PLANT SUCCESSION ON LEVEES IN THE ILLINOIS RIVER VALLEY

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In studying the vegetation of the lower Illinois River Valley through four growing-seasons, the author discovered an interesting case of plant succession on the land reclamation levees. As levees ranging in age from one to forty years are found at convenient intervals, one could scarcely ask for a more convenient field for the study of plant succession.

HISTORY OF LEVEE CONSTRUCTION AND LAND RECLAMATION

River floodplains have long been known to contain extremely fertile soil. It is not surprising then that as early as 1893 drainage and reclamation projects were initiated in the Illinois Valley when an extensive drainage district was organized southwest of Havana and a levee was constructed by team and hand labor. It is possible, of course, to farm the bottoms without the protection of a levee and pumps but the proposition is on a sounder footing with these aids. After the first pioneer experiment, levee construction increased rapidly, reaching its height in the Illinois Valley between the years 1902 and 1918. Post-war conditions are probably responsible for the slump that has existed since 1918. However, up to 1930, 339,700 acres had been reclaimed through the organization of sixty-seven drainage districts, forty-five of which are located in the former floodplain of the river. It is not uncommon for a single district to incorporate 12,000 or more acres, and the largest contains 40,760 acres. Most of the leveed districts lie on the east side of the river as the channel occupies the west side of the floodplain throughout most of this range.[1]

Quite significant from the standpoint of the fish and game conservationist is the amount of land in the valley that has not been reclaimed and is still subject to overflow. Some 134,560 acres below Ottawa are still subject to flooding. The bulk of this acreage is included in five unleveed areas of which the most extensive, picturesque, and

[1] Pickels, G. W., and Leonard, F. B., Engineering and Legal Aspects of Land Drainage in Illinois, Illinois State Geol. Survey Bull. 42, 1921 (revised 1928).

interesting is at the mouth of Sangamon River. The others are the Meredosia Bay region, territory above and below Havana on the east side of the river, the area at the mouth of the river, and some territory northeast of Peoria. Some of these areas contain fairly extensive lakes and swamps and retain some of the charm of the primitive state, yet these scattered tracts represent a rather pitiful remnant of what was once one of the finest fish and game areas in America.

FIG 1. *(Above)* Constructing a levee with a dredge boat. *(Center)* Repairing a levee with a caterpillar shovel. *(Below)* A new levee.

DESCRIPTION OF A LEVEED DISTRICT

The area to be reclaimed is surrounded by an earthen wall ranging from eight to twenty-five feet in height, the highest part on the riverward side of the district and lowest part on the opposite side where the land is higher. Modern practice employs a dredge boat in the construction of the levees or, when the ground is dry enough, the caterpillar power shovel is used. The dredge boat floats in the ditch from which the earth is taken to form the levee so that the two operations,

ditch and levee construction, take place simultaneously. Obviously a deep ditch is the constant accompaniment of the levee. Good engineering practice places the outer base of the wall back some five or six feet from the edge of the ditch in order to avoid any slipping or crumbling of the levee when the water is high enough to wash the base. This earthen shoulder, or "berme," as it is named is a rather important feature in later plant succession as it is here that the first trees usually become established.

The outer, or riverward wall of the leveed district may be within twenty-five yards of the river channel, roughly approximating in its course the natural contours of the river. Not only land subject merely to periodic overflow, but also areas formerly occupied by lakes and marshes have been reclaimed. This is all very creditable but as a consequence there is relatively little territory left between the levees and the river channel, even though some of the reclaimed land is of questionable value for agriculture. Possibly it might have been better if a wider fringe had been left, not only for the reason suggested above but also that this strip might more profitably be occupied by lakes and swamps that would function as game preserves.

Plant Succession

Introduction

In making this study of plant succession the location and age of levees was first determined. This was done through the aid of a very excellent and pertinent publication, "Land Drainage in Illinois."[2] It was essential to know not only when a levee was originally constructed but also if it had been repaired and when. By employing a motor boat it was possible to visit levees throughout a range of one hundred fifty miles. The study included observations of the levees throughout the summers of three years and from April to November of 1930.

Actual counts were made, or line quadrats run in order to determine the dominance or relative importance of species. Gray's New Manual of Botany, 7th Edition is the authority for the species named.

