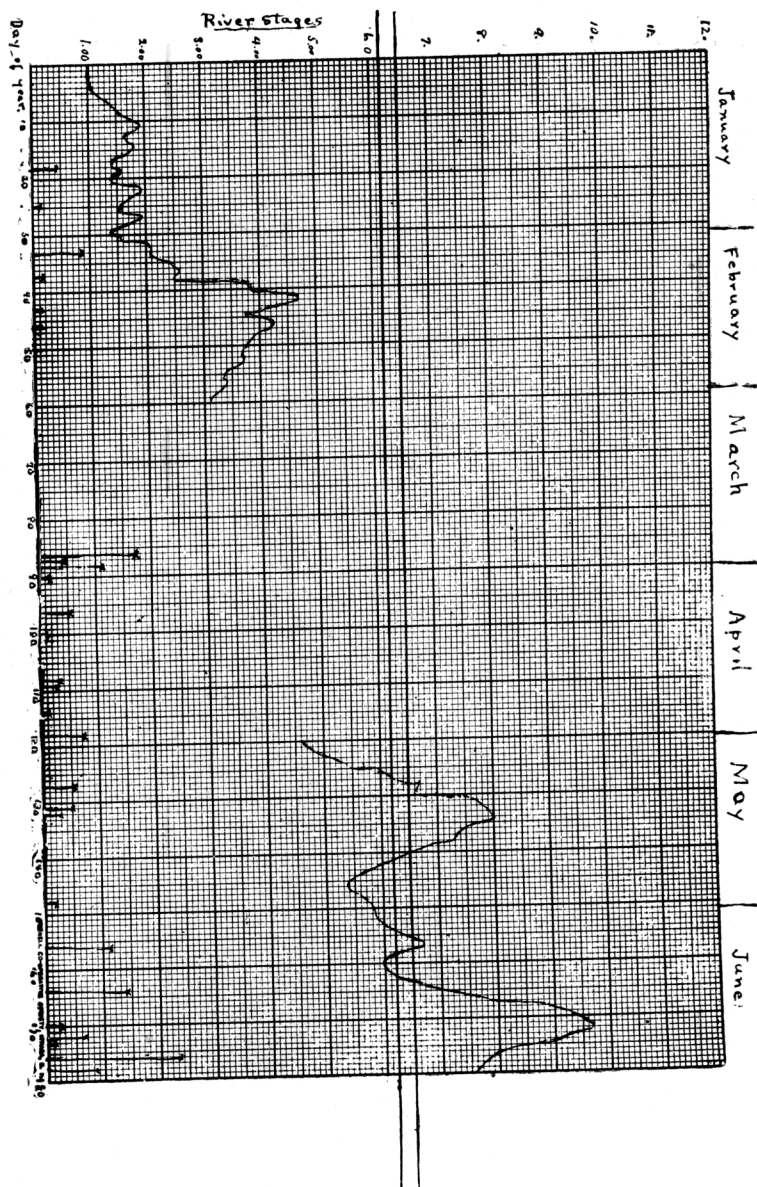


DWARF SHORE FLORAS

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Among the areas characterized by well-marked plant associations or societies recognizable by ecologists, two, the temporary woodland ponds and the low area along shores of rivers and lakes, resemble each other in that their members generally represent remarkable adaptability in their relations to water supply, and both are accordingly regions of polymorphic or dimorphic species. Along shore-lines of permanent bodies of water stratified polymorphism, or variation of the same plant in different levels is frequent, as exemplified in the water plantain, *Alisma plantago-aquatica* L. and several *Potamogetons* which have three forms of leaves, the thin semi-transparent submersed, or often linear phyllodes, the flaccid floating leaves and stiff erect aerial ones, or which is exhibited most strikingly by the water parsnip, *Sium cicutaefolium* Gmel. with its finely cut lower leaves, serrate medium leaves, and almost entire upper ones. Dimorphic forms such as the water Star-Grass, *Heteranthera dubia* (Jacq.) MacM. are also present. In the temporary woodland ponds, although stratified variation is present, the water parsnip being a member of the pond region also, there is a more marked tendency toward seasonal

