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EVAPORATION AND PLANT ZONES IN THE CEDAR POINT MARSH.*

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Yapp[1] in trying to account for the xerophytic structure of marsh plants by means of evaporation studies has shown a definite correlation to exist between the strata of marsh vegetation and rates of evaporation at corresponding levels. The following studies were made in an attempt to discover what additional correlations, if any, exist between distribution of marsh plants and the evaporational power of the air at different portions of the habitat. While the exact quantitative significance of such work as the following may be brought into question, as it often is, the striking results obtained by Transeau,[2] Livingston,[3] Fuller,[4] Weaver,[5] Yapp,[1] and others, show that when such work is carefully done it is of unusual efficiency, considering its extra-laboratory character.

The studies were carried on in the strip of marsh between Beimiller's Cove and Fred's Cove, at Cedar Point, Ohio. The physiography of this region has been beautifully worked out by Mosely,[6] while we are indebted to Jennings[7] for an excellent account of the phytoecology of Cedar Point. A glance at the accompanying maps[8] will make clear the nature of the region studied. It is a cove marsh along the inside of the lengthy sand-bar (Cedar Point) which, forming across the sunken mouth of the Sandusky River, has served to practically separate Sandusky Bay from the rest of Lake Erie. Save for the occasional violent northeasterly winter gales which have served to pile up Cedar Point, the prevailing winds here are largely from the southern and western quarters of the compass.[9]

Zonation is certainly the most obvious phenomenon of plant distribution in the marsh, and was chosen as the feature most profitable for investigation. Beginning with the outermost zone of severely exposed vegetation the following clearly defined zones are encountered in order:

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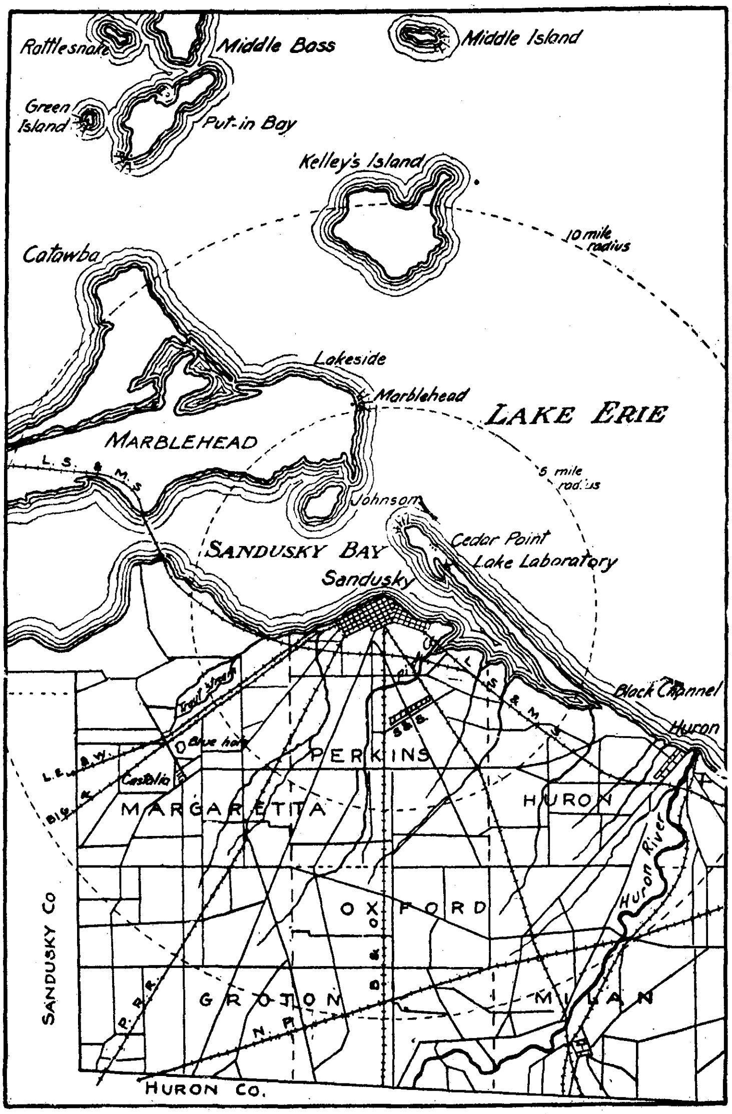
* Contribution from the Botanical Laboratory of the Ohio State University, No. 93.

