The detailed examination of the composition and extent of this

association has been so well made by Cowles¹ that little could be added to his account. To summarize: it is characterized by the one tree species only and extends from immediately within the fore-dune to the region where the dunes become established, comprising the greater part of the moving dune-complex and forming a zone from 100 to 300 meters wide. In the dune region comparatively few cottonwoods are found beyond these limits, mingling with the members of other associations.

It is the purpose of this paper to discuss briefly two of the physical ecological factors of the association which have been quantitatively studied, viz.: the evaporating power of the air,² and the range of soil moisture during the growing season,² and to attempt to relate the germination and growth habits of the principal tree member of the association to these factors.

EVAPORATING POWER OF THE AIR.

This factor has been measured by means of the Livingston atmometer during the past two growing seasons, and some of the results for the summer of 1910 have been reported to this Academy.² The readings of the atmometers were taken weekly and corrected by the application of the coefficients necessary to express the results in term of loss from the standard instrument adopted by Livingston. When these results are plotted as graphs having the weekly intervals as abscissae and the loss per day in cubic centimeters as ordinates (Fig. 1), they show that the evaporating power of the air in the lower stratum of the association is excessive and subject to extreme variations, indicating that the demands for water made upon the aerial parts of the vegetation are very great. The average rate for the season of 1910 was 21.1 cc. per day and that for 1911 amounted to 24.6 cc. per day. A further comparison of the conditions existing during these two years may be obtained by a study of these two graphs, representing as they do the mean of the observations taken at three stations from May 1 to October 31 of these years. The graphs will be seen to be similar in character, the differences being traceable to differences in atmospheric conditions peculiar to each particular year, and they demonstrate that the evaporation conditions are rigorous and indicate a xerophytic response. The amount of xerophytism may be indicated by a comparison with the evaporation occurring

¹ Cowles, H. C. The ecological relations of the vegetation of the sand dunes of Lake Michigan. *Bot. Gaz.*, 27: 95-117, 1899.

² Fuller, G. D. Evaporation and plant succession. *Trans. Ill. Acad. Sci.* 4: 119-125, 1911.