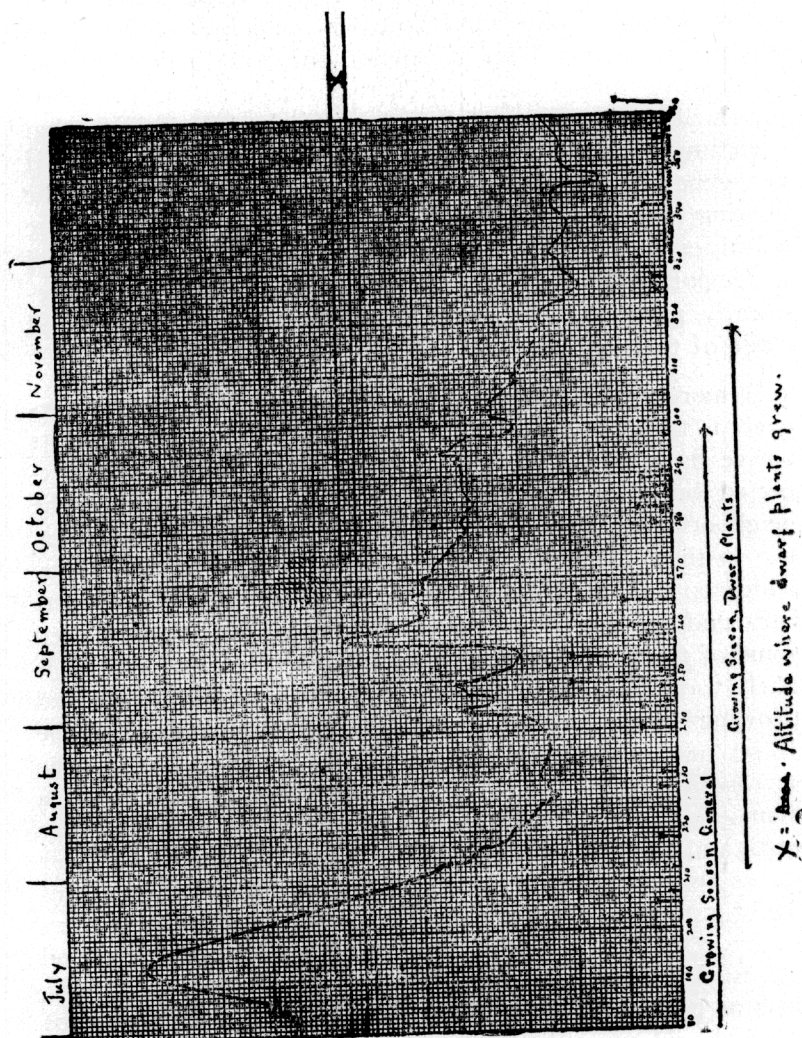
dimorphism; in one fairly common and characteristic form, the yellow water-crowfoot *Ranunculus delphinifolius* Torr. we have indeed, during the high-water season, a stratified variation; but there is a metamorphosis also, the plant during the dry season being represented by the so-called var. "terrestris,"



a plant of entirely different aspect from the aquatic form. On these ponds it is that seasonal dimorphism reaches perhaps as great perfection as is found anywhere in the vegetable kingdom, in the "mud liverwort," *Riccia lutescens* Schwein. The change of this plant from an elongate creeping thallus with inconspicuous slender rhizoids into a butterfly-shaped floating thallus, well furnished with conspicuous balancing scales and reproducing itself, much like an amoeba, by bipartition, and the process of its change—all the heavier posterior portion sinking and dying while a newly developed spongy heart-shaped apical portion survives to develop into the floating form—is almost as remarkable as the metamorphosis of a butterfly. The change is indeed so striking that even among good botanists this floating form is frequently, if not generally mistaken for an entirely different plant, the floating liverwort, *Ricciocarpus natans* L. and, to increase confusion, the just mentioned liverwort, which is never found in temporary bodies of water, but only in lakes, rather infrequently produces a creeping form simulating the dry-pond stage of the mud liverwort.

A more remarkable effect of the region along shore, however, is the influence it exerts, not upon the members of its native flora, where great variability might naturally be expected, but upon such plants as have strayed down from the neighboring uplands, plants which here suffer a modification, not in their form, but in their size. In many cases plants, which on their native uplands, reach to a respectable stature, here undergo such diminution that they often barely exceed some of the larger species of moss. This diminutive flora is likely to be almost or entirely overlooked during the general growing season, and attracts attention to itself only after the frosts of autumn have cut down the tender herbage of the surrounding country. After this has happened, the humble plants along shore, protected by their closeness to the warmer earth and adjacent water surface, remain still unscathed, their leaves retaining the verdure of summer, and their blossoms the brightness of their prime. Even at this season, when they show up at their best, they are an inconspicuous group, and are usually discovered only when looking for something else, such as pebbles or shells along shore. During the survey of the Lake Maxinkuckee region, the writer become tolerably

familiar with minute representatives of several plants, the most noteworthy being the common black nightshade, *Solanum nigrum* L., horseweed, *Leptilon canadense* (L.) Britton, Eclipta, *Verbesina alba* L. and various sticktights, *Bidens*, and smartweeds, *Persicaria*, on the sandy bars and pebbly beach of the shore, but the diminutiveness of the plants was attributed to the sterility of the sandy shore, and little more attention was paid to it.



