LEAF-VARIATION IN LIQUIDAMBAR STYRACIFLUA L.

THEO. HOLM

(Plates 200 and 201)

ENDLICHER was the first author to remove the genera *Liquidambar* and *Altingia* from the *Hamamelideae*, referring these genera to a family of their own: *Balsamifluae* "*Juliflorae* cohors II apetalae," between *Platanaceae* and *Salicineae*. This view became supported by Van Tieghem,[1] who pointed out the important fact that these two genera possess a system of resin-ducts traversing the primary leptome of the roots and the primary hadrome of the stems and leaves. In this manner the two genera actually combine the root-structure of the *Anacardiaceae* with the stem- and leaf-structure of the *Dipterocarpeae*. By Van Tieghem they were referred to a new family: *Liquidambareae*, between *Dipterocarpeae* and *Simarubeae*.

With regard to *Liquidambar*, our native species *L. Styraciflua* L. shows a remarkable variation in the leaf-shape, which is not mentioned in the botanical manuals, and which is very characteristic of the species. The leaves are by Bentham and Hooker described as "palmati lobata," and by Gray as: "rounded, deeply 5–7 lobed, glandular-serrate, the lobes pointed." None of these terms, however, give us the characteristic shape of the leaf, when compared with similar palmately lobed forms, and the term proposed by Linné: "foliis palmato-angulatis" is much more expressive.

We have in *Liquidambar* a variation corresponding with that of *Liriodendron*,[2] when we compare the foliage of the seedlings with that of the mature tree, and also, to some extent, when we compare the leaves according to their position on the branches. One character remains constant in *Liquidambar*, however, the margin being always serrate. The typical shape of the leaf (FIG. 9) is five-lobed, the two basal lobes forming an angle of 180°, and there is no indication of any secondary lobes. We consider this to represent the typical form, because it is the most frequent on the mature tree, and because it is borne on the flowering branches. But beside this, the typical form, there are many others, of which several appear on the mature tree, intermixed with the typical, or they may represent the only foliage

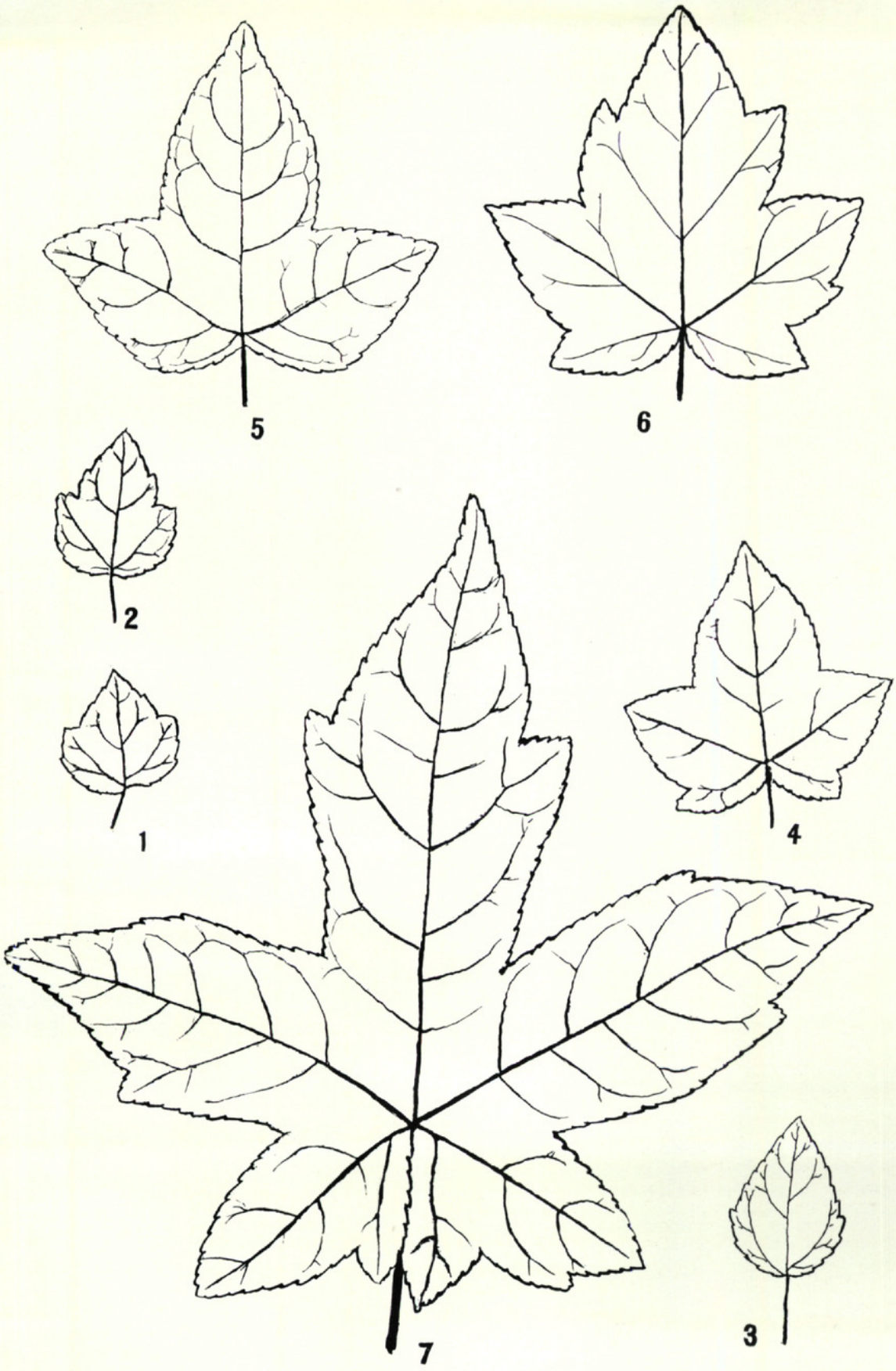
[1] Van Tieghem, Ph. Second mémoire sur les canaux scéréteurs des plantes. Ann. d. Sc. Nat. Bot. Sér. 7. Vol. 1. Paris 1885, p. 80.

