THE CONTRAST BETWEEN CLIMAX

AND

SERAL TYPES OF VEGETATION

BY

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Contents.

Plates.

Cross sections of leaves and stomata of plants indicated.

THE CONTRAST BETWEEN CLIMAX AND SERAL TYPES OF VEGETATION

by

Helen Anastasia McGinnis

I. Introduction.

The primary object of this study has been to determine how much contrast there is between the type of vegetation found in the final or climax stage of succession and that which is characteristic of the seral or developmental stages of succession. For the sake of concreteness in description a detailed study was made of the vegetation in fifteen ten-foot quadrats. These quadrats include representative parts of an area which lies one half mile north of the city of Urbana, Illinois. Fig. I makes clear the definite location of this area with reference to the position of the county drainage ditch. Part of this area is covered by a remnant of a climax deciduous forest; the other part comprises a grassy plot with waste land adjoining - seral vegetation. The latter had been ploughed up at some recent period but had lain idle for at least a year preceding the time at which the study was made; hence the ruderal vegetation in this place was luxuriant. Seven of the quadrats studied were a part of the wasteland portion, three were in the forest remnant, while the remaining six were in the grassy area which lay between the ruderal and forest remnant portions of the region. Selected in this manner they formed representative parts of the vegetation of the locality.

The field work was begun September 29, 1917 and continued until November 17 when the weather prevented further outdoor study. During this time the quadrats were measured off, a plant census was taken, and certain experiments were performed to show the characters of this

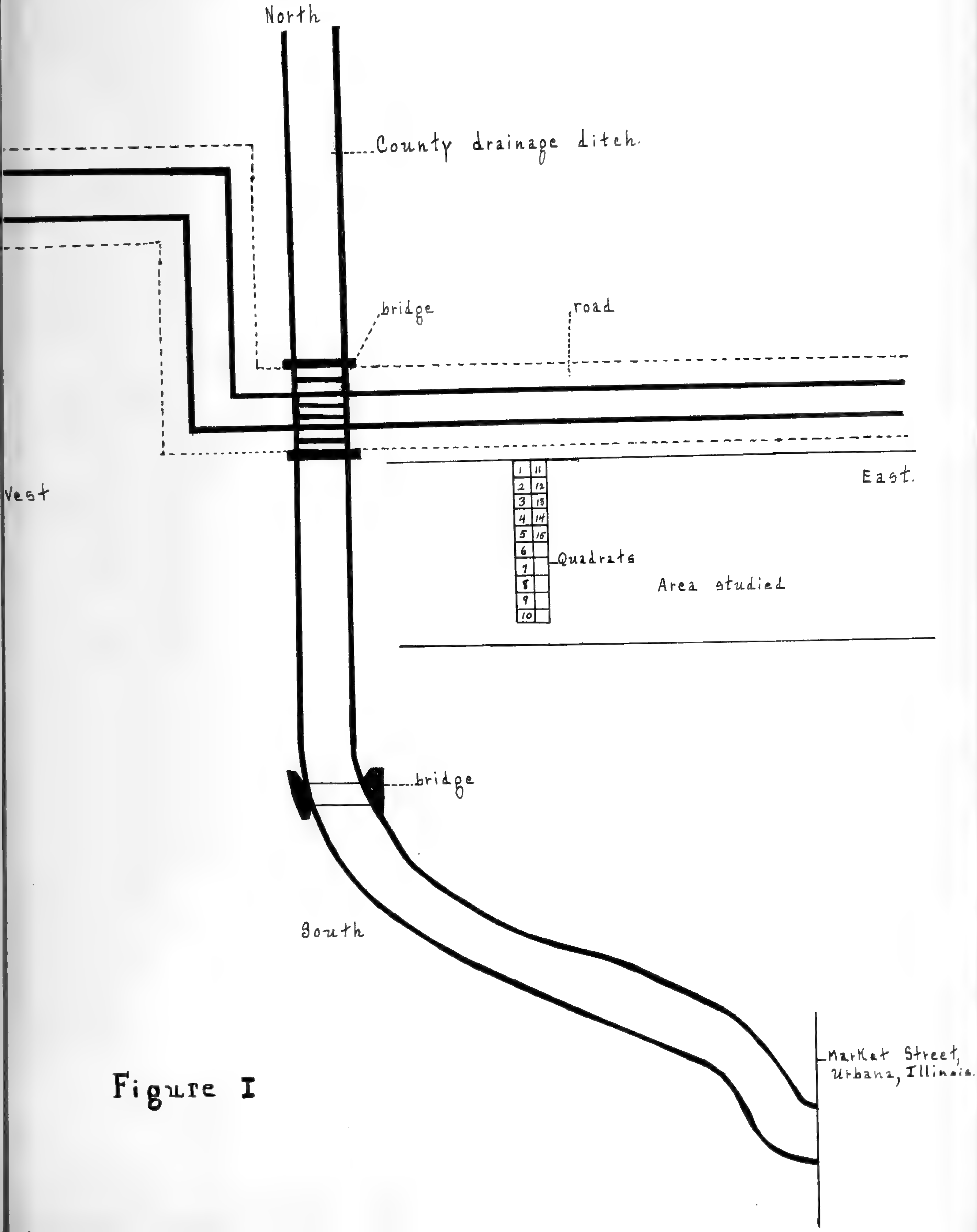

North
County drainage ditch.
bridge
road
Vest
East.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Quadrats
Area studied
bridge
South
Market Street,
Urbana, Illinois.

Figure I

autumnal vegetation. A few visits to the region were made in the spring of 1918, also, for the purpose of studying the prevernal and vernal vegetation.

In the first part of this paper an attempt has been made to point out some of the contrasts between seral and climax vegetation that have been presented in the writings of former workers. Following this general treatment of the subject is the description of the detailed quadrat study.

II. Primary and Secondary Succession.

According to Cowles (1) ecology has two well marked phases; "one phase is concerned with the origin and development of plant structures, the other with the origin and development of plant societies and formations." In a consideration of primary and secondary successions with regard to development we need concern ourselves only with the second phase - "the origin and development of plant societies and formations."

Warming (16) made the first systematic attempt to classify formations. In place of the word "formation" he introduced the term "society" and made the water content of the soil the basis of his classification. According to this grouping plant societies were divided into hydrophytic, mesophytic, and xerophytic. No other divisions were recognized.

Schimper (10) considers the conditions which determine the distribution of plants at large and attempts the classification of climatic formations. His classification is based, therefore, upon climatic factors.

Clements' system (1), the clearest and most workable one, is based primarily upon development, with especial reference to reaction, and secondarily upon initial causes. His first division was into

primary and secondary successions which were based upon development. Clements' "succession" is an abstract term referring to the phenomena while a "sere" is a concrete example or unit succession.

A primary and a secondary sere often look very much alike but can be distinguished by the plants found in the early stages of development. The primary sere or prisere is characterized by having the pioneer stage while the secondary sere or subsere begins with a late initial or subpioneer stage. By pioneer stage is meant that stage in which we find plants which are usually the first ones to occupy an initial bare area. The initial or subpioneer stage is characterized by plants slightly higher up on the scale and which are always found as first species of a secondary bare area.

1. Prisere.

The cause of the beginning of the prisere is topographic while in the subsere it may be biotic as well as topographic. A destruction of the vegetation by topographic or biotic agencies gives rise to a subsere which begins with a medial or subpioneer stage and ends in the belated climax. There exists in the prisere an extreme condition of water content, either wet or dry, but this is usually not true of the subsere. With regard to one factor the prisere and subsere agree and this is the tendency of both to become stable in a mesophytic habitat. This tendency of the various plant communities causes them to pass through a series of successive types from their original condition to the mesophytic community, which is the climax or culminating type.

In the study of plant communities it is found that orders of succession are not the same in various regions. However there is a close analogy between the community life histories of places where climatic conditions are essentially the same. In studying a region

the Clements classification which is presented below may be used to advantage.

I. Prisere - a sere which begins in a primary bare area with a pioneer stage and ends in the climax.

A. Hydrosere - a sere which begins its life history in open water.

(a). Halosere - a sere which passes through a stage in which physical water is abundant but physiological water scarce.

(b). Oxysere - a hydrosere which does not pass through a halophytic stage.

B. Xerosere - a sere which begins in a primary dry area.

(a). Lithosere - a sere which begins on bare rock.

(b). Psammosere - a sere which begins on bare sand.

II. Subsere - a sere characterized at the beginning by a late initial or subpioneer stage and ending in a climax.

A. Hydrosere - a sere which begins in a secondary wet area.

B. Xerosere - a sere which begins in a secondary dry area.

A secondary area is a bare area which has been produced by a destruction of the vegetation. In the following consideration of seres and subseres the leading classification followed will be that of Clements (1) while other findings will be made to correspond to this grouping. The region under consideration is that of the deciduous forest climax. The nomenclature used is that of Gray's manual.

A. Hydrosere.

(a). The halosere - The halosere begins its life history in open water but passes through a xerophytic or bog stage during which there is an abundance of physical water but little physiological water. The succession of vegetation begins with the plankton

associes. This is characterized by the presence of bacteria, diatoms, single celled algae, and Chara. Chara is a good soil producer since its remains accumulate with little or no decay. For this reason also, it hastens the process of filling in or making the lake shallower. As the submerged zone fills in, new plants become established. These new species form what is called the lily zone. Chief among the plants of this belt are white and yellow water lilies (Castalia tuberosa and Nelumbo lutea), the pondweeds (Potamogeton), the bladderworts (Utricularia vulgaris, and U. intermedia), water weed (Elodea canadensis), diatoms, and desmids.

Following the lily zone and outside of it is found the floating associes. In this group are found such plants as the duckweed (Lemna minor), liverworts (Riccia fluitans, and Ricciocarpus natans), and masses of algae including Spirogyra, Zygnema, and Cladophora. The accumulation of debris in the lake interferes with drainage, increases the difficulty of absorption, prevents oxidation and so causes the habitat to become xerophytic.

This xerophytism is shown by the marginal type of vegetation which follows. The dominant species are the leatherleaf (Cassandra calyculata), the swamp blueberry (Vaccinium corymbosum), cranberry (Vaccinium macrocarpon), alder (Alnus incana), dwarf birch (Betula pumila), hoary willow (Salix candida), and the poison sumach (Rhus vernix). Sub-dominant marginal plants are the sedges (Carex) and bulrush (Scirpus lacustris). In the open patches are found characteristic herbs among which are the pitcher plant (Sarracenia purpurea), the sundew (Drosera rotundifolia), and in addition peat moss (Sphagnum).

In a relatively short time conifers advance upon the bog flora. Among them are the tamarack (Larix laricina), and the arbor vitae

(Thuja occidentalis). As the shade becomes dense mosses and a few herbaceous plants appear among which are Mnium, Viola blanda, and Impatiens palida and I. biflora. Following this tree group is one which is characterized by the presence of pines (Pinus strobus, and P. banksiana). Later as the soil becomes drier and better drained oaks arrive.