Throughout the range studied the common type of soil forming the levees is a mixture of alluvial material containing some rocks, gravel, and mollusk shells. It is slightly alkaline, results of tests ranging from pH. 7.2 to 8.0. As these levees were built in widely separated areas it might be expected that there would be differences in the character of the alluvial soil employed. In general these differences were inconsequential. It is well known that the moisture-equivalent of soils,

[2] Pickels, G. W., and Leonard, F. B., Op. cit.

as computed by the centrifuge method, gives a useful summary of the condition of soils in relation to plant needs (exclusive of nutritional needs, of course, which is certainly not a functional variable here). Examination of soil samples taken from many levees indicates that the moisture-equivalent of levee soils does not vary more than 2 per cent. The wilting coefficient of the same soils ranges from 13.5 to 16 per cent. These facts seem to corroborate the statement that soil differences are neglible in importance at least within the range studied. Soil moisture during the growing season of 1930 was as follows:

	April	May	June	July	Aug.	Sept.
Adjacent floodplain forest soil..	30.9	20.0	21.0	20.2	18.7	24.4
Lower third of levee.....	17.8	19.7	16.5	18.0	9.8	18.6
Middle third of levee.....	14.8	14.7	20.1	13.1	7.8	17.7
Levee top.....	15.3	9.0	16.5	9.2	7.0	10.5

The above analysis was made on a levee on which the middle stages of succession were taking place, that is, the plant cover was made up of herbs, shrubs, and small trees. Soil moisture determination was also made on a levee on which the sub-climax was present, that is, the cover was made up of full-sized trees. In this instance the percentage of soil moisture averaged three points higher in all stations throughout the season. In both cases the soil samples were taken at a foot from the surface.

It will be noted that the soil moisture at a foot in depth on the levees fell considerably below the wilting coefficient (average 14.7) during the latter part of the summer. In considering the effect of this dry condition on the plants of the levee it is of course recognized that most of the roots penetrate much deeper into the soil than this. The effect on seedlings would doubtless be critical, particularly if the condition obtained year after year, but in this connection it will be recalled that the season of 1930 was much dryer than the average.

As the soil is thrown up by the shovels in building the levees it is thoroughly saturated with water and this together with its fine texture establishes poor aeration. It dries and bakes somewhat the first season but continued contact with the air and the ramification of plant roots soon convert it into a reasonably favorable edaphic habitat.

Pioneer Stage of Plant Succession

(One to three years)

Almost all circumstances are favorable for the quick establishment of plants on the new levee. The soil is very soon in a favorable condition, its moisture is usually sufficient, and light, humidity, and air movement all favor plant growth. Furthermore the very-necessary

seeds or propagules are soon brought in by flood water. It is not at all surprising then that plant succession and the establishment of the climax is rapid.

The first plants occurring on the new levee in the order of abundance are as follows: *Amaranthus blitoides* Wats., *A. retroflexus* L., *Erigeron canadensis* L., *Lactuca scariola* L., *Acnida tuberculata* Moq., *Xanthium canadense* Mill., *Chenopodium album* L. and *C. murale* L. Of second rank are: *Ambrosia trifida* L., *Polygonum lapathifolium* L., *P. Pennsylvanicum* L., and *Rumex crispus* L. A third group made up of species somewhat less common is as follows: *Eupatorium serotinum* Michx., *Echinochloa crusgalli* (L.) Beauv., *Radicula palustris* (L.) Moench., *Ambrosia bidentata* Michx., *Lippia lanceolata* Michx. , and *Mollugo verticillata* L. Seedlings of trees appear at this time also. They commonly occur in rows where successive high water levels leave the seeds in the spring. It is quite significant but not surprising that both the levee subclimax and the climax tree species start along with the pioneer group. Seedlings of *Acer saccharinum* L., *Populus deltoides* Marsh., *Ulmus americana* L., *Salix nigra* Marsh., *Salix amygdaloides* Anders., *Salix longifolia* Muhl., and *Salix fragilis* L. are abundant in this early stage. Less commonly are found those of *Fraxinus pennsylvanica* Marsh. var. *Lanceolata* (Borkh.) Sarg., *Platanus occidentalis* L., and *Celtis occidentalis* L. The seedlings of two shrubs that play an important rôle in the middle stages of succession, namely *Sambucus canadensis* L. and *Rhus glabra* L., occur to a considerable extent at this time.

The condition described above persists for three or four years during which time the trees and shrubs rapidly increase in size, particularly the elder, sumach, willow, and cottonwood. As the sprouts of these species attain a height of five or six feet their shade begins to have its influence on the herbaceous plants and this heralds the next phase of the succession.