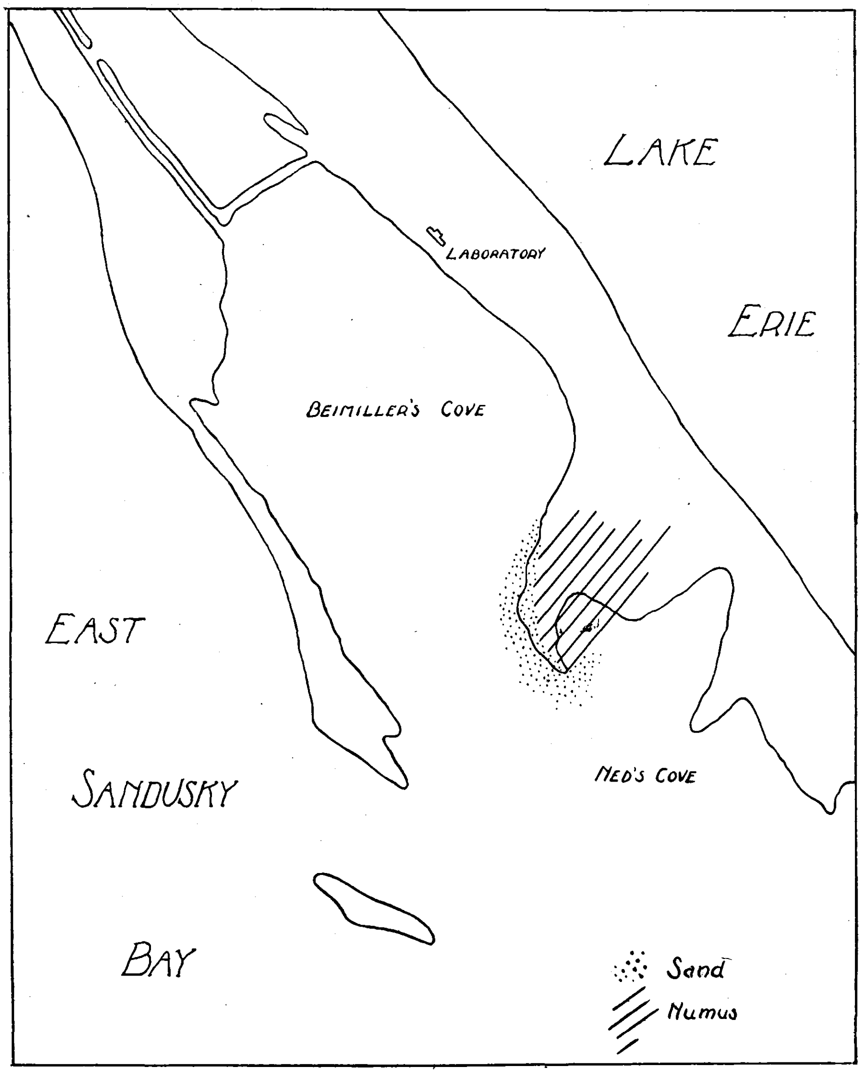
The Scirpus Zone—This is a region of extreme exposure so far as vegetation is concerned, and includes points 50 to 100 feet (15 to 30 metres) offshore from the bar. The water here