[2] Holm, Theo. Notes on the leaves of Liriodendron. Proceed. U. S. National Mus. Vol. XIII, no. 794. Washington 1890, pp. 15–35.

of the species, when a mere shrub or a seedling. The variation may be expressed by a smaller number of lobes, only three (FIG. 5), or by the blade being entire, ovate (FIGS. 3 and 10); or the number of lobes may be increased by the development of secondary lobes borne on the primary (FIGS. 6, 7 and 8); finally the basal lobes may be directed downward, forming a distinct sinus of very variable depth and width.

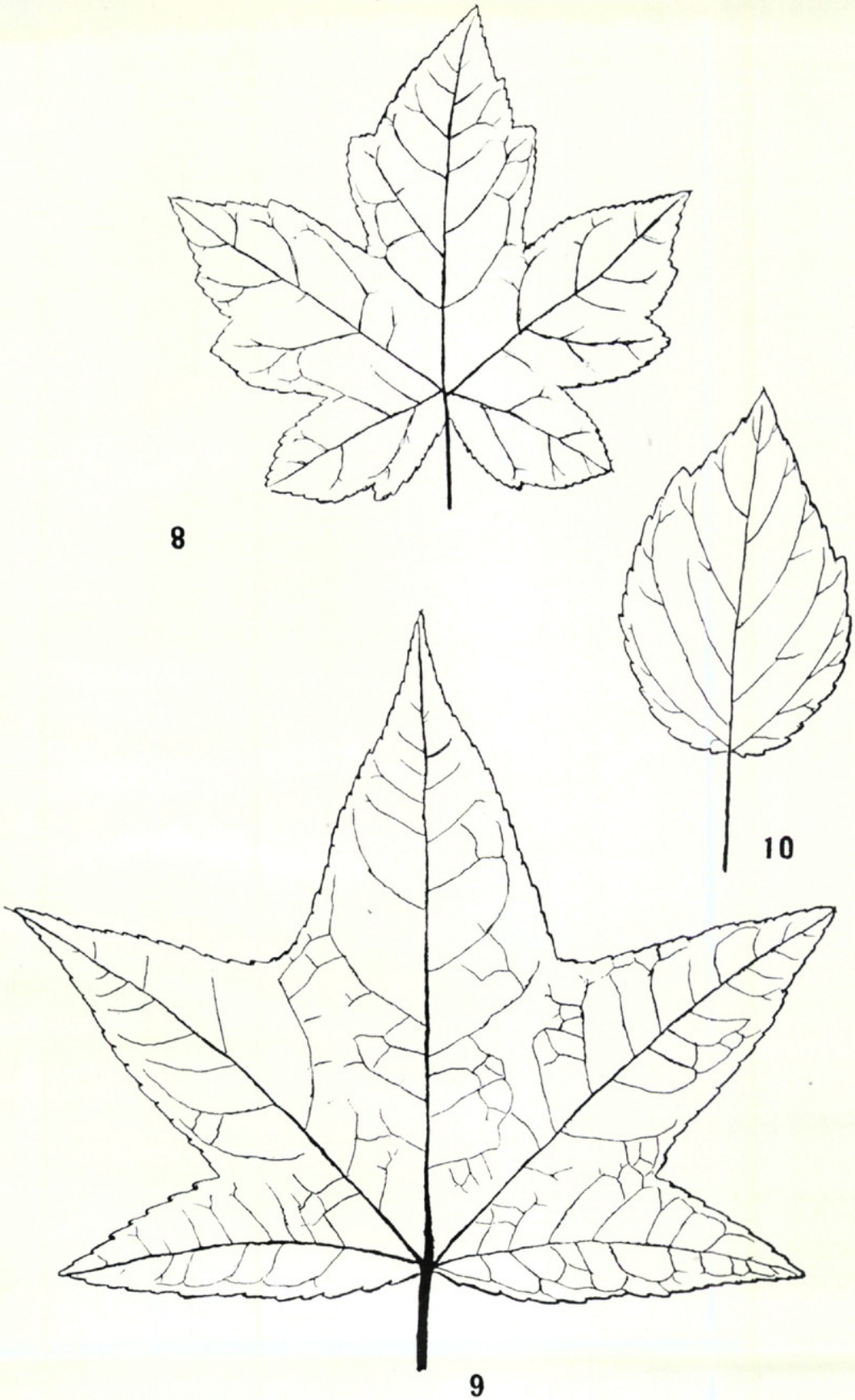
There is thus ample room for variation, notably with reference to the number and distribution of the secondary lobes, a variation fluctuating between the simple, ovate leaf and the form with 17 lobes, 5 primary and 12 secondary, which is not infrequent. But the number of primary lobes, 5, seems to be constant or at least the most general, for we have only found a few leaves on a single shrub, where seven ribs proceeded directly from the apex of the petiole, and where the number of secondary lobes aggregated 14, making a total of 21 lobes; the size of this leaf was 15 cm. in length, 13 cm. in width, and the shrub measured about 40 cm. in height with only four shoots. The size of the typical leaf with five lobes, and with no indication of secondary lobation, is about 17 cm. in length and 22 cm. in width, or more.