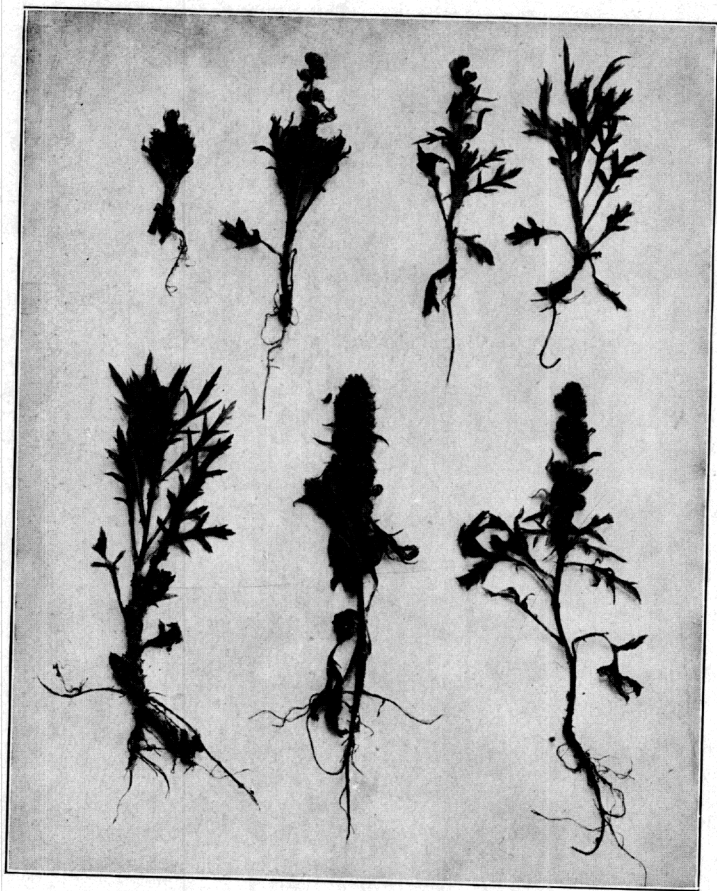


Plate II. *Artemisia caudata* Michx.

Inasmuch as the black nightshade was not found dwarfed in the region about to be more fully discussed, it may be worth while to mention it more fully in detail. Everyone is familiar with this plant, which is usually a rather large diffusely branching herb. The dwarf plants found at the lake were minute objects consisting of only two or three leaves, a simple stem, a flower or two and a full-sized berry. The small size of the plants was no more striking than their completeness, and the single berry would doubtless outweigh several times the entire remainder of the plant.

About October 21, 1914, while walking along the shore of the Mississippi bordering the grounds of the Fisheries Biological Station at Fairport, Iowa, in search of the little mud liverwort, *Riccia lutescens* Schwein, a species usually rare along rivers, and generally absent at lakes or other permanent bodies of water and which, perhaps on account of its unusual habitat, was passing through a remarkable stage of its development, it was noted that a number of the common flowering plants of the region, representing a dozen or more not closely related species were remarkably diminutive in size, although fully developed and in flower and fruit. If it had not been for the search of the *Riccia*, the whole flora would probably have been overlooked. Owing to the pressure of other duties, a few of the pygmy plants which were collected, were not taken care of at once, and allowed to spoil. On October 25th there was a rather severe frost which killed much of the tender vegetation of the general region. On October 30th and again on November 12th, this stretch of shore was re-visited and a number of the dwarf plants which were still verdant and flourishing were collected. Each subsequent visit to the place, until freezing weather had entirely wiped out the tender flora, tended to increase the number of species found, and—as the eye became accustomed to pick them out—to furnish specimens of still more minute size. In all the final collection contained representatives of 18 species, as follows, the nomenclature and sequence of species being that of the latest edition of Britton and Brown's Illustrated Flora:

1. Barnyard Grass, *Echinochloa crusgalli* (L.) Beauv.
2. Panic Grass, *Panicum*, sp.

3. Creeping Eragrostis, *Eragrostis hypnoides* (Lam.) B. S. P.
4. Low Cyperus, *Cyperus diandrus* Torr.
5. Awned Cyperus, *Cyperus inflexus* Muhl.
6. Pink Smartweed, *Persicaria pennsylvanicum* (L.) Small.
7. Rough-fruited Water Hemp, *Acnida tuberculata* Moq.
8. Carpet weed, *Mollugo verticillata* L.
9. Clammy-weed, *Polanisia graveolens* Raf.
10. Three-seeded Mercury, *Acalypha virginica* L.
11. Spotted spurge, *Chamaesyce maculata* (L.) Small.
12. Conobea, *Conobea multifida* (Mich.) Benth.
13. Long-stalked False Pimpernel, *Ilysanthes dubia* (L.) Barnhart.
14. Ragweed, *Ambrosia elatior* L.
15. Eclipta, *Verbesina alba* L.
16. Smaller or Nodding Burr Marigold, *Bidens cernua* L.
17. Beggar ticks, Sticktight, *Bidens frondosa* L.
18. Tall or Wild Wormwood, *Artemisia caudata* Michx.