As the habitat becomes more mesophytic the climax association makes its appearance. The dominant trees are Beech and Maple (Acer saccharum and Fagus grandifolia). The secondary species consist principally of Fraxinus pennsylvanica, var. lanceolata, Juglans cinerea, Quercus alba, Quercus rubra, and Ulmus Americana. The dominants in the shrub layer are chiefly Cornus stolonifera, Crataegus sp., Prunus americana, and P. macrophyllus. The lower herbaceous layer in the climax forest is rich in kinds of plants, among which are Aster cordifolius, Galium triflorum, Smilacina stellata, S. racemosa, Rubus triflorus, Trillium cernuum, Viola sp., and Hepatica triloba.

In all of the peat bog successions the marginal flora agrees in essential details but variations occur in the bog zone. Even if the kinds of plants vary in the different zones, however, all those which occur are of a common type. They require the same physical conditions for growth and so are ecological equivalents.

(b). The oxysere - The oxysere may begin in an open inland lake. The stages of the succession in this sere follow each other rapidly. Where the vegetation is not subject to currents nor to stagnant conditions the flora is luxuriant. The first submerged vegetation layer is always rich both in species and in individuals. Alga forms are usually abundant and include Cladophora, Spirogyra, Oedogonium, and Hydrodictyon.

The floating stage follows. Among the plants of this zone are Riccia, Ricciocarpus, Lemna, Spirodela, and Wolffia. In the next zone, that of the attached forms, are very large numbers of plants such as species of Potamogeton, Brasenia, Myriophyllum, Elodea, and Naias. Since the currents are not sufficiently strong to carry away the plant remains the rank vegetation rapidly advances and fills in the lake. Marginal plants such as the bulrushes and coarse grasses encroach in a short time. As the habitat becomes more mesophytic shrubs such as Cornus stolonifera, Salix candida, and Salix cordata appear among the coarse herbaceous plants. The first trees which appear are Larix and Picea. Following this Larix Picea associes is the Populus-Betula associes. In this zone consocies of Betula papyrifera and of Populus tremuloides occur distinct from each other. The most important shrubs found growing with these trees are Cornus stolonifera and Rosa blanda. The herbs have become abundant. Among the most conspicuous are Ranunculus abortivus, Smilacina stellata, and Aster macrophyllus. As the habitat becomes drier the climax forest of beech and maple enters.

B. Xerosere.

(a). The lithosere - A succession which begins its development upon bare rock is called a lithosere. The first plants which gain a foothold are the lichens. Soon crevice vegetation consisting mostly of mosses (Cerotodon and Bryum), various grasses, and a few other plants among which is Solidago nemoralis, make their appearance. With the decay of the rock and the accumulation of plant remains the first soil is formed. This first soil is found usually in the crevices and giving rise to a more varied flora makes this part of the sere interesting.

Among these soil crevice plants are Potentilla arguta, Verbascum

Thapsus, Heuchera hispida, and Poa compressa. As the soil becomes deeper shrubs enter chief among which are the chokecherry (Prunus virginiana), ninebark (Physocarpus opulifolius), poison ivy (Rhus toxicodendron), sumach (Rhus typhina), and the wild crab (Pyrus coronaria). Encroaching upon the shrub vegetation are the xerophytic forest trees. Somewhat later as more mesophytic conditions prevail an oak-hickory forest becomes established. Seedlings of beech and maple thrive in the light oak forest and give rise to the climax deciduous forest.

(b). The psammosere - Another type of xerophytic habitat is that of the sand dune. The sere taking place upon such an area is a psammosere. Since all plants are not able to check the advance of a dune we find some migrating dunes which are still barren. Only those plants which can endure all extremes of cold, heat, and drought, and all degress of covering by the sand, are successful in dune capture. Commonly, the first plant to gain a foothold is Ammophila arundinacea. Other plants follow in quick succession. Some of these are Asclepias syriaca, Equisetum hyemale, and Calamagrostis longifolia. All of these plants are perennial herbs and have an extensive vegetative propagation and so make the capture of a dune a relatively rapid process. Annuals and biennials growing with these plants are of little value in dune capture. Before many years have passed shrubs and small trees find an entrance upon the dune and drive out the herbaceous vegetation. The most common species of shrubs are Cornus stolonifera, Salix syrticola, and Prunus virginiana. Commonly young Tilia Americana trees appear with these shrubs. Probably the only trees which aid extensively in dune formation are the cottonwoods. Seedlings of maple appear with the basswood and a deciduous, mesophytic, climax forest results.

2. Subsere.

In the areas where moraines have been left by the great continental glaciers the development of the climax mesophytic forests has been rapid. Because of this rapidity of development these forests are very old, and have existed so long that few traces of their history have been left behind. It is "where such mesophytic forests are disturbed" that "we may get some notion of what took place in the post-glacial centuries." Complete or nearly complete destruction of a cummunity results in secondary succession. "In secondary succession the conditions of the habitat are due to the reactions of the original vegetation."

A. Hydrosere.

The hydrosere develops the mesophytic climax forest from some initial stage of succession in a relatively short period. After the initial stage progress is similar to the hydrosere in a primary succession with the exception of the element of time. Stages are of shorter duration and smaller in number in the subsere.

B. Xerosere.

The clay bank secondary succession described by Cowles (4) is of xerophytic origin. This subsere begins on the clay banks of a drainage ditch. The succession is rapid; a series of plant cummunities leading to the climax forest. No pronounced lichen or moss stage is present but the first vegetation consists of xerophytic annual and perennial herbs. Xerophytic shrubs as the willow and poplar soon appear. As humus accumulates rapidly a mesophytic flora develops in which the dominant thicket species are the wild crab (Pyrus coronaria) and red haw (Crataegus sp.). These shrubs are the forerunners of an oak-hickory type of mesophytic forest. Seedlings of beech and maple grow in this forest and give rise to the climax

forest. When an oak-hickory forest is destroyed it returns in a comparatively short interval preceded only by the described thicket stages. If seeds and roots are left by the denuding agent succession is shown only in the herbs.

In summarizing the most prominent distinctions between the prisere and subsere the following may be given.

1. The stages of the prisere are usually of longer duration than are those of the subsere.

2. The prisere begins its life history with a pioneer stage. The subsere commences with a late initial or subpioneer stage.

3. The resulting condition of the areas in both seres is mesophytism.

III. Contrasting Areas.

1. Descriptive.

The first visit made to the region under consideration was on September 29, 1917. The luxuriance of the flora upon the wasteland portion was typically autumnal and especially noticeable. This abundance of color and bloom was in striking contrast to the aspect of the forest remnant which did not produce its vast numbers of fall flora until a week or more later. At the first glance one would say the dominant herbs were Chenopodium album in the wasteland and Solidago sp. in the woodland but it was necessary to plot out areas by the quadrat method in order to get a definite idea of the numbers of individuals and of species.

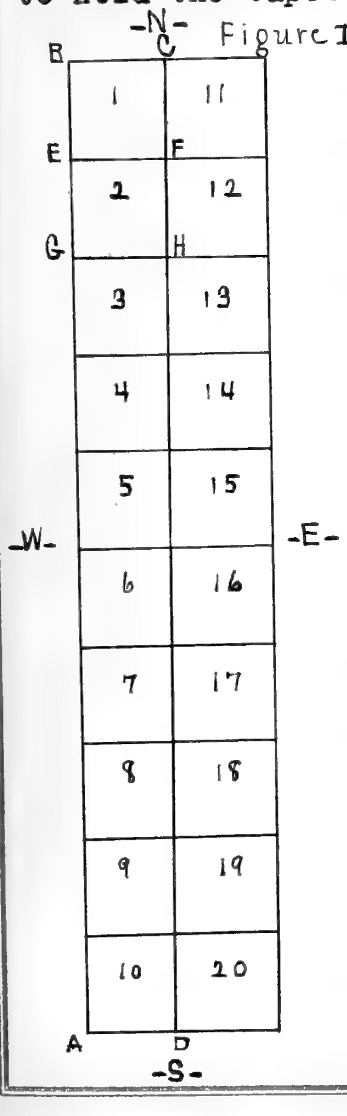
The quadrat is a square area of varying size marked off in the formation and is used to determine the minute structure of vegetation.

The method known as the chart quadrat method, in which the position of each plant is recorded upon a chart, was used. Since it was impossible to study the entire area with the same thoroughness fifteen representative quadrats were marked off. In this way the entire range of structure was ascertained.

In addition to the chart the list quadrat was used. By this method the number of individuals of each species is counted and listed upon the chart. In brief, a plant census was taken in the fifteen plotted squares.

The quadrats were marked off by means of steel tapes one hundred feet long. These tapes are divided into ten-foot intervals which are numbered from left to right. Steel tent-pegs were used to hold the tapes close to the ground.

Figure II.



Two tapes of the above length were used and the points A, B, C, and D (Fig.II) were marked by small permanent wooden stakes, the tapes extending between A and B, C and D. The distance between A and D, B and C is ten feet and was measured by ten foot steel tapes. E B C F, Quadrat 1 in Fig.II or Fig.III, is ten feet square. The quadrats are numbered from the northern end to the southern end. The square areas were carefully located so as to get a part of the woodland and a part of the wasteland into the plotted portion. Quadrats 1,2,3,11, 12,13 are in the wasteland, quadrats 4,5,6,14,15 are in a grassy plot while quadrats 7,8,9,10 are in the forest remnant. When the plants in the first quadrat had been counted, listed on the chart, (Fig.III) and classified whenever possible

Figure III

North

West

1	P-n AR-6 AM-m EU-9 Cy-1 CA-10 L-3 A-SE 9 11 B-10 D-5 OB-40 E-m	A-30 OB-n E-12 B-15 SC-6 AV-7 D-4 F-/-1 PC-SE P-4 EH-SE	11
2	[illegible]A-10 OB-18 A[illegible]-n A-[illegible] D-[illegible] ER-m SC-10 H-1 S[illegible]-n AV-n	AE-20 OB-n S[illegible]-3 GR-n AM-3 CA-5 E-4 SC-8 F-/-[illegible] P-12 B-n AV-6 EX1	12
3	P-17 UX-1 U-X-2 [illegible]X- CI-5 AM-9 AE-3 D-6 OB-n E-9 B-7 GR-n CA-8 TC-m	L-[illegible] P-5 CI-1 B-1 OB-6 A-1 N-3 AV-4 GR-5 AM-2 F-/-3 [illegible]-1 Hy-SE	13
4	P-[illegible] L-6 OE-2 AV-9 [illegible]-4 U-/-1 SV-4	FX-1 CRX-1 CR-/-2 AV-2 AM-1 F-/-1 P-1 C-/-2 P[illegible]-n [illegible]-4 TO-3 Hy-SE	14
5	U/-1 A-4 AM-[illegible] AE-5 P-n CA-3 A[illegible]-10 D-6 L-5 SC-3 LV-2 CR-/- PC-n EH-9	CR-/-5 CR-n O-1 AE-4 SA-1	15
6	SA-2 P[illegible]-[illegible] SC-1 AA-5 F-/-- [illegible]		16
7	SA-1 S9-2 CA-8 CR-/-		17
8	AD-/1 SA-[illegible] AD-/-1 CA-12 F/-1		18
9	SA-n AD-/1 ADX2 AA-5 Hy-1 EC-3 SR-2		19
10	SA-n Q-3 F-1 AE-5 O-6 V-7 F-/-1 GR-9 CA-1		20

South.