The seedling has a long, thin primary root, and the hypocotyl is relatively tall (about 4 cm.), erect; the cotyledons are oblong and obtuse with short petioles; their leaf blades measure about 15 mm. in length, and 7 mm. in width. From three to four leaves are developed in the first season, and they vary from entire, ovate (FIG. 3), to more or less distinctly three-lobed, but the lateral lobes are very short and obtuse (FIGS. 1–2). In the second year the stem remains unbranched, and may attain a height of 18 cm. bearing about ten leaves. Of these the lowermost is generally entire or with two lateral lobes, very short and obtuse; the other leaves are five-lobed, but the lobes are very broad and short-pointed. In specimens of the same age, but of a more vigorous growth, some of the leaves may show indication of secondary lobes, especially on the central lobe, thus representing the form shown in FIG. 6, which also is from a specimen in its second year. Finally the form, shown in FIG. 8, may be observed in similar, unbranched specimens, where the primary lobes bear short, but very distinct secondary lobes, making a total of 11 lobes, 5 primary, 6 secondary. Characteristic of the lobed leaves of the seedlings in the second year is the distinct basal sinus, especially deep and narrow in the leaves with secondary lobation (FIGS. 6 and 8).



Theo. Holm delin.

LIQUIDAMBAR



Theo. Holm delin.