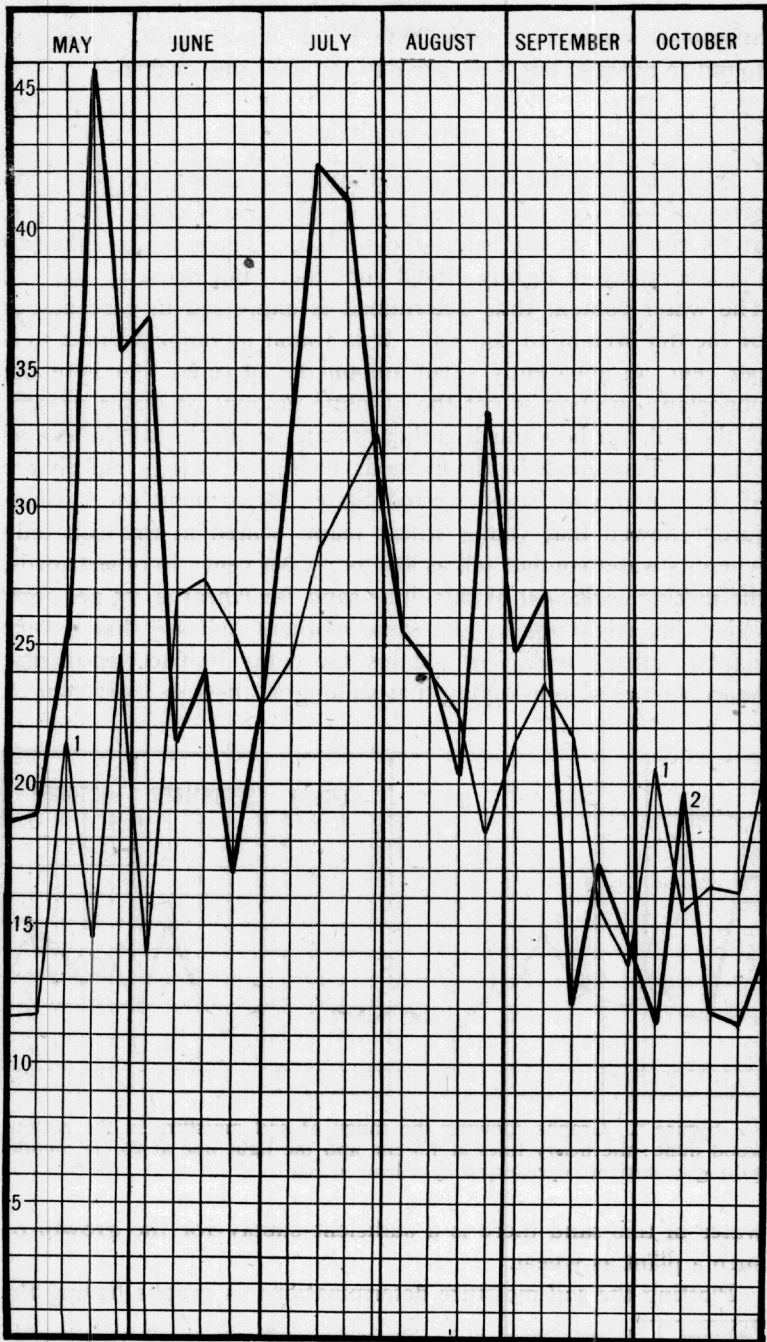


Figure 1. Graphs illustrating evaporating power of the air during 1910 and 1911.

in similar strata of the mesophytic beech-maple forest, which was found to average but 8 cc. per day for the same period.

SOIL MOISTURE.

In determining the range of soil moisture, samples of about 200 grms. of soil were taken weekly from May 1 to October 31, 1911, at 7.5 cm. and 25 cm. below the surface. The soil was taken to the laboratory in tightly closed containers and dried at 104° C. The water content thus determined is expressed in percentages of the dry weight of the soil. It is found to range from 2 to 8 per cent, an apparently small amount at all times, but here the important question is not the absolute amount of water present in the soil, but how much is there that is available for the use of plants? Tests made by the methods devised by Briggs and Shantz of the Bureau of Soils, United States Department of Agriculture,³ showed that young wheat plants wilted in this soil only when its water content fell as low as .75 per cent; in other words, the *wilting coefficient* of this dune sand for wheat is .75 per cent. Other investigations by the same workers indicate that a very similar *wilting coefficient* obtains for many herbaceous plants; hence we are safe in saying that so long as there is 1 per cent of

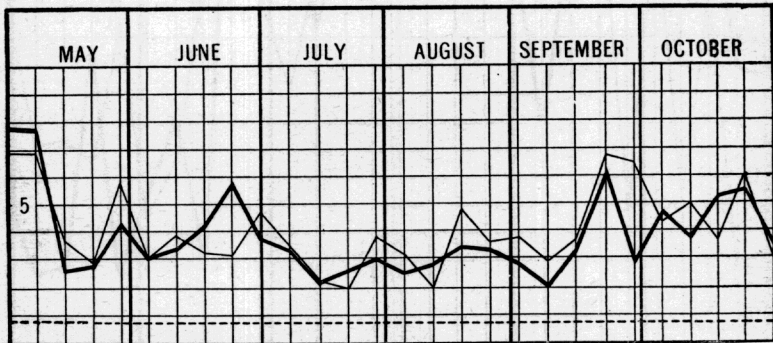


Figure 2. Graphs showing the range of soil moisture in the cotton-wood dune; the heavy lines at 7.5 cm. and the light line at 25 cm. depth; wilting coefficient represented by a broken line.

water in this sand there is a sufficient supply for the growth of such a plant as wheat.

Plotting the soil moisture determinations as graphs having the

³ Briggs, L. J., and Shantz, H. L. The wilting coefficient for different plants and its indirect determination. U. S. Dept. Agric. Bur. Plant Ind., Bull. 230: 1912.



Figure 3. Cottonwood with roots uncovered by removal of sand. Young trees developing from the exposed roots.