The following are special notes on the plants encountered. Along with the notes is given the range in size as given in current descriptions, those of Britton & Brown's Illustrated Flora, 2nd Edition, and in the 7th edition of Gray's Manual, Revised by Robinson & Fernald. It is not believed the describer meant the dimensions given to cover the greatest extremes, but they are, however, given for comparison.

1. *Echinochloa crusgalli* (L.) Bauv. Barnyard Grass.
Cockspur grass.

Rather common in the region in wet places. It usually forms a narrow fringe about the margins of the artificial fishponds on the Station where it grows tall, usually about 5 feet high. Often found along river and lake shores. "Culm 2-4 tall (Britton & Brown) "3-18 dm. high" (Robinson & Fer-

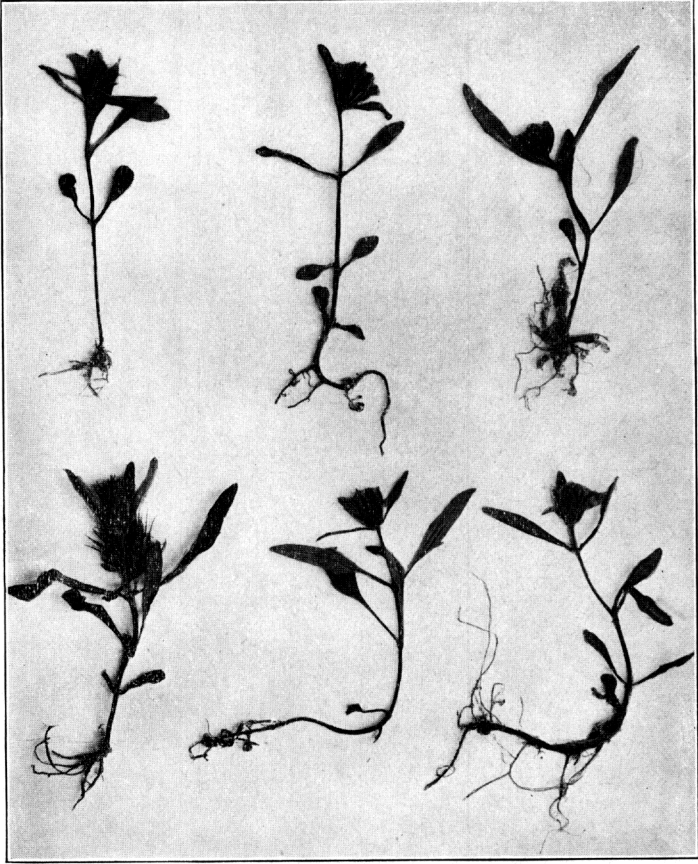


Plate III. *Bidens cernua* L.

nald.) This species in the dwarf form was rather frequent in the stretch of shore under consideration, the whole plants being little over one centimeter high and consisting only of a short culm, a few blades, and the head of a single spikelet or two.

2. *Panicum* sp?

Not common; a remarkably small form, the parts being so minute and material so scarce that identification was not satisfactory. One plant was only 17 mm. from root to tip of head.

3. *Eragrostis hypnoides* (Lam.) B. S. P., Creeping Eragrostis.

A rather common plant in the region in moist places, and, when conditions are favorable, especially abundant on mud flats between high and low water-marks, where it spreads extensively, forming large round mats. During the summer of 1910, low water prevailed without marked fluctuations of level, and shortly after the river had fallen the black, barren mud flats were quickly covered, as if by magic, by the minute seedlings of this grass which spread extensively over the flats, rooting at every point, the circular mats often being 18 inches or more in diameter. "Culms 1'-18' long," (Britton & Brown) "2-5 dm. long," (Robinson & Fernald). Common along shore, the plants frequently being hardly more than 1 cm. long and bearing but 3 or 4 blades and a small spike.

4. *Cyperus diandrus* Torr. Low Cyperus.

A common plant of river and lake shores, thriving especially in moist sand. "Culms 2'-15' tall." (Britton & Brown.) "Culms 0.5-4 dm. high" (Robinson & Fernald). Some very small plants hardly more than 1 cm. tall noted.

5. *Cyperus inflexus* Muhl. Awned Cyperus.