LIQUIDAMBAR

When the stem begins to branch at the age of about five years, the height may be about one meter, and the foliage is then very different from that of younger, unbranched specimens. The first developed leaves, at the base of the branches, are small, three-lobed, a little larger than the one shown in FIG. 2, and with the central lobe narrower and a little longer. All the other leaves are large, five-lobed, but with the lobes relatively much broader than in the typical form, and with distinct secondary lobes like the leaf figured in FIG. 8. In these leaves the basal sinus is narrow and deep; in some of them the secondary lobes of the basal primary pair may overlap each other (FIG. 7), thus completely covering the sinus; some of the largest leaves may have seven primary lobes, and all the lobes bearing secondary pairs; the number of lobes may thus aggregate a total of 21, as described above. Not a single typical leaf was to be observed on shrubs of that age and height (one m.). In shrubs of greater height, about two meters, the leaves are smaller than in the preceding specimens, and the lobation is much less developed, frequently confined to the central lobe, and in all the leaves the basal sinus is deep and narrow; no typical leaves were observed. Characteristic of the foliage of the young shrubs are thus the relatively broad and short primary lobes, bearing several secondary lobes; besides that the basal sinus is constantly deep and narrow.

For several years the species retains the form of a large shrub, measuring four to five m. in height, and the foliage begins now to approach the type of the mature tree. The leaves are ample, and two types are present: one with the five primary lobes broad at the base, with a small, secondary lobe only on the basal pair, and with the sinus forming an obtuse angle; or with the primary lobes elliptical, tapering gradually to the base, with small, secondary lobes, on the central especially, and with a relatively narrow sinus at the base of the blade. Of these the latter form is less frequent than the former, which resembles the typical, except that the basal, primary lobes bear secondary ones, and that the sinus represents an obtuse angle instead of an angle of 180°.

When the species has reached maturity, and has become the stately, large tree so very characteristic of the North American forests from Connecticut to Illinois, and south to Florida and Texas, the typical leaf-shape (FIG. 9) is predominant. In the spring, the month of April, the flowers appear, and at that time all the leaves represent

the typical form. Some few months later variation becomes much in evidence, and we may then observe some long shoots with the lowermost leaf entire (FIG. 10); moreover, three-lobed leaves may comprise almost the complete foliage of dwarf-shoots, here and there; in these three-lobed leaves the lateral lobes form a broad, convex arch at the base with no indication of any sinus. Or on the same tree leaves of ample size may be observed with the lobes, especially the central, showing a slight indication of seconday lobatrion, and with a distinct basal sinus. It is interesting to compare the foliage of the long, slender branches where the basal leaves are of the typical form, the succeeding with indication of secondary lobes, and the apical eleven-lobed (five primary, six secondary), and with a deep sinus; such cases are frequent on the mature tree. When trees have been cut down, shoots may develop from the stump, and the leaves are generally large and with several secondary lobes, besides with a deep, narrow sinus, resembling the form drawn in FIG. 7. There is thus a well marked variation to be observed even on the mature tree, but the typical form of the leaf is constantly to be found on the floral shoots themselves.

A variety of *L. Styraciflua* has been found in Mexico: "mexicana," and is figured by Oersted;[1] the plate shows one branch with four leaves, of which only the uppermost is three-lobed, all the others are five-lobed; but in this three-lobed leaf, the lateral lobes do not form an arch at the base, but taper gradually downward into the petiole.

The leaf-variation in *Liquidambar* is really remarkable, when we consider the fact that the mature tree shows several characteristic forms of leaves, as is also the case in *Liriodendron,* but to a smaller extent. In common with many other genera of trees with lobed or parted leaves, *Liquidambar* has the foliage of the seedling representing a very simple form, destitute of lobation. As we have described in a previously published paper[2] the seedlings of many trees are developed in the shade, and the relative size and outline of the primary leaves agrees well with the nature of the environment: diffuse light and a calm atmosphere, sometimes excellently illustrated also by the internal structure. We remember for instance *Liriodendron,* but furthermore several species of *Quercus* (*palustris* Du Roi, *rubra* L.