Second Stage

(Three to six years)

The woody growth as far as species are concerned remains essentially the same at this stage with the exception of a few vines which now become established. This group includes *Tecoma radicans* (L.) Juss., *Vitis vulpina* L., *Celastrus scandens* L., and *Clematis Pitcheri* T. & G. Also, *Hibiscus militaris* Cav., *Adelia acuminata* Michx., and *Cephalanthus occidentalis* L. sometimes become established at the water's edge. The significant change which begins in this period is in

the herbaceous growth which from now on becomes more shade-tole ant, made necessary by the increasing size of the woody plants and t accompanying shade increment. The herbs at and immediately abov the water line remain essentially the pioneer group because this a is annually inundated and the herbaceous growth is destroyed. C the upper part of the levees the following plants appear: *Ipomea p durata* (L.) G. F. W. Mey., *Convolvulus sepium* L., *Epilobium de* Raf., *Phytolacca decandra* L., *Gonolobus Laevis* Michx., *Cap Bursa-pastoris* (L.) Medic., *Amphicarpa monoica* (L.) Ell., *Asclep tuberosa* L., *Teucrium canadense* L., *Potentilla monspeliensis* *Oenothera biennis* L., *Polanisia trachysperma* T. & G., *Cassia Cha aecrista* L., *Cassia Chamaecrista* L. var. *robusta Pollard.*, *Verbe stricta* Vent., and *Oxybaphus nyctagineus* (Michx.) Sweet.

This phase persists for four or five years. During this time the habitat is further modified by the growing trees, and the soil is improved by the accumulation of a small amount of humus. In general the vegetation becomes somewhat more mesophytic and less xerophytic due to the increased water-holding capacity of the soil and to the greater humidity of the air caused by impeded air movement.

Third Stage

(Six to ten years)

Significantly, by the beginning of the third stage the shrub and tree cover (sumach, willow, cottonwood) has so increased that some of the shade-tolerant floodplain forest vines and herbs can gain a foothold. Among these are: *Menispermum canadense* L., *Rhus Toxicodendron* L., *Smilax rotundifolia* L., *Smilax hispida* Muhl., *Smilax herbacea* L., *Cissus Ampelopsis* Pers., *Vernonia missurica* Raf., *Vernonia illinoensis* Gleason, *Bidens* spp., *Amsonia Tabernaemontana* Walt., *Solanum nigrum* L., *Anemone canadense* L., *Asclepias syriaca* L., and *Oxalis corniculata* L.

Fourth Stage

(Ten to fifteen years)

Within the following four to six years two important things take place, the establishment of a more mesophytic herbaceous flora and the beginning of the struggle for supremacy among the trees. Under the first item the herbs coming in or becoming better established are, *Amorpha fruticosa* L., *Cassia* spp., *Apios tuberosa* Moench., *Lysimachia terrestris* (L.) BSP., *Stachys Nuttallii* Shuttlw., *Cicuta maculata* L.,

and *Viola* spp. The soft maple and the American elm begin to be prominent and the willow and cottonwood begin to decline. Occasional ash, sycamore, pecan, hackberry, and pin oak trees which have matured more slowly are found on the upper part of the levee, and the honey locust occurs rarely at the water's edge.

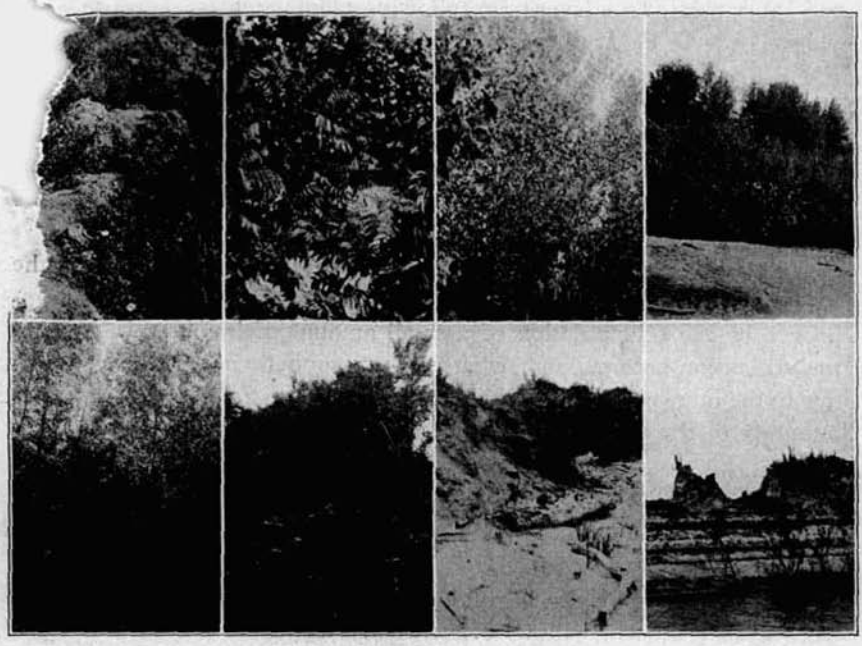

FIG. 2. *(Upper row)* (1) First stage of plant succession, weeds and tree seedlings; (2) second stage, shrubs and tree sprouts; (3) third stage, sumach, cottonwood, and willow; (4) fourth stage, beginning of the elm-maple era. *(Lower row)* (1) Fourth stage, advanced, elm-maple; (2) the climax, elm-maple; (3) A sand levee destroyed by waves (1927 floods); and (4) an unforested dirt levee destroyed by 1927 floods.