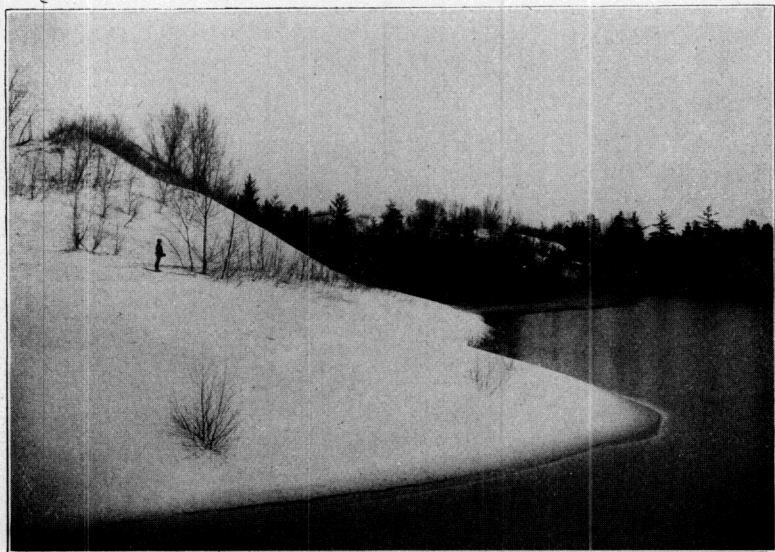


Figure 4. Dune moving into Calumet river. Cottonwood seedlings persisting although sand is encroaching upon them. The buried branches rooting and becoming independent trees.

weekly intervals between the collections as abscissae and the percentage of water present in the soil as ordinates (Fig. 2), it will be seen that the moisture present in the soil is at all times more than double the wilting coefficient. The interval between the curve representing the soil moisture and the line representing the wilting coefficient represents the amount of water available for growth, and has been termed *growth water*.⁴ It will be apparent that there is always a supply of growth water, although it must be admitted that the amount available in July could permit no very heavy draughts, still the soil conditions must be regarded as by no means very arid,—so mesophytic, indeed, do they appear, viewed from the point of water supply, that one would be quite at a loss to account for the very sparse vegetation upon any such basis. A cause for the xerophytism may be found in the instability of the substratum, a factor fully discussed elsewhere by Cowles and others.

VEGETATIVE REPRODUCTION.

It has been previously stated that the cottonwood dune association is one almost entirely dependent upon vegetative reproduction for its maintenance. As the sand advances over the trunk and branches of these trees, adventitious roots are given off, and what was originally one tree becomes a group of several (Fig. 4), each with its own root system. Doubtless the constancy of the soil moisture supply is closely related to this condition of vegetative reproduction. A vegetation dependent upon such a method of reproduction will, however, increase in amount very slowly, especially as the very instability which multiplies the trees by burying them afterwards destroys them by removing the sand, exposing the roots, and finally leading to their overthrow (Fig. 3). In this uncovering process there is also a limited amount of vegetative reproduction from adventitious buds which arise upon the exposed roots at a distance from the parent plant (Fig. 3). When the amount of erosion by the wind is limited and soon checked, such adventitious shoots may result in the production of a considerable number of new trees grouped about the parent, but such reproduction is again to be regarded as limited in extent and of minor importance. These two methods, however, do account for the permanency of the tree upon the unstable substratum of the moving dune complex, although they

⁴ Fuller, G. D. Soil moisture in the cottonwood dune association of Lake Michigan. Bot. Gaz., 53: 512-514, 1912.

do not explain the establishment of the species. For this establishment we must find the seedlings, and none exist upon the moving dune complex.

REPRODUCTION BY SEED.

In the experience of the writer, cottonwood seedlings are to be found in the dune region in two situations, and in two only. In the recession of the waters of Lake Michigan, many shallow ponds and lagoons were cut off from the main body of water and not a few still persist, more or less filled by the action of the moving sand and vegetation. Their damp margins are often sprinkled with cottonwood seedlings (Fig. 4); some of these survive and surmount the advancing sand and thus account for the presence of these trees at any considerable distance from the lake.