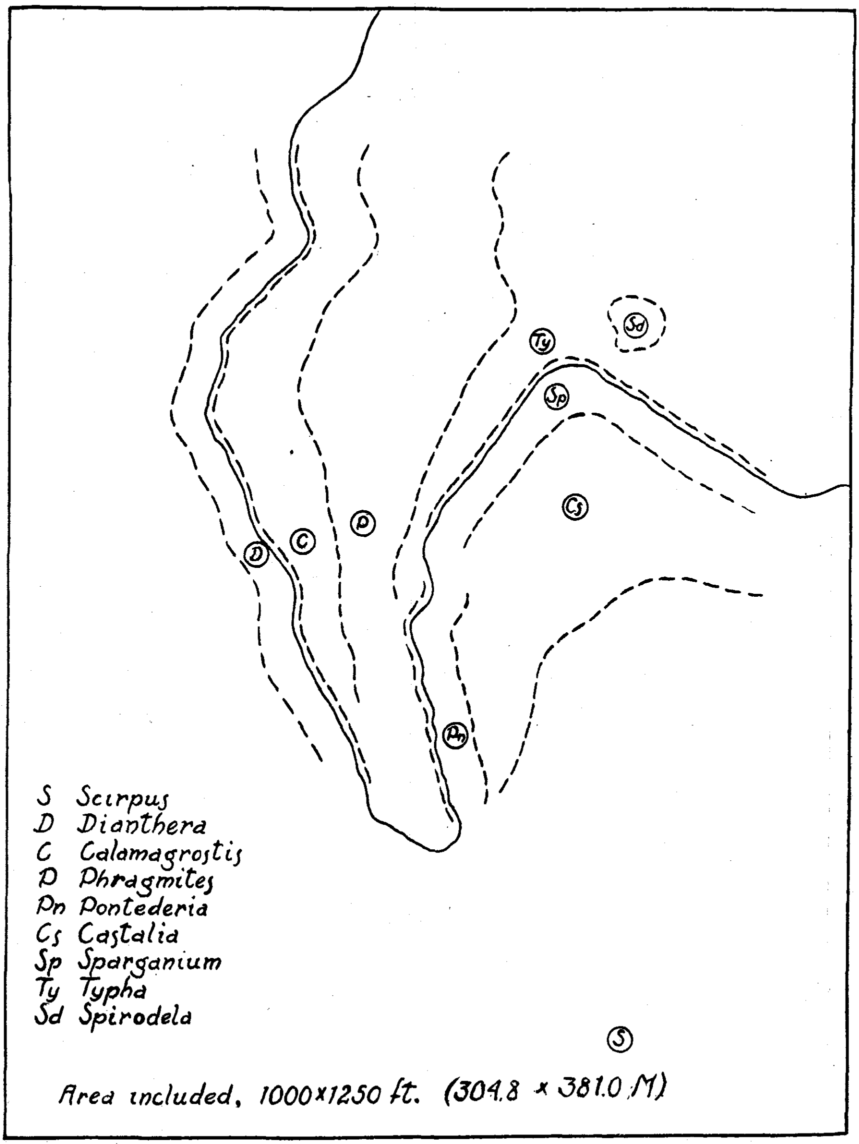
ADAPTED FROM MOSLEY'S "SANDUSKY FLORA."

is about three feet (.9 metre) in depth, with a sandy, much-washed bottom. The only form of emersed plant life here is *Scirpus validus* in more or less scattered clumps.

The Dianthera Zone—This comprises the western and southwestern edge of the bar, as indicated on the map, Fig. 3, and is consequently more or less exposed to the prevalent winds. The



water depth here ranges around six inches (1.5 decimetres), with a bottom that is sandy, well washed, and that has a very slight admixture of dark organic material indeed. The dominant species here is *Dianthera americana*, present in considerable abundance, with a few plants of *Scirpus americanus*, *Scirpus nanus* and *Carex* sp.



The Calamagrostis Zone—Wherever the sandbar actually rises above water level, it is covered with this distinctive type of vegetation. Anything above the height of the *Dianthera* here receives considerable exposure to the winds from the prevailing quarter, obviously. The soil is almost pure sand, averaging about four to six inches (1 to 1.5 decimetres) above water level. The vegetation in this area so restricted is almost exclusively *Calamagrostis canadensis* with scattered and small individuals of *Salix longifolia*.

The Phragmites Zone—Behind the Zone just mentioned the sandbar extends for some distance, but is nowhere emersed. The depth of water at this portion of the habitat fluctuates, generally being less than three inches (.7 decimetres), and the sand contains a considerable amount of organic material. *Phragmites phragmites* flourishes here almost exclusively, the only invaders being occasional sickly plants of *Dianthera* and scattered small colonies of *Spirodela polyrhiza*. The luxuriant tops of the *Phragmites* compel rather wide basal spacing of the plants, giving room for such invasion as does occur.