Fairly common in wet places, and generally reaching a normal size. "1'-6' tall," (Britton & Brown). "2-20 cm. high," (Robinson & Fernald.) Dwarf plants very common along the stretch of shore, the entire plants exceedingly minute, hardly so conspicuous as a plant of the greater duckweed, even if that evident.

6. *Persicaria pennsylvanicum* (L.) Small. Pennsylvanica
Persicaria.

Rather common and varying considerably in size, but all the plants markedly dwarfed. Several were greatly reduced, one with only two leaves and a single flower. Britton & Brown give the size as "1-3 tall." Robinson & Fernald do not mention the size.

7. *Acnida tuberculata* Moq. Rough-fruited water-hemp.

Like many other plants along the shores of the Mississippi, this species varies greatly in abundance from year to year, in favorable years being exceedingly abundant and in unfavorable years rather scarce. It is pretty closely confined to the stretch of shore between the base of the fringe of willows that mark the normal high-water line, and the low-water line. During the summer of 1910, a period of prevailing low water, the mud flats along the sloughs were left uncovered most of the summer, and great stretches were densely overgrown with this species. It is indeed one of the most remarkably variable, even under conditions of normal growth, of all our plants, many of the individuals being tall and erect, much resembling the common rough pigweed (*Amaranthus*) others prostrate, many with the flower clusters interrupted, others with these continuous in a conspicuous dense furry-looking spike, many of the plants green, others of all shades of red and purple reminding one strongly of a near relative, the Celosia or cockscomb of gardens, the whole mass giving to shores in autumn an appearance of a wild, barbaric mixture of splendor and somberness. Current descriptions do not give any lower limit of size. Britton & Brown say "Sometimes 10° high," and Robinson & Fernald make no mention of size. All the plants found on the stretch of shore were very small, some of them minute. It was a common plant and seven exceedingly small examples were collected, one 14.5 mm. long with a slender stem, 3 leaves and 4 flowers, a third specimen 31.8 mm. high, the others were about the same size. The year 1915, being a year of high water and rather few fluctuations, was not favorable for the development of the dwarf shore flora; however, at the edges of a slough known locally as Sunfish Lake, some very minute examples of this plant represented by little more than a little speck of purple, were seen. They hardly projected above the soil.

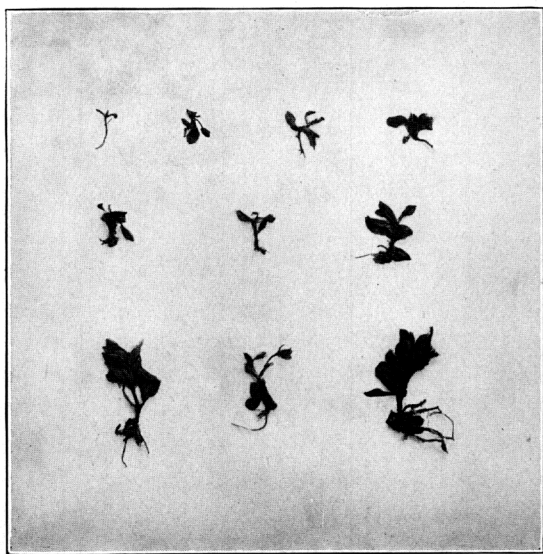


Plate IV. *Ilysanthes dubia* (L.) Barnh.

8. *Mollugo verticillata* L. Carpet weed.

Fairly common in the region of cultivated grounds, especially where the soil is somewhat sandy. Current descriptions do not give any "minimum" size. Britton & Brown mention it as "forming patches sometimes 20' in diameter" and Britton's Manual mentions 5 dm. as the "maximum" size. Dwarf plants were abundant along shore; one measured 12.5 mm. or but little more than a half inch entire extent, and bore 6 leaves and 3 fruits.

9. *Polanisia graveolens* Raf. Clammy-weed.

Common in the vicinity along the railroad in ballast, where in spite of the barren dry soil it reaches a fair size. Rather uncommon along the river, although it is said to be naturally distributed along sandy and gravelly shores. Normal size as given in Britton & Brown, 6' to 18' high. One minute plant found, bearing a few leaves and a single pod. The pod was of normal size; it was, indeed, the most conspicuous part of the plant, and at first glance was taken for some sort of cocoon attached to a slender, delicate plant. It was by an attempt to pick up the supposed cocoon that the parent plant was discovered.

10. *Acalypha virginica* L. Three-seeded Mercury.

Several greatly diminished plants, consisting of only a short stem, 2 or 3 leaves, and flowers and fruit were obtained, but no comparative measurements taken.

11. *Chamaesyce*, probably *humistrata* (Engelm.) Small.
Hairy Spreading Spurge.