LV. Lepidium virginicum.

CR	Crataegus sp.
EU	Euphorbia sp.
T	Tilia americana.
FA	Fraximus americana
TO	Taraxacum officinale
I	Iris sp.
AS	Acer saccharum
OB	Oenothera biennis
[illegible]	grasses.
SE	[illegible]
QA	Quercus alba.
G	Gleditsia triacanthos
EH	Echinochloa crusgalli
[illegible]	Setaria glauca
AG	Agrimonia microcarpa.
CI	Cirsium altissimum.
Hy	Hy[illegible]phyllum sp.

East

P	Polygonum Persicaria.
[illegible]	[illegible]
[illegible]	[illegible]
/	tree
X	Shr[illegible]
-/-	seedling
S	scarce
U	Ulmus Americana
Q	Quercus rubra
L	Lactuca scariola
B	Bidens Aristosa
A	Ambrosia trifida.
V	Vinca minor.
SR	Smilax rotundifolia
O	Oxalis stricta
N	Selena Nigra
AR	Amaranthus retroflexus
F	Fraxinus pennsylvanica lanceolata
E	Eupatorium serotinum
SO	Sida spinosa.
SA	Solidago rugoso, hispida, and ulmifolia
H	Helenium autumnale.
EC	Elymus canadensis
AE	Aster ericoides.
D	Aster depauperatus
PC	Panicum capillare
CO	Carya ovata.
AA	Aster [illegible]s
V[illegible]	Verbena urticaefolia
LS	Lobelia siphilitica
[illegible]	Prunella vulgaris
P[illegible]	Plantago lanceolata.
CV	Cynoglossum officinale.
SC	Solanum Carolinense.
ER	Er[illegible]
AM	[illegible]a [illegible]folia
CA	Chenopodium album.
[illegible]	Cornus stolonifera.
A[illegible]	Acalypha virginica.

[illegible]

[illegible]

the cross tape was moved to the position G H and this new quadrat was studied. This process was repeated until all of the quadrats were finished. The legend on the chart giving the list of abbreviations and species serves as a key to the chart.

B. The autumnal vegetation.

(a). The forest remnant - As has already been stated the climax formation of the region is the beech-maple or the maple-basswood deciduous forest. The forest remnant portion of the area studied is an association because the climax stage has become established. A number of layers appear in the association. There is the tree, the shrub, the herbaceous, the smaller vegetation, and the subterranean layers. Quadrats 7, 8, 9, and 10 as shown in Fig. III give the species and number of individuals found in a representative part of this deciduous forest remnant.

In the tree layer the dominant species are easily seen to be maple and basswood. American elm (Ulmus americana) red oak (Quercus rubra), white oak (Quercus alba), green ash (Fraxinus pennsylvanica var. lanceolata), hawthorne (Crataegus sp.) and hickory (Carya ovata) make up the important secondary species. There is a number of oak trees in the area, the examples of red oak nearly equaling in number those of white oak.

No distinctly pronounced shrub layer exists but seedlings of some of the forest trees are present in large numbers, especially of Crataegus, ash, and hard maple.

The three species of Solidago gave a definite aspect to one entire portion of the woods since they were the dominant plants of the herbaceous layer and formed what may be called a society of Solidago with secondary species such as Chenopodium album, Viola blanda, Oxalis stricta, Vinca minor, and various grasses (Panicum capillare, Echinochloa crusgalli, etc.).

Aster ericoides, Aster depauperatus, and Aster azureus formed another society which claimed the same secondary species as were found in the Solidago society.

(b). The adjoining wasteland - This area was rich in numbers of individuals as shown by the quadrat study. The wasteland was in the process of development. The ground had lain idle for a year or more. The time required for this portion to reach the climax stage will be short since the changes in the progress of a secondary bare area are quite rapid. The denuding agent in this area had been a biotic agency or man with his plow and a desire for new corn fields.

The shrub layer was just beginning to make its appearance in the form of a few seedlings of Crataegus, Fraxinus, Cornus, Ribes, and Gleditsia.

The herbaceous layer was represented by a goodly number of species and individuals quite making up in numbers the loss in other layers. The plants may be listed according to order of abundance as follows:

Polygonum Persicaria
Oenothera biennis
Aster ericoides
Bidens aristosa
Ambrosia artemisiifolia
Ambrosia trifida
Amaranthus retroflexus
Solanum carolinense
Chenopodium album
Eupatorium serotinum
Lactuca scariola
Aster depauperatus
Panicum capillare
Echinochloa crusgalli

Erigeron ramosus

Euphorbia sp.

Oxalis stricta

Cirsium altisimum

Potentilla monspeliensis

Viola blanda

Lepidium virginicum

Prunella vulgaris

Hydrophyllum appendiculatum

The lower layer was very meager in representatives in both portions of the region. Mosses, the bird's nest fungus (Crucibulum vulgare), and the alga, (Pleurococcus) were the only forms that were found. The Pleurococcus was found on the north sides of the maple tree trunks.

C. The prevernal vegetation.

The first spring visit was made on April 22, 1918. No attempt was made to plot out the area into quadrats since the many individuals which were present represented but a very few species.

The aspect was that of early spring. The forest trees were yet dormant, the bud scales of the dogwood and hawthorne were just beginning to burst open, and the ground was softly carpeted with the leaves and flowers of Erythronium albidum, the dog's-tooth violet. Among the spotted leaves of this dog's-tooth violet society were sprinkled the stars of the spring, the cheerful spring beauties (Claytonia virginica). In fact it was hard to determine which was more dominant, the spring beauty or the dog's-tooth violet since both were so plentiful.

Besides the spring beauty and the dog's-tooth violet there were found in the forest and grassland the following:

Dicentra canadensis

Dicentra cucullaria

Dentaria laciniata

Podophyllum peltatum

Hydrophyllum virginianum

Cystopteris fragillis

All of these plants are those of a sunny forest. There were no leaves out yet and so no shade produced to prevent rapid growth of these early spring flowers.

The aspect of the wasteland was quite different; that of a barren, open area in winter. The stout, dead stalks of the coarse ruderal weeds were still present and there were only here and there bunches of green where the rosettes of Bidens aristosa, Cynoglossum officinale, and Oenothera biennis had begun to show signs of life. Several coarse grasses were becoming active and a few buttercups (Ranunculus micranthus) were in bloom.

On April 29, the woods presented rather a gloomy appearance. The air was cold and sharp. The leaves of Erythronium albidum still persisted but the flowers had disappeared. The spring beauty and pepper-root were still blooming in large numbers. Both species of Dicentra had finished blooming leaving only the leaves and fruits. The Hydrophyllum was rapidly becoming more evident. The ground in some places was covered with the young fronds of Cystopteris fragillis. The wasteland was yet desolate but in the woodland many plants were coming into bloom among which were the following:

Crataegus mollis.

Ribes floridum

Staphylea trifolia

Pastinaca sativa

Ellisia nyctelea

Floerkea proserpinacoides

Phlox divaricata

The above named are those which were not found in bloom on the first trip.

Several warm rains and a heavy flood of sunshine had caused the trees to come into leaf by May 8. The species of Pyrus and Crataegus were in full bloom. Around the pretty and fragrant blossoms of the Pyrus buzzed a large yellow-backed bumblebee busy in his task of collecting honey and pollinating the flowers.

The grass in the forest was long and green and the leaves of the dog's-tooth violet were dying away. The two species of Hydrophyllum had spread rapidly to a larger area and the fern and false mermaid controlled the aspect in some parts of the forest. One of the bedstraws (Gallium triflorum) was developing numbers of individuals rapidly. Sweet Williams, violets, and spring beauties still persisted and the buttercups had increased in numbers. The dogwood and gooseberry bushes were just coming into bloom. The wasteland had become quite clothed with a cover of sweet clover and the rosettes and coarse grasses were thriving well.

The spring vegetation is the reverse of the autumnal vegetation in this area. In the late summer and fall when the shade of the forest had prevented extensive growth in the herbaceous layer we find more herbs in the open wasteland. Upon this area in the spring while the forest, which is not yet shaded, has a greater abundance of temporary species, the fragile, early spring, wild flowers, the wasteland has only a few old coarse stalks of the preceding year. A little later however rosettes, coarse grasses, and weeds make their appearance. In the summer when the ruderal vegetation has once more

become established in the wasteland the number and kinds of individuals will probably far exceed those to be found in the forest portion of the area.

2. Experimental

The evaporation data given in table I was obtained by the use of Livingston's standardized cylindrical porous cup atmometers. Soil thermometers were used in making the record of table II. In all of the experiments representative situations in the habitats were chosen.

The leaf sections were taken from the various trees, preserved in formalin, embedded in paraffin, cut, and mounted in balsam in the usual way. All drawings of the cross sections of the leaves and of stomata were drawn with camera lucida and are enlarged 720 diameters.

Table I.

A. Evaporation.

Date	Atmometer	Reading in Woodland	Reading in Grassland	Reading in Weedland
Nov.10	7-443	3.55cc		
	7-449	4.97cc		
	7-436		4.97cc	
	7-448			7.10cc
	7-450			6.745cc
Nov.17	7-443	6.035cc		
	7-449	5.68cc		
	7-436		3.195cc	4.26cc
	7-408		2.84cc	3.55cc
	7-448			
	7-450			
	Average	5.053cc	3.66cc	5.41cc

Two porous cups were placed in the woodland, two in the grassland, and two in the weedland at the same time. All were placed on the ground and allowed to operate for three hours prior to each observation.

Table II.

B. Temperature of the soil.

Date	Reading in Woodland	Reading in Weedland
Oct. 6	51.5°	59.8°
Oct. 9	51.5°	50.0°
Nov.10	51.9°	50.5°
Nov.17	62.0°	49.5°
Average	54.475°	52.45°

One thermometer was placed in the woodland, the other was placed in the wasteland. They were left in the soil for three hours before each reading was made.