The Pontederia Zone—Along the inner or northeasterly edge of the sandbar just mentioned the water again deepens, composing an extremely sheltered zone, hence one very rich in organic detritus. The water depth here ranges between six and twelve inches (1.5 and 3 decimetres), and the dominant species is *Pontederia cordata* while *Sagittaria latifolia* is present in considerable amount, with *Carex* sp. and stragglers of *Dianthera* and *Sparganium*.

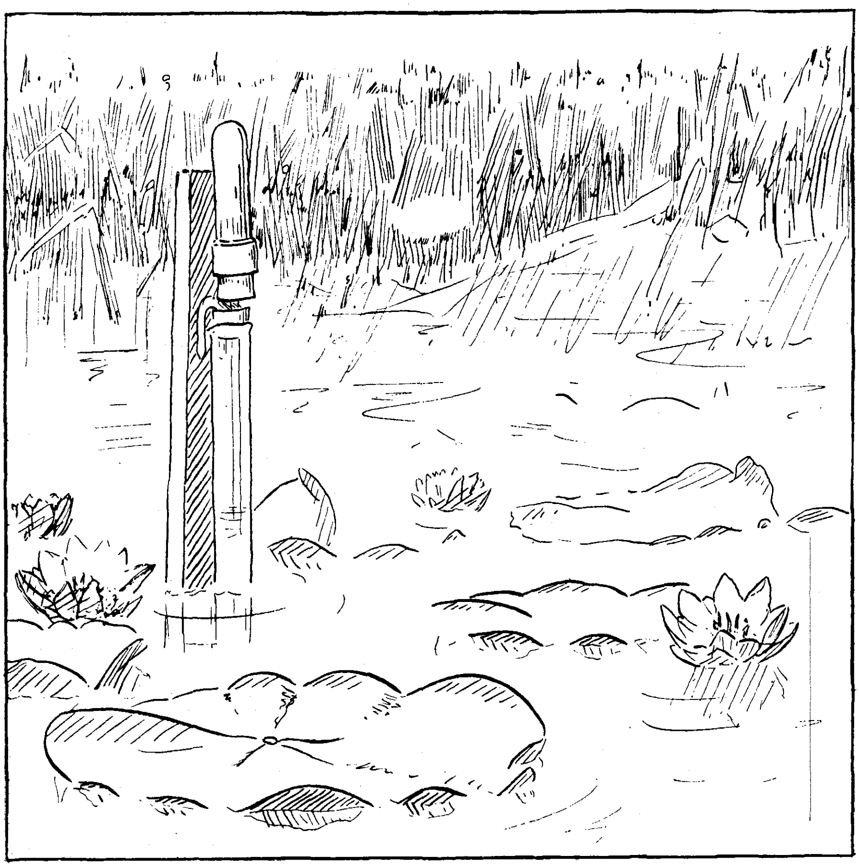
The Castalia Zone—The sandbar mentioned above is sufficiently long to form a tiny sheltered cove to the northeast, as a glance at the map will show. Actually this little cove is a mere recess at the western end of the larger Ned's Cove. Needless to say the bottom here is heavily covered with mucky organic matter, and the water, which ranges from one to four feet (.3 to 1.2 metres) is quiet. The conspicuous and abundant species here is *Castalia tuberosa*, while there is a plentiful admixture of *Nymphaea advena*, *Nelumbo lutea*, *Utricularia vulgaris*, *Potamogeton natans et sp*.

The Sparganium Zone—Fringing the northerly border of the cove, but in other respects like the *Pontederia* zone which fringes its western border, we find the next distinctly marked type of vegetation, which is an almost pure stand of *Sparganium eurycarpum*.

The Typha Zone—Inside of the fringe of *Sparganium* just mentioned, and extending in all directions until it encounters regions seized by *Phragmites*, lies the clear-cut cattail habitat.