[1] Oersted, A. S. L'Amérique centrale. Prem. livr. Copenhague, 1863, planche 11.
[2] Holm, Theo. Sciaphilous plant types. Beiheft. Botan. Centralbl. Vol. 44. Dresden, 1927.

etc.); in *Acer saccharum* Marsh. the first leaves are either entire with the margin dentate, or slightly three-lobed; in *Negundo aceroides* Moench the first leaves are simple with the margin entire or serrate, while the typical leaves are pinnate; similar, simple leaves occur also in species of *Carya*, for instance *glabra* (Mill.) Spach; in *Platanus occidentalis* L. the first leaves are cuneate, and entire. A still more remarkable structure is represented by *Cecropia peltata* L., where the first leaves of the seedling are ovate, the succeeding three-lobed, thus very different from the leaves of the mature tree, which are peltate, almost orbicular in outline and divided into 9–11 radiating segments. In *Carica Papaya* L. the first leaf of the seedling is ovate, acuminate, with the margin entire; the second leaf is three-lobed with the lobes acuminate, while in the mature tree the ample leaves are deeply seven-lobed, the lobes pinnatifid and pointed. Several other cases might be cited, but it, nevertheless, appears to be characteristic of *Liquidambar* in contradistinction to these examples cited, except *Liriodendron*, that the variation is continued even when the tree has reached maturity. The fact that the floral shoots in *Liquidambar* always bear the typical form of leaves may depend on the different space inside the buds, when we compare the floral buds with the purely vegetative. In the former the staminate and pistillate inflorescences, developed at the same time, occupy the greater space in the bud; thus the subtending leaves, on account of the pressure, become simply five-lobed, and with the lobes narrow.

It may be mentioned at this place that the leaves sometimes show small, but dense, tufts of hairs on the lower face, in the angles of the larger veins, but only at the very base of the blade; these hairs are mostly pluricellular, *i. e.* consisting of several cells in a single row, and wherever these tufts of hairs are developed the epidermis shows several strata of cork, which may possibly indicate the development of acaro-domatia, so very frequent in trees of various families as described by Lundstroem.[1]

We have mentioned in the preceding that the foliage of the seedlings in *Liquidambar* corresponds with that of several other trees developed in the shade, so far as concerns the outline. Furthermore, we have observed that the internal structure resembles that of sciaphilous plants. The characters are as follows:

[1] Lundstroem, Axel. Die Anpassungen der Pflanzen an Thiere. Nova Acta Reg. Soc. Upsala. Ser. 3. 1887.

1. The typical leaf of the tree.

Epidermis: lateral cell-walls straight on ventral face, undulate on dorsal.

Chlorenchyma: two layers of compact palisade-cells, and a pneumatic tissue of about seven, more open strata.

Collenchyma: several hypodermal strata above and beneath the primary veins.

Stereome: a closed sheath around the mestome-strands of the primary veins.

Mestome-strand of midrib: three strands fused together so as to form an apparently single "concentric," in this case a perileptomatic strand with a central pith containing three resin-ducts.

2. The leaves of the seedling in the first year.

Epidermis: lateral cell-walls undulate on both faces.

Chlorenchyma: almost homogeneous of isodiametric cells, here and there with one layer of short, plump palisades; pneumatic tissue of four strata, more open.

Collenchyma: only one hypodermal layer beneath the midrib.

Stereome: a separate, open arch on the leptome-side, and a separate, small strand, covering the hadrome.

Mestome-strand of midrib: one single strand, arch-shaped, open on the ventral face, with one resin-duct.

Clinton, Maryland.

Explanation of Plates 200 and 201

Plate 200. Liquidambar Styraciflua L. Figs. 1–3, leaves of seedlings in the first year. Fig. 4, leaf of a small, unbranched specimen, 25 cm. in height. Fig. 5, leaf of a shrub, 1 m. in height. Fig. 6, leaf of a small specimen, 25 cm. in height. Fig. 7, leaf of a shrub, 1 m. in height, from the same branch as the leaf figured in fig. 5.

Plate 201. Liquidambar Styraciflua L. Fig. 8, leaf of a small, unbranched specimen with in all five leaves; the leaf figured is the basal. Fig. 9, leaf of a large tree, showing the typical shape. Fig. 10, leaf of a large tree, the lowermost on a branch near the inflorescence; the other leaves were normal, five-lobed. All the figures are two-thirds of the natural size.

EUPHORBIA ESULA AS A WEED IN NEW YORK STATE.

W. C. Muenscher

Among that host of troublesome exotic weeds which have become established in our country is the Leafy Spurge, *Euphorbia Esula* L. Apparently this perennial weed is not only very persistent where it has taken a foothold, but is spreading rapidly into new areas.