IV. Discussion.

1. Prisere stages.

In nearly every portion of Illinois where the land has not been disturbed by human agencies the vegetation dates back to the disappearance of the last ice sheet. The descriptive part of this paper traces the normal life histories of priseres and subseres beginning in both wet and dry habitats. It is to be supposed since the part of the country under consideration lay in the path of the glacier, that the climax stage of this prisere has been brought about in the usual way and that the area studied has passed through the usual number of stages. The presence of the oak and hickory in the beech-maple forest gives a clew to the dominant species of that stage which came before the climax. We have seen also from the description the steps of progression through the seral units to the final climax characterized by the beech and maple as dominant trees. In all instances in which the dominant trees were these two species the secondary species included specimens of oaks, hickory, elm, ash, hawthorne, and dogwood. These are the characteristic secondary species found in beech-maple forests. The region studied is like the prisere described except in the paucity of individuals and of species in the herbaceous layer. The only abundant plant in this layer was the goldenrod. This scarcity was due in all probability to disturbing factors. The presence of the dominant trees shows that the region has reached the extreme mesophytic condition since these species never make their appearance until this has occurred. The presence of oak and hickory as secondary species further proves the existence of the climax stage of development.

2. Subsere stages.

When the normal life history of a sere is disturbed by man de-

siring further extension of land for cultivation the vegetation suffers. This is what happened in the wasteland area some time in the past. The plants were destroyed but evidently the seeds of some had been so numerous as to allow many to remain in the ground after the great disturbance. When the field was allowed to lie idle these seeds which were present in the soil germinated and the ruderal vegetation described in a previous section became established quickly. It is true that not all of the plants were brought in, in this way. In some instances roots or rootstalks escaped the plough and in others, perhaps, birds, furbearing animals, and the wind may have assisted in the migration of the plants. This is especially true of those species which produce numerous light indigestible seeds or burs.

The plants found in this portion of the area are those which produce numerous seeds and which grow rapidly. For the most part, if not in all instances, they are either annuals or biennials. These coarse weeds are able to endure the extremes of sun, the higher evaporation rates of the open wasteland and are typical of any early seral stage of a subsere.

Since this is a subsere this seral stage will hardly be of long duration and the plants have, no doubt, become more quickly established than they would have in a similar stage of a prisere. This is because of the incomplete destruction of all plant parts of the previous generation and the possible presence of seeds.

An example of this kind in which the stage of the subsere is so totally unlike the climax in its general appearance, structure, and kinds of individuals which it supports makes it easy to decide which is the climax type of vegetation and which is the seral type. In the later stages of the sere however, when the oak-hickory forest has become established differences are so slight that it is harder to

distinguish between the seral forest and the climax forest. The conditions of mesophytism in this instance are relatively the same, the rates of evaporation similar, the individuals of the herbaceous and thicket layers are practically alike, and the only sure way of determining would be to find out the dominant trees.

In the region studied the chief distinction between the two portions of the area is shown in the kinds of plants characteristic in each. Had the two types of vegetation been more widely separated in time the contrast would have been more marked and would have been shown in more ways. More extensive areas separated in space would likewise show more differences.

3. Experimental data.

A. Evaporation.

In all experiments upon evaporation in deciduous forests and in open regions the results are comparatively the same, that is, the rate of evaporation is always greater in the open than it is in the forest. The shade produced by the forest trees tends to decrease the rate of evaporation in this type of vegetation. In the open where the sun's rays may pour unchecked upon the surface of the ground, the high rate of water loss is sustained. It is obvious that in a dense forest the shade is greater and the rate, therefore, is correspondingly decreased.

In the seral stage and the climax stage studied the rate of evaporation was measured as previously described. The record is not a sufficiently complete one. This much, however, may be drawn from the comparison of the readings in the habitats. It was found that the average rate of evaporation during the three hours interval in the woodland was 5.05cc. while it was somewhat higher in the wasteland being 5.41cc. for the same length of time. This slight amount

of contrast shown in these readings agrees favorably with data of earlier workers. The highest rate of evaporation is always found in the open region.

The more extreme condition is found in the developmental stage. If even a slight difference occurs in two such closely related seres, how much greater would be the contrast between the prisere and subsere which are widely separated. The difference would indeed be greater but varying in the direction in which it varies in these areas considered.

B. Soil temperature.

The soil temperature is not such an important factor here in distinguishing between the seral and climax vegetation. It is significant in this respect. The soil of an open area being subjected to many cold blasts in the late fall cools off more rapidly than does the protected ground of the dense forest. There is a time when the temperatures of the two habitats will be equally cold. In the spring however, the absence of leaves from the forest trees makes the temperature of the soil in the forest similar to that of the wasteland. The absence of shade, the presence of humus and protective leaf covering makes the forest an excellent place for the abundant growth of the prevernal vegetation. This is interesting principally because of its influence upon the order of appearance and disappearance of the plants of the herbaceous layer. The soil measurements were too small in number to offer much satisfactory data. As may be seen, however, from the table the slight variation which does occur in the measurements in the two seres serves to substantiate the above statements. The lowest temperature was found in the wasteland. This shows that the ground was cooling off faster there than it was in the forest. In a denser forest the contrast would have

been greater. If measurements had been continued the time would have come when the soil temperatures of the two areas would be equally cold.

C. Leaf structure.

The cross sections of the leaves were made in the usual way. All of the sections showed the mesophytic type of structure. In all the palisade tissue was about equal in amount to the spongy parenchyma. The conditions of the subsere were not sufficiently extreme to cause the leaves of the representative plants to depart toward either the xerophytic or hydrophytic type of leaf. In the forest trees the leaf showed a fairly thick upper and lower cuticle. The leaves of some of the plants in the subsere showed only a thin upper and lower cuticle, others had only an upper cuticle, and still others had no cuticle at all.

A late seral stage such as this wasteland, has become mesophytic enough to make the examination of leaf sections of little value in determining the contrast between it and a climax forest. If the forest and wasteland had been more widely separated and subjected to different environment and physical factors there might have been a difference in leaf structure, although even that is not probable.

V. Summary.

1. The earlier stages of a subsere are easily distinguishable from the climax stage of a prisere.

2. The main contrast between the subsere and prisere studied was found in the kinds of plants, their character, and relative abundance of individuals. In autumn the individuals are more abundant in the wasteland. In early spring they are more abundant in the forest.

3. Differences between seres which are close together in space and time become very slight and are hardly discernible.

4. The relative rates of evaporation are higher in wasteland than in forest vegetation regions. In the fall the ground in the wasteland cools off more rapidly and has a lower temperature than the ground in the forest.

5. When the habitat of the seral stage of a subsere has become nearly as mesophytic as that of the climax, little difference can be ascertained from a microscopic study of the leaf since both produce mesophytic types.

6. A seral stage of a subsere which lies in close proximity to a climax stage of a prisere may appear very much different from the latter. This difference is shown in the kinds of plants, the numbers of plants, and physical factors. They may both have become so much alike as to the mesophytic character of the habitat that the leaf structure will be similar.

In conclusion grateful acknowledgment is made to Dr. W. B. McDougall under whose kind and patient guidance this work has been accomplished.

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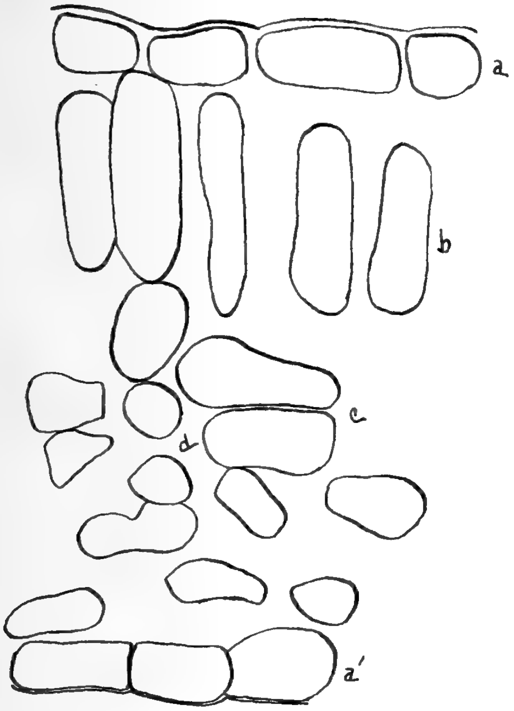
Plate I.

A



B.

C

Quercus alba.

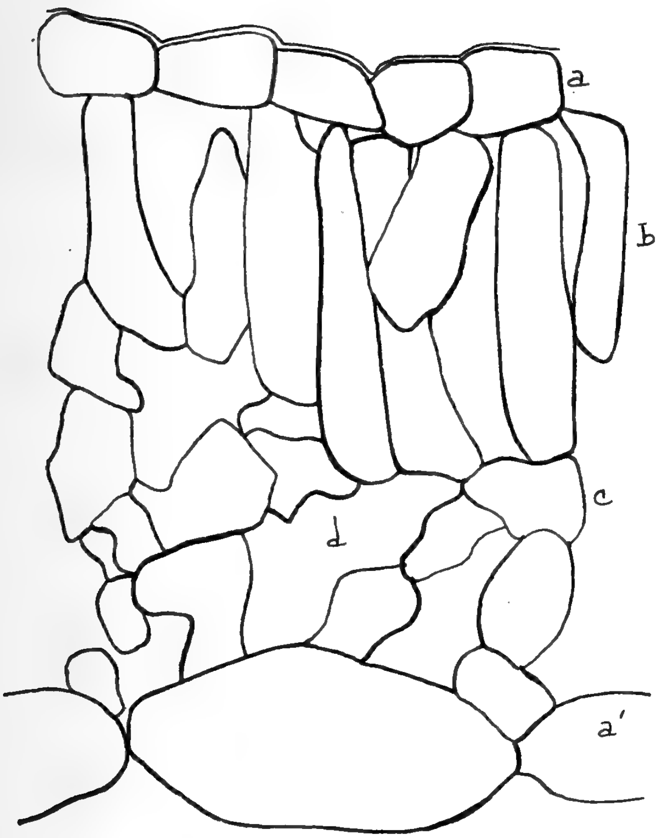
A. Cross section of leaf.
- a. Upper epidermis.
- a'. Lower epidermis.
- b. Palisade cells.
- c. Spongy parenchyma.
- d. Intercellular space.

B. Stoma.

C. A Leaf.

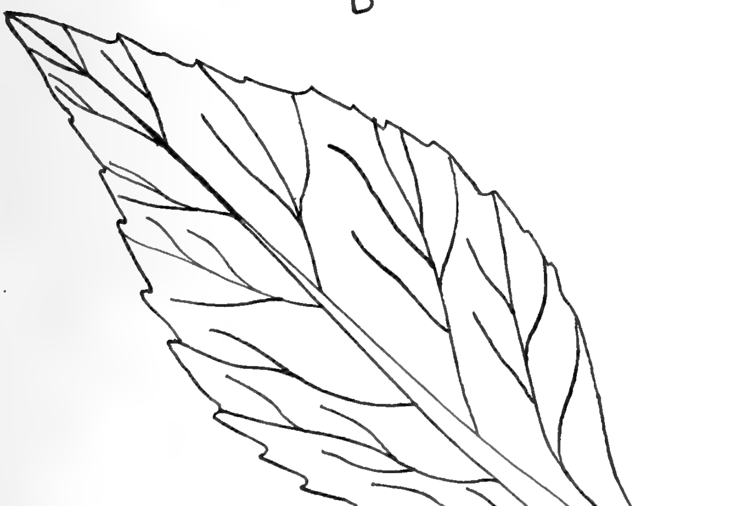
Plate II.