A minute spurge, consisting of only a few mm. of stem, 3 or 4 leaves, and abundance of fruit, was common along part of this stretch. The fruits were markedly conspicuous, in some cases, indeed, the most conspicuous part of the plant. One entire plant measured 13.5 mm., the above-ground portion from base to tip of terminal blossom 4.4 mm. and it bore 2 dried cotyledons, 6 functional leaves and 2 fruits. Two other plants measured 13 mm. over all. Britton & Brown give measured normal size as "4'-12' long." Robinson & Fernald give "8-18 mm. long."

12. *Conobea multifida* (Michx.) Benth. *Conobea*.

Only one plant found, it being only 24.6 mm. long and bearing several blossoms. Its natural habitat is said to be "long streams and shores." It does not appear to be common in the region. Britton & Brown give its dimensions at "4'-8' high" and Britton's Manual mentions it as being "1-2 dm. high, very leafy," while Robinson & Fernald who do not mention size limits, speak of it as being "diffusely spreading, much-branched."

13. *Illysanthes dubia* (L.) Barnhart. Long-stalked False Pimpernel.

Numerous minute plants were present. One had a stem 5.5 mm. long and root about the same length, 6 leaves, 2 of them old, and shrivelled and probably representing the cotyledons, and 3 fruits. A second stemless plant had 4 leaves and 2 fruits, a third was 8 mm. high and 3 had flowers and fruits and 8 broad leaves. A fourth of the robust type had the stem about 5 mm. with 7 broad leaves and 2 fruits. Normal size given as "3'-8' long" (Britton & Brown), or "1-3 dm. long (Robinson & Fernald.)

14. *Ambrosia elatior* L. Ragweed.

The well known ragweed was represented by a few dwarfed but markedly fruitful examples, ranging from only about 75 mm. high up to near the lower limits of the normal size. The normal size is given as from 1°-6° high (Britton & Brown), or .3-2.5 m. high (Robinson & Fernald).

15. *Verbesina alba* L. Eclipta.

This species, familiar to students of the floras of shores and borders of lakes often forms in favorable situations, tall well-branched plants. It was the most abundant of the dwarfed plants found along the stretch of shore under consideration. Between 100 and 150 examples of minute plants with only a few leaves and tipped with a small flower or sometimes bearing also several axillary flowers, were observed. The following measurements are fair examples:

- a. 18.5 mm. in length, root and all, one branch, 4 leaves, one flower, aerial portion of plant 10 mm. high.

b. 18.5 mm. high over all; 2 pairs foliage leaves, cotyledons persistent, but dried; fruit consisting of 8 full sized achenes as a result of the single flower.

c. 15 mm. over all, 3 pairs of leaves, 1 pair dried cotyledons, 3 achenes.

d. 17.5 mm. over all, 3 flowers, cotyledons present but dried.

e. 15 mm. over all, 1 large flower, 10 achenes.

f. 10.5 mm. over all.

In wet sand along the shore of Lake Maxinkuckee, during the autumns of 1904 and 1907, exceedingly small plants of this species, bearing only 3 or 4 leaves and a terminal flower were collected. It was frequent about some of the Biological Station ponds where plants reached normal size. This is given as 6'-3° high (Britton & Brown), or 2-9 dm. high (Robinson & Fernald.)

16. *Bidens cernua* L. Small or Nodding Burr-Marigold.

Numerous examples along shore, one 30 mm. high with 2 pairs of leaves, one of which are the cotyledons and tipped with a minute blossom. A second with a stem 14.5 mm. high, 2 pairs of leaves, one of which are the cotyledons, and one blossom. Another, 19 mm. high, normal size "2'-3° high, consisting of many races differing in size" (Britton & Brown). "2-7 dm. high, very variable." (Robinson & Fernald.)

17. *Bidens frondosa* L. Sticktight.

Occasional along shore; it does not seem to be especially common in the locality away from the river. Known through many parts of the country as "Spanish-needles"; a local appropriate name is "boot-jack." Not so common as the former; small plants are often noted growing in piles of lodged driftwood or on lodged logs out in the sloughs. One plant bore 4 leaves and 1 flower; the stem was very short but too crooked to measure exactly. Normal size "2°-3° high" (Britton & Brown.) "Stems tall, 7 dm. or less in height." (Robinson & Fernald.)

18. *Artemesia caudata* Michx. Tall or Wild Wormwood.

Dwarf plants numerous—one plant measured 12 mm. or a little less than half inch over all and bore 1 persisting cotyledon, 5 leaves and 1 flower. Another perfect plant measured 18 mm. over all. The writer is most familiar with this species in dry sandy places where it grows to be a tall weed. Britton & Brown give the size as 2°-6° high, and Robinson & Fernald gives it as 0.5-1.5 m. high.

In addition to these dwarf species there are a few plants of the wild bean (*Strophostyles helveolus*) which had evidently germinated in late summer and bore a blossom or two. They were, however, far from mature.