Like the last several zones mentioned, it has a bottom rich in humus, while the water ranges from six to twelve inches (1.5 to 3 decimetres) in depth. *Typha latifolia* grows here to the practical exclusion of everything else, save for an occasional space which may be called—

The Spirodela Habitat—These spaces are usually a couple of yards or more (1 to 2 metres) in diameter, and are open areas of water rather closely hedged in by *Typha*, with occasional straggling plants of *Sparganium*. The water here is, of course, quiet and usually about three to six inches (.7 to 1.5 decimetres) in depth, richly strewn with colonies of *Spirodela polyrhiza* and *Lemna trisulca*, principally the former.



The Castalia Station

On June 29th an instrument was set up in each of the zones indicated and daily morning readings taken, with the exceptions and interruptions shown in the table, until July 22nd, when the last readings were made. The corrected totals given in the table are for the actual number of days during which every instrument was in working condition. It may be fairly asserted that this period covers, in spite of its shortness, a critical time of year for vegetation so far as actual transpiration is concerned. It will also be noted in the table that all figures have been reduced to a percentage basis, using the lowest total as 100%.

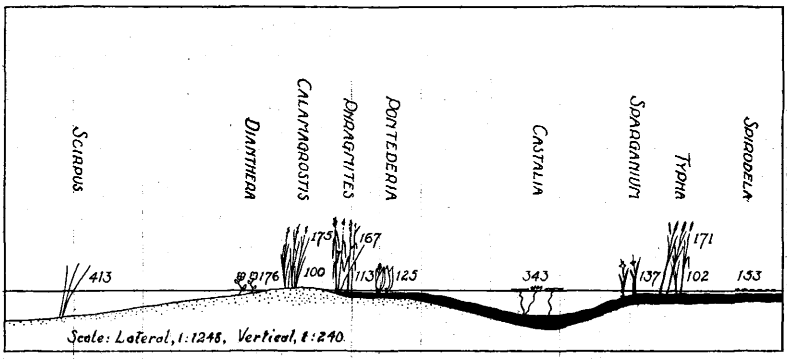
TABLE SHOWING DAILY WATER LOSS FROM EACH INSTRUMENT DURING TIME OF EXPERIMENT.

Abbreviations for Stations as on Map, Fig. 3.

	S	D	C UPPER	C	P UPPER	P	Pn	Cs	Sp	Ty UPPER	Ty	Sd
June												
29	......	25	26	10	19	3	......	29	9	......	7	18
30	......	14	15	11	11	6	......	21	12	......	6	15
July												
1	......	21	24	13	19	13	......	44	19	......	18	18
2	......	10	6	4	5	3	......	12	8	......	5	7
3	35	17	17	9	13	11	14	26	12	14	9	13
4	19	10	9	4	12	5	12	17	8	10	7	9
5	35	17	17	11	9	8	7	28	11	13	8	12
6	36	18	18	7	18	14	18	28	15	14	9	14
7	28	11	12	6	4	8	11	27	10	11	8	10
8	53	10	22	10	18	14	11	42	21	25	16	19
9	34	16	18	7	14	10	14	29	15	15	9	14
10	39	14	18	7	18	10	15	30	13	15	10	13
11	......	27	23	12	12	13	15	44	16	20	15	20
12	......	15	13	6	14	7	9	30	12	11	7	13
13	......	16	20	10	17	13	16	35	16	22	5	13
14	......	13	12	7	11	10	7	18	10	17	7	9
15	......	3	4	......	2	1	1	3	2	1	0	2
16	......	12	15	5	15	10	8	24	9	15	8	10
17	38	17	16	9	15	8	7	40	11	16	11	13
18	67	27	23	19	27	16	15	53	18	25	9	26
19	62	28	19	13	32	16	16	47	21	27	14	23
20	49	19	19	13	16	15	10	41	13	18	11	18
21	51	23	26	16	25	15	16	45	14	23	14	18
22	48	14	25	12	26	16	16	......	14	20	10	17
Net Total	546	233	234	132	221	150	166	453	182	226	135	202
Per c'tage	413	176	175	100	167	113	125	343	137	171	102	153

Standardized porous cups mounted as shown over ordinary 100 cc. graduates, with curved tubes for equalizing the air pressure, were used. When set at ground or water-level, this gave a means of measuring the drying power of the air at 11–14 inches (2.7–3.5 decimetres) up.