A



C

B



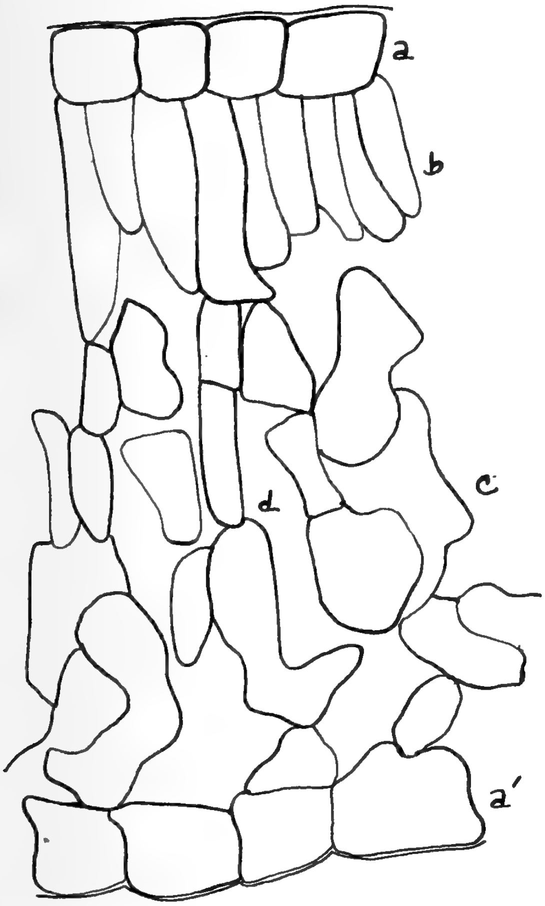
Oenothera biennis.

A. Cross section of leaf
- a. Upper epidermis.
- a. Lower epidermis.
- b. Palisade cells.
- c. Spongy parenchyma.
- d. Intercellular space

B. A leaf

C. Stoma.

A



B

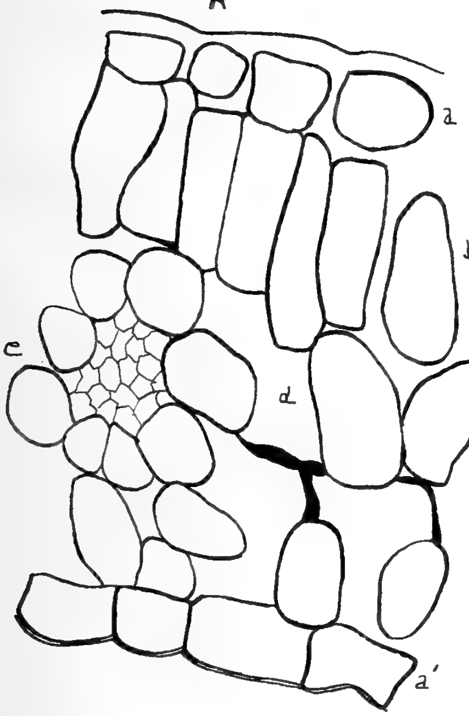
A. Cross section of leaf
- a. Upper epidermis
- a'. Lower epidermis.
- b. Palisade cells
- c. Spongy parenchyma
- d. Intercellular space

B. Stoma.

Carya ovata.

Plate IV.

A



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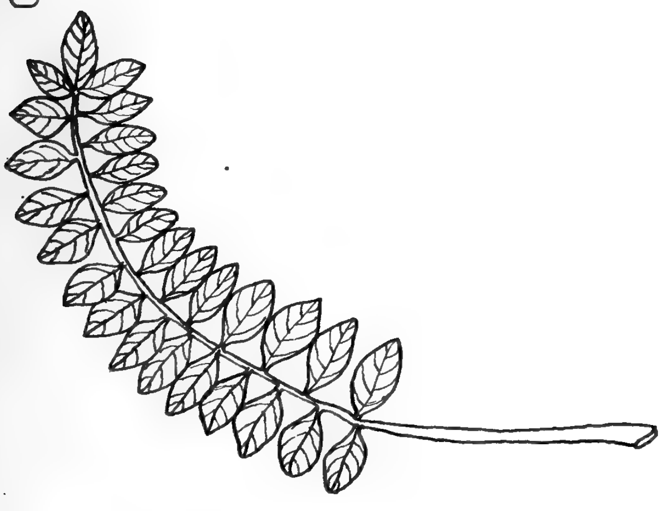


Gleditsia triacanthos.

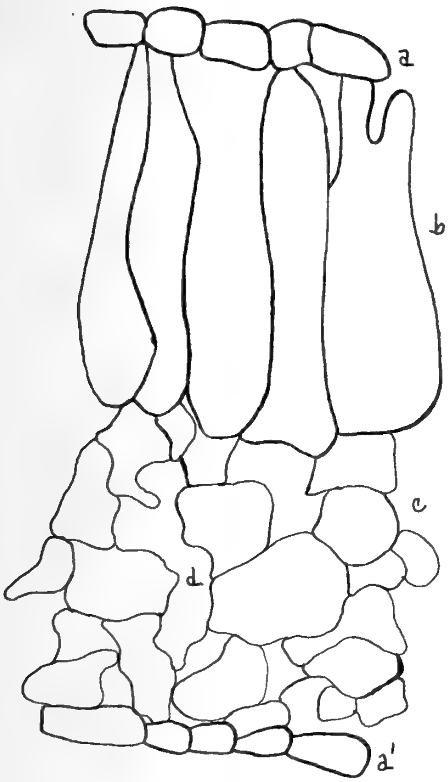
A. Cross section of leaf
- a. Upper epidermis
- a'. Lower epidermis.
- b. Palisade cells.
- c. Spongy parenchyma
- d. Intercellular space
- e. A vein.

B. Stoma.

C. A Leaf.

Plate V.

A



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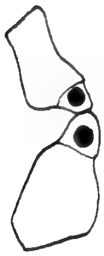


C

Bidens aristosa.

A. Cross section of leaf

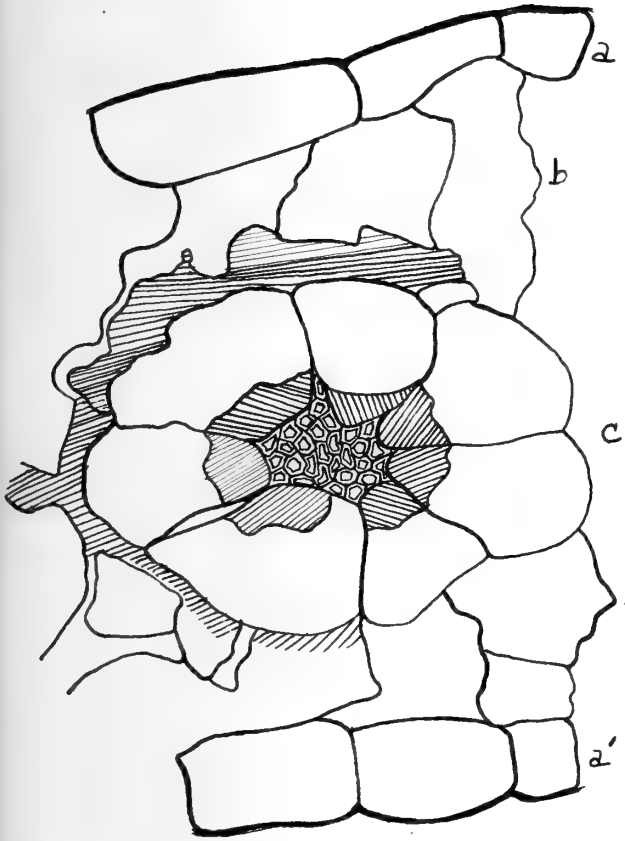
a. Upper epidermis.
a'. Lower epidermis.
b. Palisade cells.
c. Spongy parenchyma.
d. Intercellular space.

B. Stoma

C. A Leaf.

Plate VI.

A



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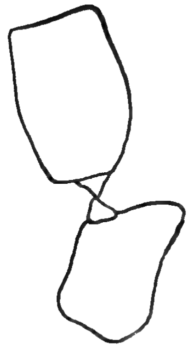


A. Cross section of leaf

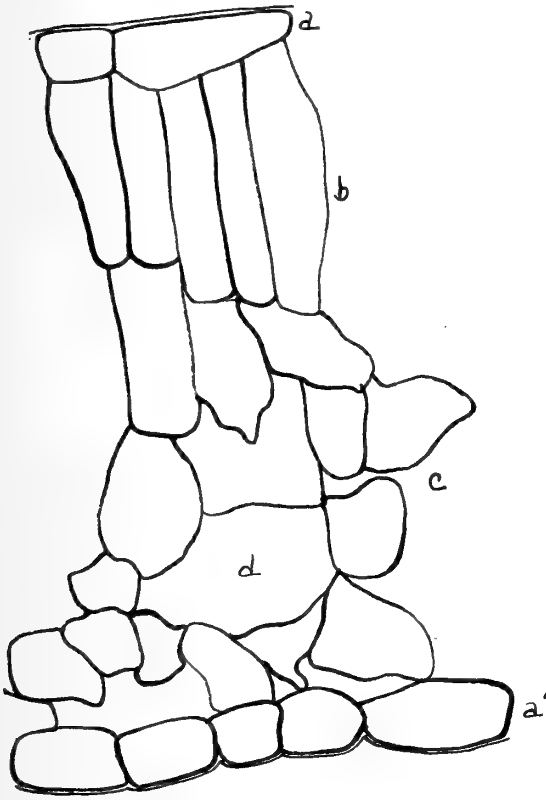
a. Upper epidermis.
a'. Lower epidermis.
b. Spongy parenchyma
d. Spongy parenchyma
c. Vein.

B. Stoma.

Euphorbia sp.

Plate VII.

A



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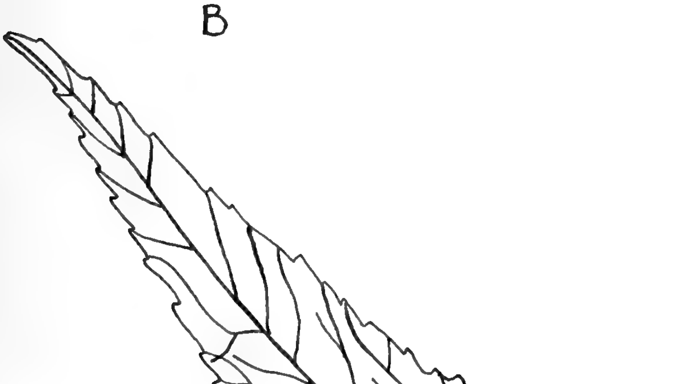


Eupatorium serotinum.