Now, one striking feature of this dwarf flora was that while the dwarfs varied considerably among themselves as to size, the whole flora was markedly dwarfed, not merely single individuals here and there. This fact, along with the fact that several unrelated species were involved, indicated that some markedly dwarfing influence was at work.

In seeking an explanation, two obvious facts forced themselves upon the attention: one was the persistence of the cotyledons on many of the plants, indicating that they were not only dwarfed, but young precocious plants, and another was that the ground where they grew was considerably below the high-water line of the river, which covered the ground where they grew until considerable late in the season. They would therefore have a considerably shorter growing season than their upland relatives. Although, as will be stated more fully hereafter, this shortness of season is in itself hardly sufficient to explain adequately the dwarfness of the plants, it is one factor which we can give in terms of more or less precise measurement by a consultation of records of the weather and of the river stages. They are therefore given in considerable detail, especially as, on account of their measurableness, they can be represented in compact, graphic form.

The strip along which the dwarf plants were found growing was between about 6.21 and 6.50 feet above the low water mark. Now, during the early part of the season—from May 9th to May 22d, on June 6th to 8th and from June 14th to July 28th, the water was above the 6.50 stage. Even with

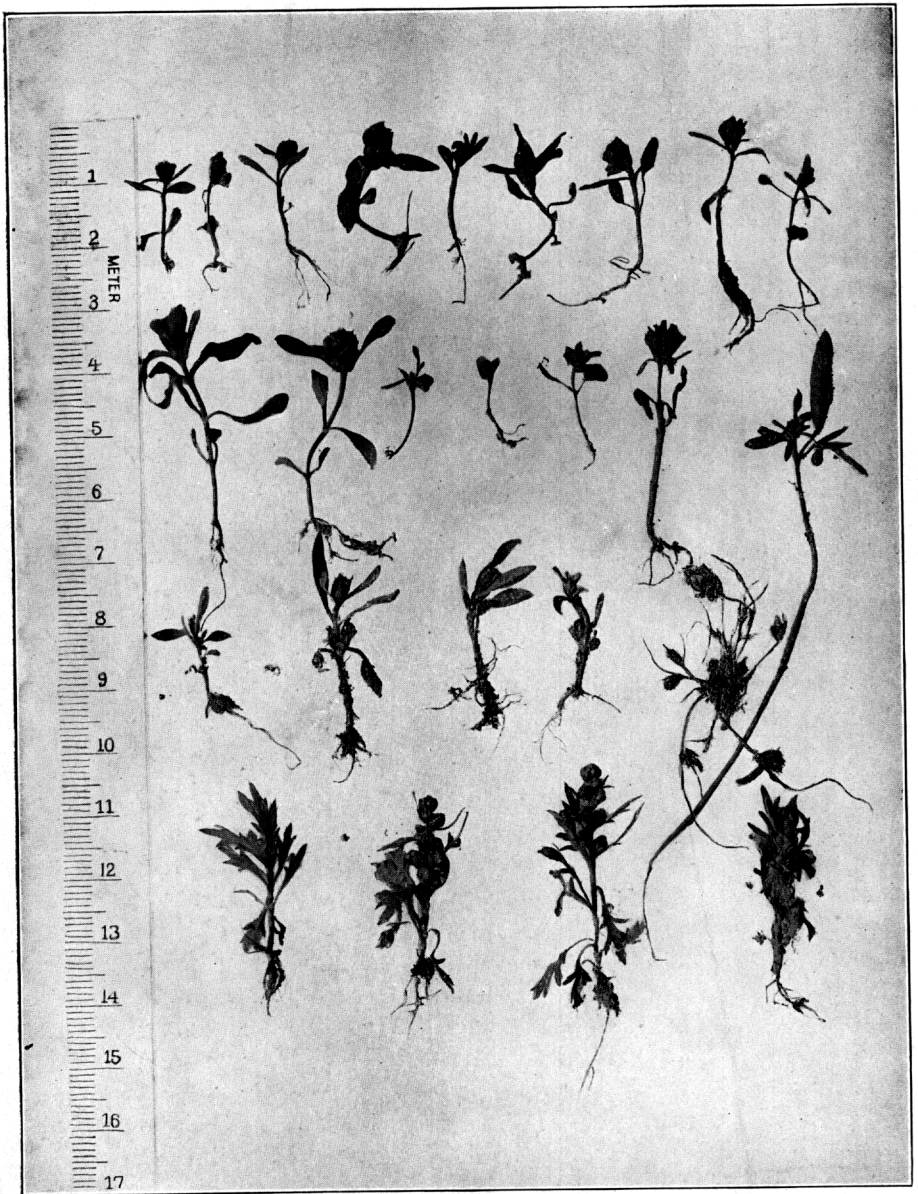


Plate V. *Bidens*, *Cyperus*, *Polanisia* and *Artemisia*

the water somewhat below this stage, the play of waves, especially of the strong scouring wash made by passing steamers, would make the germination of seeds impossible.