At each station (see map, Fig. 3) an instrument was set at this lowest possible level. At the *Scirpus* station an anchored raft was utilized, to which the evaporimeter was stoutly lashed, while at the other stations the instruments were fastened to firmly set cypress stakes. In the *Calamagrostis*, *Phragmites*, and *Typha* zones the stakes were of sufficient height to allow the location of a second instrument approximately four feet (1.5 metres) above the first.



Composite Profile Showing Evaporation Percentages.

All readings were taken by myself to eliminate error due to personal equation, and were taken from the bottom of the meniscus. So often as necessary the graduates were carefully refilled to the 100 cc. mark.

That the profile, Fig. 5, is a composite is readily seen from the zone map, but it has been chosen as affording the most graphic means at hand of setting forth at the same time the majority of relative habitat conditions and the evaporation percentages obtained. The profile will be better understood if it is borne in mind that the left-hand side represents the quarter from which the prevailing winds come, and that during the days for which the corrected totals were figured the actual wind movement from that quarter was 202 miles in excess of that from the opposing quarter,[9] which moreover is strongly sheltered by Cedar Point itself.

The *Scirpus* zone, with its maximum exposure to wind and light, shows the highest rate by far—413%. It seems not improbable that to survive in such an environment the *Scirpus* must possess unique characters beyond its undoubted ability to withstand the heavy beating of surf, which Jennings[7] mentions.

The zone characterized by *Castalia* and *Potamogeton* ranks second, with an evaporation percentage of 343. While not directly exposed to severe winds this zone is undoubtedly one of rather free air movement, and certainly one of continual and merciless exposure to the sun. The relatively high rate of evaporation here may well be the factor that is prohibitive of emersed forms, other than stray plants of *Scirpus*, although the factor of water depth cannot be ignored.

That this habitat is a rigorous one for plant life is further shown by the fatal effects of a day's exposure of the under side of a *Castalia* leaf to the air of its habitat, whether by a continued light breeze from the proper quarter, or by accident or experiment. This phenomenon, which it is interesting to compare with "wind-burning" as noted by Gates,[10] was frequently observed during the course of the work here described.

Dianthera is a plant characteristic of washed sand bottoms,[7] a condition implying more or less exposure, and in this marsh it is found under conditions of evaporation distinctly comparable with those obtaining in the windswept tops of *Calamagrostis*, at an elevation of five feet (1.5 metres).

The remaining figures are chiefly valuable as showing rather strikingly the modifying power of vegetation on evaporation. Especially marked is the difference between the nearby instruments in the *Spirodela* and *Typha* zones, respectively, at the same level. Likewise the waterloss is much greater at the same level in the case of low-growing than of high-growing vegetation. Moreover the instrument standing in the compact and sheltered lower layers of the *Calamagrostis* lost decidedly less than the one in the leafless and wide spaced lower layers of *Phragmites*.

Finally the differences between upper and lower stations in *Calamagrostis*, *Phragmites* and *Typha* respectively, are ample enough to confirm Yapp's observation[1] that different strata of marsh vegetation afford vastly different habitat conditions, as regards the evaporational factors. This is not the less true because none of the three zones mentioned happen to show any distinct stratification.

Summary and Conclusions—Transpiration loss, so far as measured by the evaporating power of the air, is definitely correlated with physical exposure and zonal distribution of plants in the marsh studied.

Topography, substratum, direction of prevailing wind, and thickness of vegetative cover all find logical expression in the evaporation percentages obtained.

Evaporation must be assigned an important role coordinate with such fundamental factors as water depth and organic content of substratum in interpreting the plant distribution in the marsh under examination.

The writer feels under considerable obligation to Dr. Raymond J. Pool, of the University of Nebraska, Dr. E. N. Transeau of Ohio State University, and to the staff of the Ohio State Lake Laboratory for courtesies and suggestions during the course of the work and the writing of the paper presented above.

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