A. Cross section of leaf.

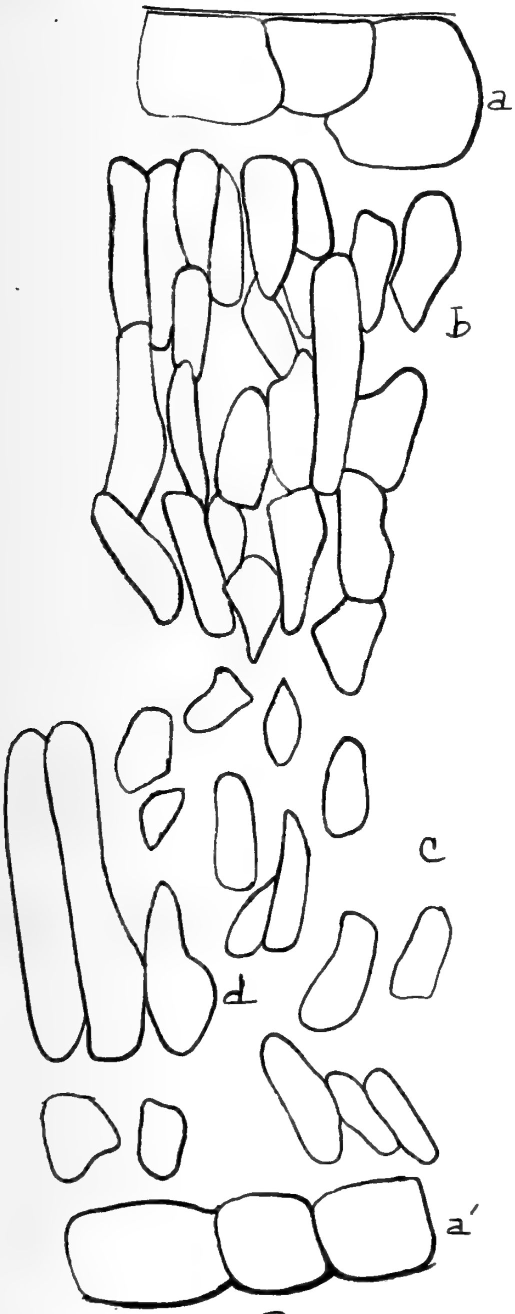
- a. Upper epidermis.
- a′. Lower epidermis.
- b. Palisade cells.
- c. Spongy parenchyma.
- d. Intercellular space.

B. A leaf.

C. Stoma.

Plate VIII.

A



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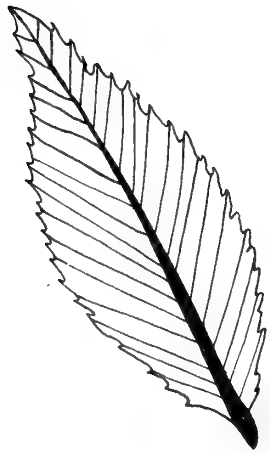


Ulmus americana.

A. Cross section of leaf

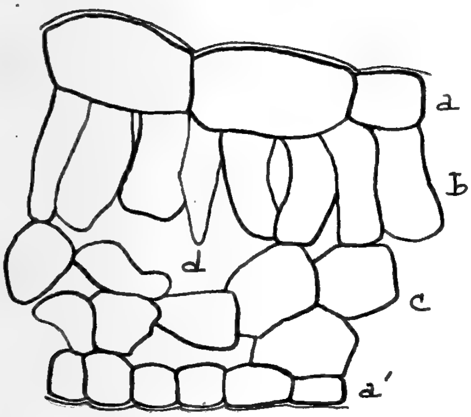
a. Upper epidermis.
a'. Lower epidermis.
b. Palisade cells.
c. Spongy parenchyma
d. Intercellular space.

B. Stoma.

C. A leaf (1/3 natural size)

Plate IX.

A



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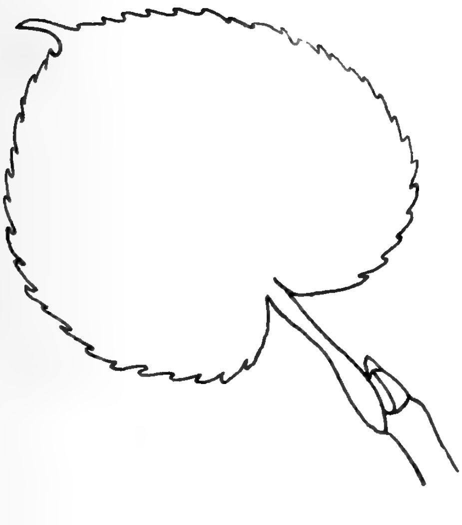


Tilia americana.

A. Cross section of leaf

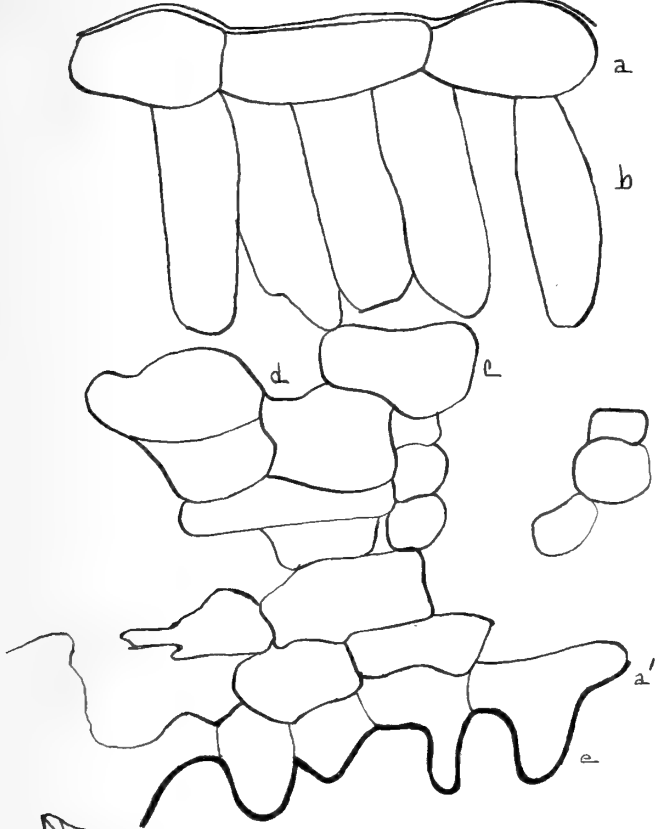
a. Upper epidermis
a'. Lower epidermis.
c. Spongy parenchyma.
b. Palisade cells.
d. Intercellular space.

B. Stoma.

C. A Leaf (1/10 natural size)

Plate V.

A



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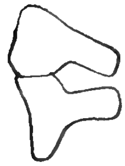

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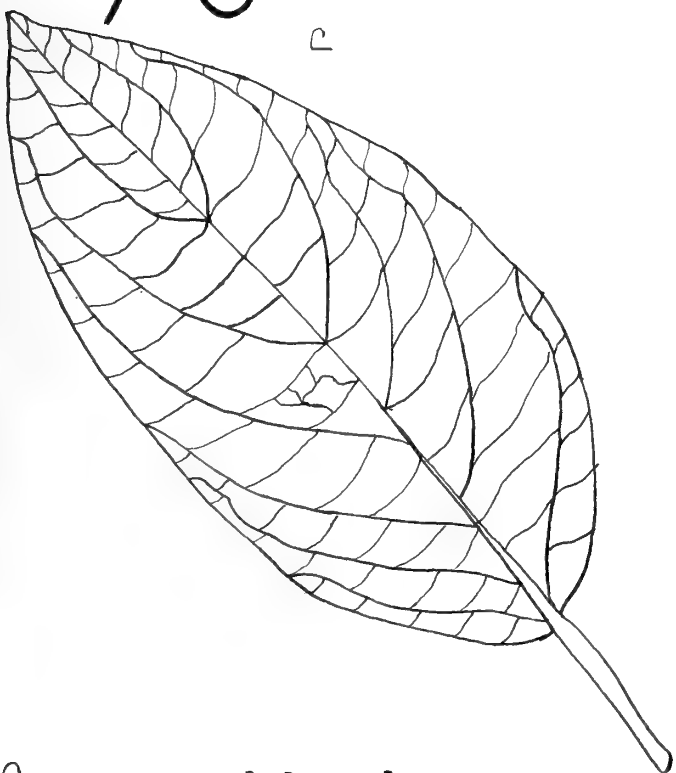


Cornus stolonifera

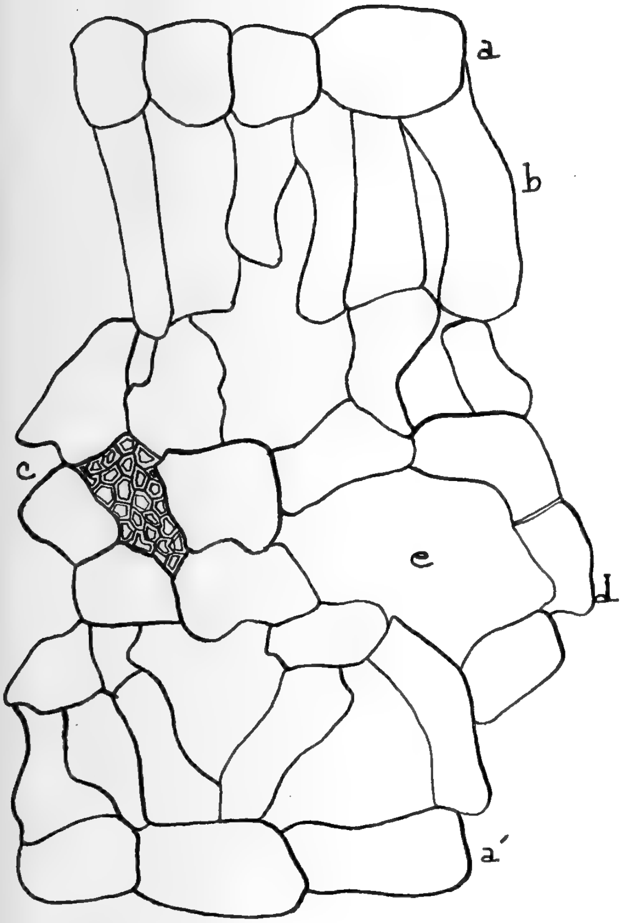
A. Cross section of leaf.
a. Upper epidermis.
a'. Lower epidermis.
b. Palisade cells.
c. Spongy parenchyma.
d. Intercellular space
e. Hairs.

B. Stoma.

C. A Leaf.

Plate XI.