It is therefore pretty certain that the dwarf plants in question could not have germinated until after July 28th, probably about the beginning of August.

Now, notes concerning the general vegetation of the region indicate that back from shore, where conditions were normal, the germination of spring seeds was fairly well under way about April 27th. This would almost certainly include *Ambrosia* and *Persicaria*, which are among the earliest of seeds to germinate, and probably the rest of the species represented. From this date the general growing season extended until October 26th, a period of 181 days, when it was terminated by a killing frost, the length of growing season being very unusual for this region. The growing season of the dwarf plants continued about a fortnight longer, or until November 14th. On account of their closeness, both to the ground and to the water's edge, they escaped the first few killing frosts and persisted bright and green until a slight freeze. This makes their growing period (from about August 1st to November 14th) about 107 days or 74 days shorter than that of the general vegetation. It was very probably considerably shorter than this; the germinating plants were not seen, and the plants were given the benefit of the doubt by assuming germination with remarkable promptness after the receding waters had left the ground bare where they were found. A part of the ground where they grew was indeed partly submerged by a 2 days rise September 15-17, and it is barely possible that the plants sprang up after that time, giving them a growing season of only 39 days. Their exceedingly small amount of growth and their persisting cotyledons makes this short season seem not improbable.

The plants collected were preserved in two forms (1) as dried specimens and (2) preserved in formalin, as it was feared that some of the more diminutive ones might be easily lost among the herbarium sheets. There is appended photographs showing some of the dwarf plants natural size, and a chart showing river stages, rainfall, and the boundary-lines of the dwarf-plant area.

The factor just considered, i.e., shortness of the growing season, appears indeed also to account in part for individual dwarfing of upland plants. Thus on the Biological Station grounds one frequently finds growing side by side normal size and extremely dwarf forms of the same species. Plants which are noteworthy in this respect are the Shepherd's purse, *Capsella bursa pastoris* L., Peppergrass, *Lepidium virginicum* L., and the Golden Corydalis *Capnoides aureum* (Willd.) Kuntze.

The Peppergrass and the Shepherd's Purse flower and fruit throughout the entire summer. The seedlings of some of the earlier maturing pods germinate early in autumn, and form stout conspicuous rosettes, which winter over in this form and in spring spring up into tall, robust plants. Seeds from the later maturing pods do not germinate however until spring, and appears as a rule to form short-season, comparatively puny plants. In Golden Corydalis, the individual plants have an exceedingly long period of bloom, from early spring until midsummer and one finds ripened pods and unopened flower-buds on the same plant. The seeds from early-ripening pods germinate in early autumn to form rosettes while those from the later ripening pods do not germinate until spring, when they frequently form puny plants, with 1 or 2 leaves and a blossom.

Still, shortness of season cannot entirely account for dwarfness and early ripening. We know that while late planted corn will mature more rapidly than the same variety planted earlier, that there is a fixed limit which cannot be trespassed, and the farmer who would plant his seed at date of germination of our water plants mentioned in the earlier part of our discussion, would reap—not dwarf corn, but would find his crop cut down by frost when still green and immature. Among land plants moreover, we have dwarf perennials, such as diminutive wild crabs, cedars, hackberry, etc., where the length of the growing season can cut no figure; and we know that the seedling of a large seed produced by the underground cleistogamous flower of the hog-peanut is a veritable giant compared with the frail "spindling" brother from the small aerial seed.

The case of dwarfing, frequently individual, among upland plants, appears on the whole to be a complex and diversified problem, assignable to numerous causes. The case of dwarf-

ness in shore floras is more general and of larger aspect. Among other causes, a water soaked compact soil by inhibiting root-development may have an important part. Especially significant in this connection is the permanent dwarfing of forms which hug the waters' edge, such as some of the little water spearworts of the genus *Ranunculus*, or the genus *Hydrocotyle* among the parsnips, or, more remarkable still, that of the family Salvinaceae among the Pteridophytes of which one representative, *Salvinia*, is aptly described as "floating like *Lemna* on the surface of stagnant waters," and the other, *Azolla*, as "appearing like a reddish hepatic moss." Finally this process of diminution reaches its consummation and approaches most nearly the vanishing point among the Lemnaceae, all of which are small, in the rootless and leafless *Wolffia* which in general appearance reminds one of *Volvox* rather than anything else, and the diminutive *Wolffiella* which bears a close superficial resemblance to some of the low plankton algae such as *Aphanizomenon*.