The second seed-bed is to be found where the wind has swept out the sand to a depth approaching the level of the waters of the lake; here the soil surface and the top of the water table almost coincide in depressions termed by European ecologists *pannes*. Such *pannes* are (Fig. 5) often found immediately behind the fore-dune within 25 to 100 meters of the shore. These depressions are flooded at high water in the spring and even at midsummer the almost saturated sand is quite stable and seems admirably suited to the production of cottonwood seedlings, for here they are found in abundance. As they increase in size they collect sand, the *panne* being transformed into an ever-increasing dune (Fig. 6), which soon begins to move inland. With the growth of the dune and its subsequent advance many of the young trees are killed, but some survive and, surmounting the advancing sand, form the only tree vegetation of the active dune complex.

CONCLUSIONS.

1. The evaporating power of the air in the exposed cottonwood dune association is great in amount and variable in degree, indicating rigorous atmospheric conditions.
2. The soil moisture is never less than twice the wilting coefficient of the soil; i. e., there is always a supply of water available for plant growth.
3. Vegetative reproduction maintains the stand of cottonwoods upon the dunes through the ability of the species to send

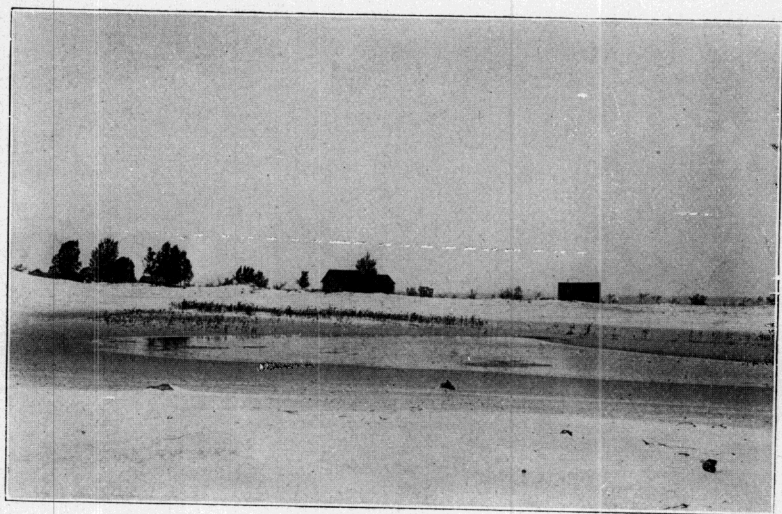


Figure 5. Panne with cottonwood seedlings.

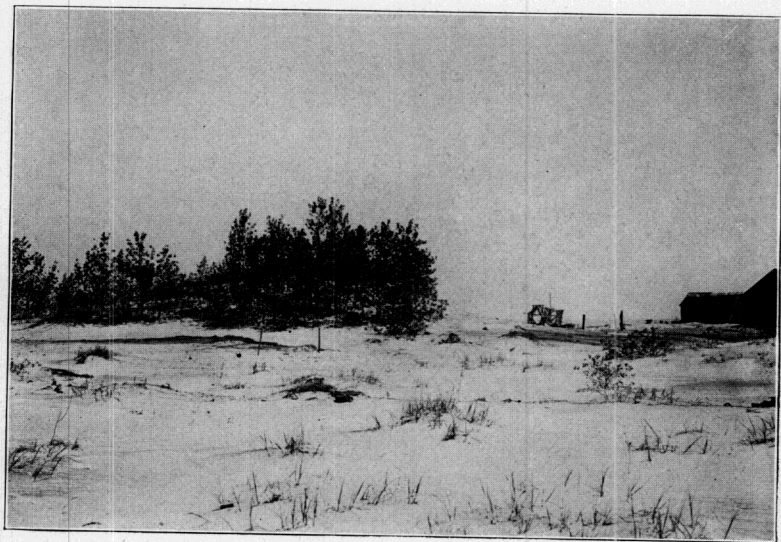


Figure 6. A small dune formed about young cottonwoods developed in a panne.

out adventitious roots as the trunk and branches are buried and to produce adventitious shoots from the roots as they are exposed.

4. The seedlings apparently require a large amount of moisture for their development, for they are found only along the margins of ponds and streams, and in the pannes; hence the establishment of the cottonwood is antecedent to the dunes upon which it is able to maintain itself.

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