FIFTH STAGE

(Fifteen to thirty years)

In the subsequent ten or fifteen years the tendency among the trees is toward the elimination of the less shade-tolerant cottonwoods and willows and the establishment of the maple and elm as dominant. An analysis of the woody flora shows the following proportion of species:

	Per cent
Ulmus americana L.	44
Acer saccharinum L.	32
Platanus occidentalis L.	7
Salix spp.	7
Populus deltoides Marsh.	5

Celtis occidentalis L., *Quercus palustris* Muench, *Betula nigra* L., *Fraxinus pennsylvanica* Marsh var. *lanceolota* (Borkh.) Sarg., and *Carya illinoensis* (Wang.) K. Koch. comprise collectively the remaining five per cent.

Rhus glabra and *Sambucus canadensis* remain rather important locally where they may occur as dense, exclusive colonies. The vines, *Vitis vulpina, Cissus ampelopsis, Psedera quinquefolia* (L.) Greene, and *Smilax* spp. persist as an important accompaniment of the tree stand.

Those levees on which this normal succession is allowed to take place develop a thick stand which so diminishes the light that the herbaceous growth is greatly reduced and modified in regard to species. *Laportea canadensis* (L.) Gaud., *Galium Aparine* L., *G. circaezans* Michx., *Impatiens biflora* Walt., *Viola cucullata* Ait., *Companula americana* L., *Hydrophyllum virginianum* L., *Cirsium virginianum* (L.) Michx., *C. muticum* Michx., and species of Aster and Solidago are prominent herbs in this phase of the succession.

Levee Climax

(Thirty to fifty years)

Although it is somewhat hazardous to state the exact nature of the climax on the basis of forty years' growth it seems probable that it is characterized as follows: the elm becomes relatively more prominent and constitutes from 50 to 65 per cent of the total stand. This is due very largely to the decline of the soft maple (now only 25 per cent) which has a higher mortality rate on the levees and in other ways does not seem to be able to compete so successfully with the elm as it does in the floodplain forest, as described by Turner.[3] The cottonwoods also die out and do not reproduce well and hence comprise only about 2 per cent of the total. The ash, sycamore, pin oak, hackberry, birch, willow, and pecan persist, comprising about 2 per cent each. The herbaceous growth remains essentially the same in quality but decreases in quantity, particularly in the summer and fall species.

Discussion

Exceptions to the foregoing scheme occur of course. Several events may interrupt the normal succession, such as, mowing, fires, grazing, cutting of trees, and floods. Mowing and grazing, and also burning are very common practices as it is the opinion of many ranch

[3] Turner, L. M., Ecological Studies in the Lower Illinois River Valley, Illinois Nat. Hist. Survey, Unpublished Mss.

managers that herbaceous growth such as grasses makes the most effective levee protection. This may be true, but the establishment of a good grass stand on the levee is quite a problem under circumstances that are so favorable to weed, shrub, and tree growth. Unfortunately the grasses that are common to the floodplains, such as *Spartina Michauxiana* and species of *Panicum*, do not thrive and hold their own on the well-drained levee. Taking all things into consideration it is the opinion of the author that the normal climax would be about as economical and effective as any other cover. Perhaps the ideal condition would be a thick stand of trees on the berm and lower outside for wave and ice protection and an herbaceous cover of bent grasses, etc., for the upper and inside parts.

Some ranchers fear that a tree growth would produce large roots which on rotting would facilitate crumbling and leaking of the levee during high water. It is doubtful if this would actually occur. At any rate it would seem that the protection from wave action afforded by trees during flood times would compensate for almost any objection that might be raised against them.

Conclusions

1. Plant succession on the levees of the lower Illinois River Valley occurs in a series of comparatively rapid stages. The levee climax is probably attained within fifty years.

2. The type of succession is secondary—that is, the original floodplain climax is destroyed by the levee construction which creates a different, less mesophytic habitat and the floodplain species adapted to this new habitat become established thereon.

3. Elm and maple are the dominant species of the climax; six to eight other trees persist but are not important in the final association.

4. The herbaceous growth in the climax is limited to a few of the floodplain forest species.

5. Due to several factors the normal succession is not commonly allowed to proceed to the climax.

6. The normal climax probably affords the best cover for the protection and maintenance of the levees.