A



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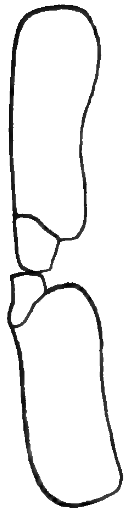

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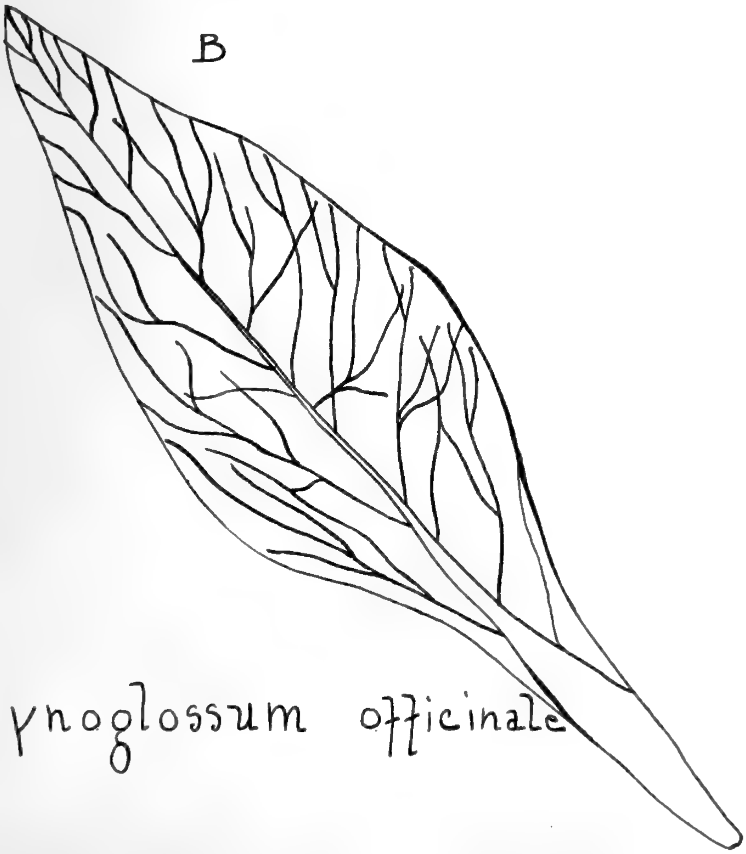


Cynoglossum officinale

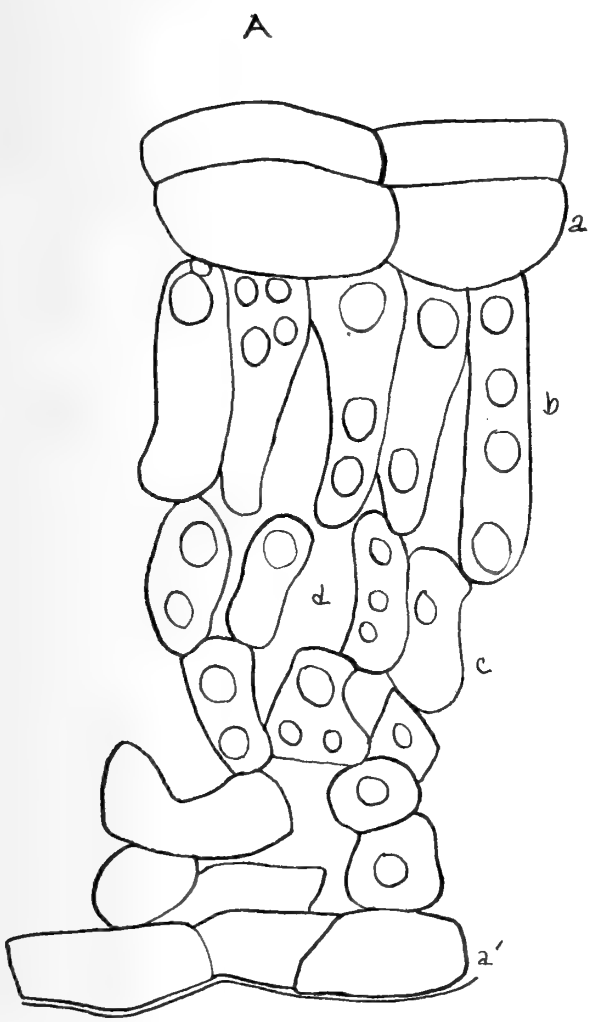
A. Cross section of leaf

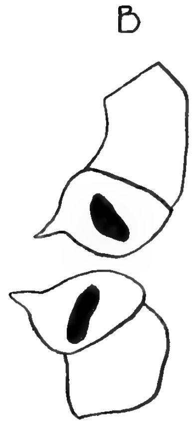
a. Upper epidermis.
a′. Lower epidermis.
b. Palisade cells.
c. Vein.
d. Spongy parenchyma.
e. Intercellular space.

B. A leaf.

C. Stoma.

Plate XII.





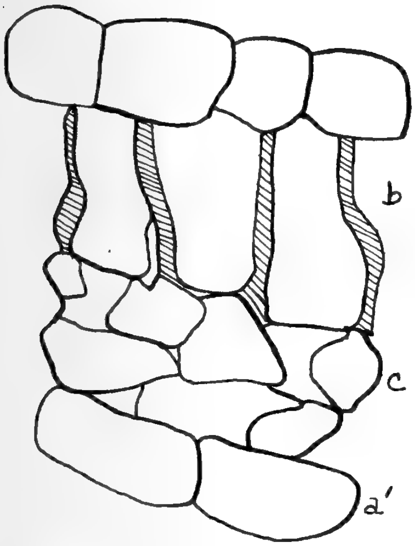
A. Cross section of leaf
a. Upper epidermis
a'. Lower epidermis.
c. Spongy parenchyma.
b. Palisade cells
d. Intercellular space.

B. Stoma.

Ribes floridum.

Plate XIII.

A



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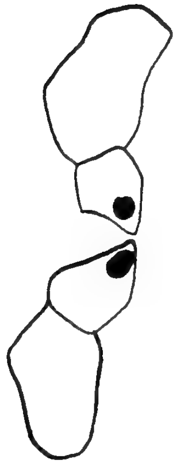


Sida spinosa.

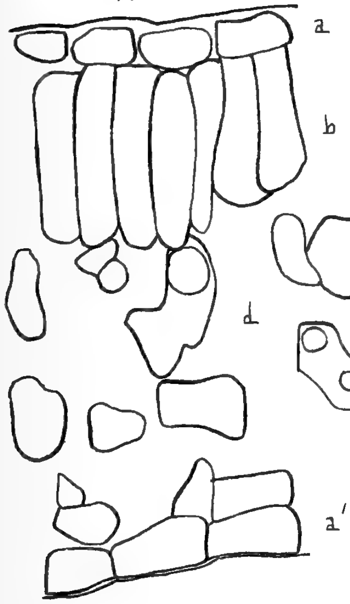
A. Cross section of leaf

a. Upper epidermis.
a'. Lower epidermis.
b. Palisade cells.
c. Spongy parenchyma

B. Stoma.

Plate XIV.

A



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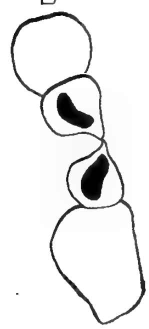

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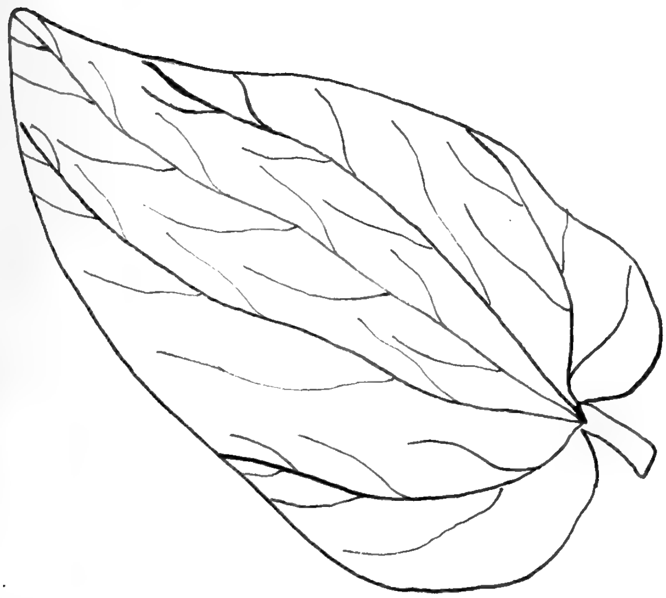


Smilax rotundifolia

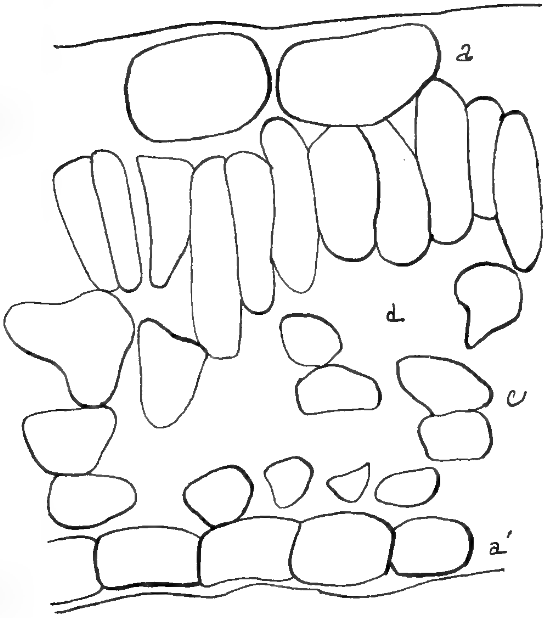
A. Cross section of leaf
a. Upper epidermis.
a'. Lower epidermis.
b. Palisade cells.
c. Spongy parenchyma.
d. Intercellular space.

B. Stoma.

C. A Leaf.

Plate XV.