Our manuals and floras give only a very imperfect idea of its distribution, but indications are that it may be already widely dis-

tributed in the northern United States. Available records indicate that it has been found in Maine, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Michigan, Wisconsin, Minnesota, North Dakota, and Colorado. House[1] did not include *Euphorbia Esula* in his "Flora of New York State." Taylor[2] in the "Flora of the Vicinity of New York" mentions it as occurring as a rare weed at Redding, Connecticut, but does not credit it to New York State.

Leafy Spurge is a perennial which produces large numbers of viable seeds and also spreads by slender creeping roots which send up new shoots in great profusion. Propagation by the roots is very rapid, especially when they are broken and dragged about a field with harrows and cultivators. Every piece of root, even though it is only one centimeter long, is capable of producing a new plant and a new center from which the weed spreads. In most places where it has become established, it has become a very serious pest in meadows as well as in cultivated land.

The following notes upon the distribution of this weed in New York State are based largely upon field observations by the writer and inquiries and specimens from farmers who have been confronted with the problem of its control. Unless otherwise indicated, the numbers refer to specimens collected by the writer and deposited in the herbarium of Cornell University.

ORANGE COUNTY: overrunning meadows and fields near Rock Tavern, New Windsor, 15,735 (1924); common and spreading in fields, meadows and along roadsides west of Newburgh, 15,736 (1924); in meadows and along roadside near the Middletown country club, Middletown, 15,737 (1924). ULSTER COUNTY: common in a meadow near Kingston, *H. P. Beals* (1925). SULLIVAN COUNTY: common in meadows and along roadside south of Bloomington, 16,217 (1925). DUTCHESS COUNTY: common and spreading in grain fields, meadows and pastures, *H. I. Hall* (1922–1927). COLUMBIA COUNTY: a large patch in a meadow near Hillsdale, 16,216 (1925). ALBANY COUNTY: common in an oatfield at Guilderland Center, *H. D. House*, New York State Herbarium, 10,787 (1925). HERKIMER COUNTY: in a field near Little Falls, *C. A. Casely*. ST. LAWRENCE COUNTY: one colony in a hayfield near Potsdam, probably extinct, *O. P. Phelps*, C. U.,[3] (1925). TOMPKINS COUNTY: on a hillside north of Ithaca, *L. H. MacDaniels & A. J. Eames*, C. U., 4493 (1915). CAYUGA

[1] House, H. D. Annotated list of the ferns and flowering plants of New York State. N. Y. State Mus. Bull. 254. 1924.

[2] Taylor, Norman. Flora of the Vicinity of New York. Mem. N. Y. Bot. Gard. **4**: 1–683. 1915.

[3] C. U. = Herbarium of Cornell University.

COUNTY: in cultivated fields and grassland, about three miles east of Aurora (1929). According to a local resident it was first noticed here in 1923. GENESEE COUNTY: abundant along roadside near Bergen, *A. E. Perkins*, C. U. (1929).

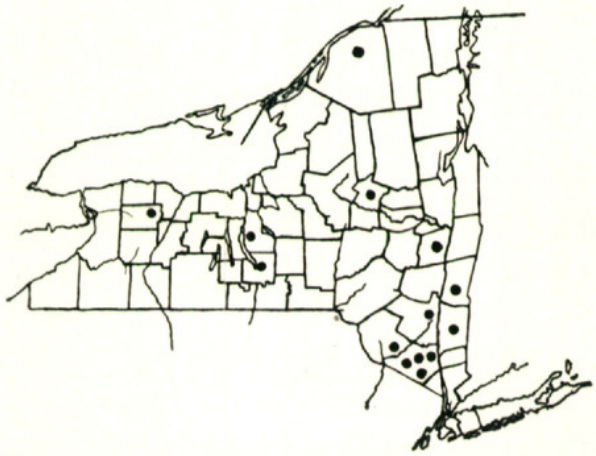


Fig. 1. Distribution of Euphorbia Esula in New York State.

These distribution records, also indicated on the map in figure 1, show that the Leafy Spurge is already known to be established in at least eleven counties in New York State: it is most abundant and troublesome in the southeastern counties but it is also found in scattered counties extending northward to the St. Lawrence River and westward almost to Lake Erie. More intensive field observations would probably show that it is already in some of the other counties. The rate at which this weed produces seed and spreads indicates that unless extreme measures are taken to eradicate new infestations, it is likely to become a much more common weed pest in the future.

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