A



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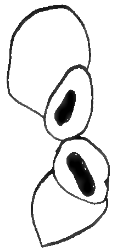

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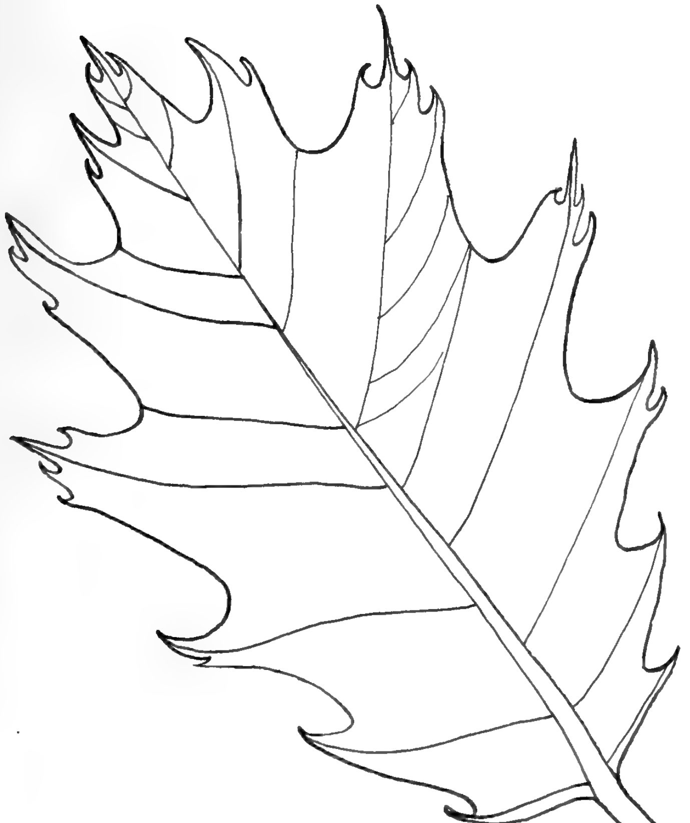


Quercus rubra.

A. Cross section of leaf

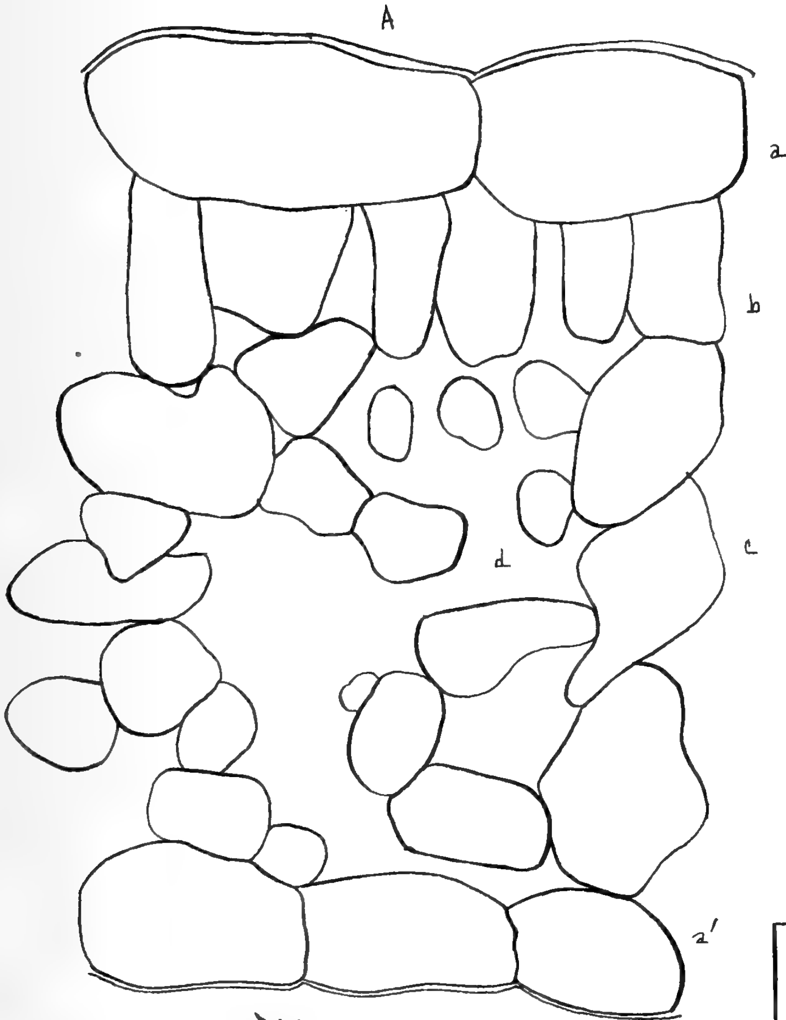
a. Upper epidermis.
a'. Lower epidermis.
b. Palisade cells
c. Spongy parenchyma.
d. Intercellular space

B. Stoma.

C. A Leaf.

Plate XVI.

A



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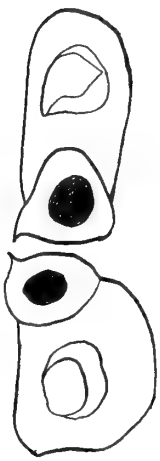
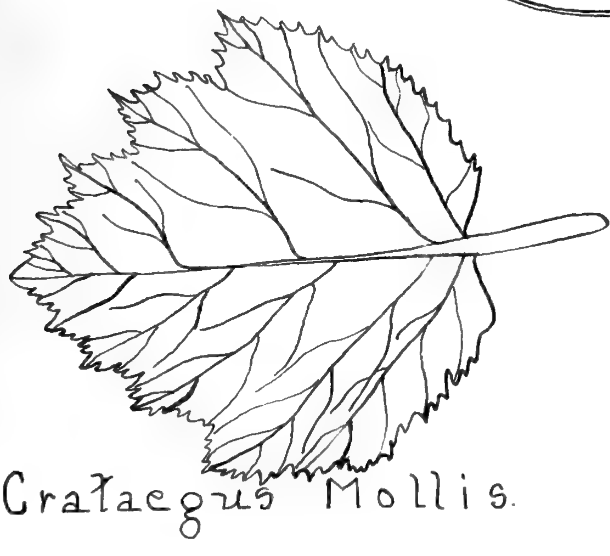




Crataegus Mollis.

A. Cross section of leaf.

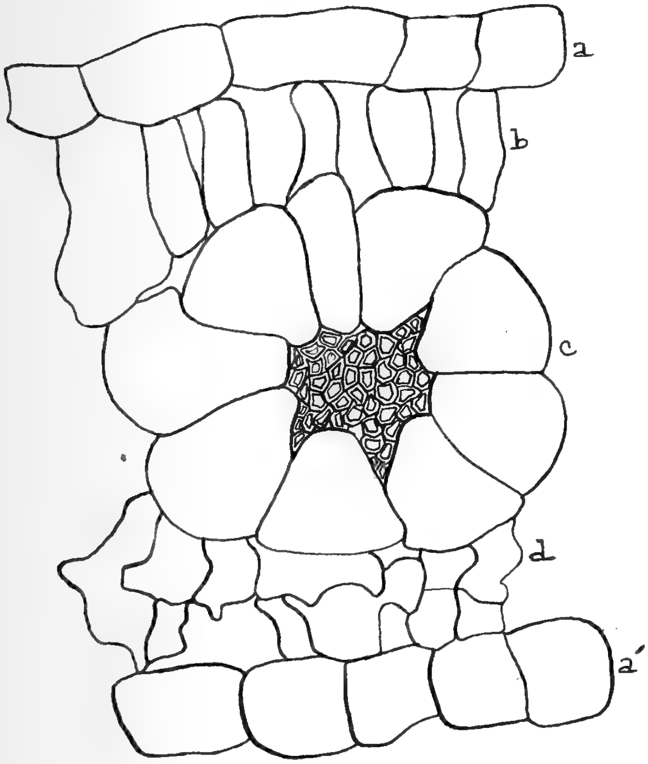
a. Upper epidermis.
a′. Lower epidermis.
b. Palisade cells.
c. Spongy parenchyma.
d. Intercellular space.

B. Stoma.

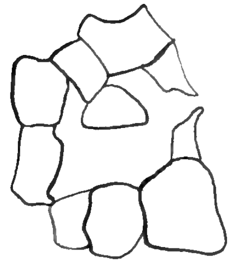
C. A Leaf.

Plate XVII.

A



C



B

Amaranthus retroflexus.

A. Cross section of leaf

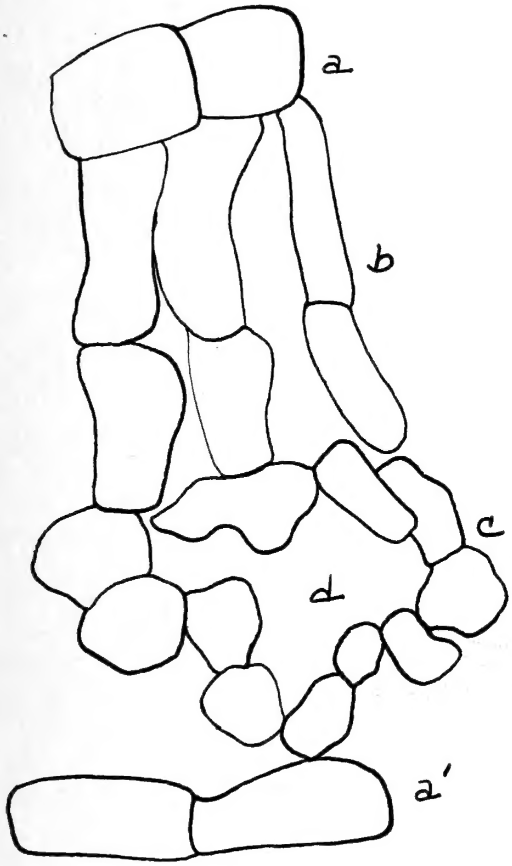
a. Upper epidermis.
a'. Lower epidermis.
b. Palisade cells.
c. Vein.
d. Spongy parenchyma.

B. A leaf.

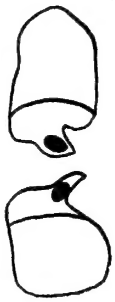
C. Stoma.

Plate XVIII.

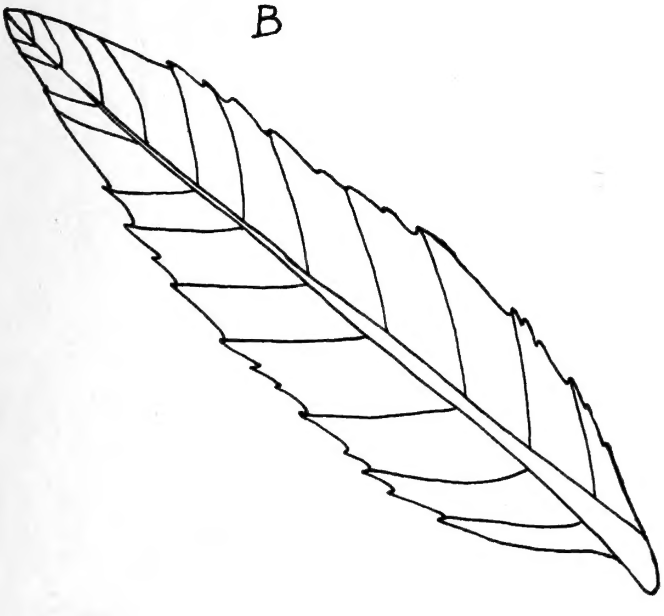
A



C



B



Polygonum persicaria

A. Cross section of leaf
- a. Upper epidermis.
- a'. Lower epidermis.
- b. Palisade cells.
- c. Spongy parenchyma.
- d. Intercellular space.

B. A leaf.

C. Stoma.