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NO. 42 **1973-1974**

RANGE EXTENSIONS OF *SAGITTARIA MONTEVIDENSIS* IN THE DELAWARE RIVER SYSTEM

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While collecting plants in the fresh to brackish intertidal zone of rivers near Philadelphia, a population of *Sagittaria montevidensis* Cham. & Schlecht. consisting of several hundred plants was found in a fresh tidal marsh along the west shore of the Delaware River in Bucks County, Pennsylvania. Several smaller populations were later found on nearby Burlington Island and the east shore of the Delaware River in Burlington County, New Jersey. Previous to these discoveries, collections of this species, recognized by Fernald (1950) as *Lophotocarpus spongiosus* (Engelm.) Smith, and by Gleason (1952) as *Sagittaria spatulata* (Smith) Buckn. and *S. montevidensis,* were restricted to the brackish shores and marshes much further downstream. Additional localities were also found along brackish tributaries of the Delaware River in Salem and Cumberland Counties, New Jersey, and New Castle and Kent Counties, Delaware.

Plants of *S. montevidensis* occurring in northeastern North America have been distinguished as ssp. *spongiosa* (Engelm.) Bogin (Bogin, 1955), and are reported to be restricted to brackish tidal shores and marshes of estuaries from northeastern New Brunswick to Virginia (Fassett, 1928; Fernald, 1950; Bogin, 1955). Muenscher (1937), however, indicates that this plant occurs along fresh tidal shores of the Hudson River as far upstream as Coeymans, Albany County, New York. On shores and in marshes of the Delaware River system, *S. montevidensis* was previously only known from the brackish intertidal zone in the vicinity of Wilmington and Delaware City, Delaware, and Salem and Elsinboro Point, New Jersey (see Fogg, 1935, and Adams, 1937, for distributional records from brackish shores and marshes of the Delaware River). This species still has a similar range along this portion of the Delaware River, although the furthest upstream along the coast of Delaware that it has been recently collected is just south of the Delaware Memorial Bridge about 2 miles northeast of New Castle (open mud in tidal marsh associated with *Peltandra virginica* and *Pluchea purpurascens* var. *succulenta,* 27 Oct 1972, *Ferren 1211* [1]). Within this brackish zone along the Delaware River, *S. montevidensis* grows in open, muddy, tidal marshes and ditches among plants of *Pontederia cordata* L. and *Peltandra virginica* (L.) Schott and Endl., and along open, sandy, muddy, tidal shores frequently associated with *Spartina alterniflora* Loisel and *Scirpus pungens* Vahl.

At the mouth of Mill Creek and the Pennsylvania Canal on the Delaware River at Bristol, Bucks County, Pennsylvania, *S. montevidensis* was found in a fresh tidal marsh with a diverse intertidal flora, including the type form of *Scirpus smithii* Gray, *Eleocharis diandra* C. Wright, *Sagittaria subulata* (L.) Buchn., and *Bidens bidentoides* (Nutt.) Britt., which in the Philadelphia area are almost completely restricted to the fresh tidal shores and marshes. Numerous robust plants of *S. montevidensis* with hastate leaves were growing among *Pontederia, Peltandra, Acnida,* and *Heteranthera reniformis* R. & P. (silt-covered sand in an open section of the marsh, 12 Jul 1972, *Ferren 942*). Smaller plants with spatulate and strap-shaped leaves were growing in association with *Lindernia dubia* (L.) Penn., *Eleocharis diandra,* and *Cyperus rivularis* Kunth, among an open mixture of *Nuphar advena* (Ait.) Ait. f. and *Polygonum punctatum* Ell. (mud at edge of marsh, 12 Jul 1972, *Ferren 944*). Other stations for *S. montevidensis* along the fresh tidal shores of the Delaware River were found in Burlington County, New Jersey, at the south end of Burlington Island where it grows in association with rosettes of *Sagittaria graminea* Michx. among the upper limits of *Nuphar advena* (open muddy tidal shore, 25 Jul 1972, *Ferren 984*); and on the New Jersey mainland opposite Burlington Island where it grows associated with *Scirpus pungens* and *Eleocharis erythropoda* Steud. in a mixed turf with *Sagittaria subulata* and *Sagittaria graminea* (sandy cobbly tidal beach about .6 mi W of Stevens below River Rd, 25 Jul 1972, *Ferren 990*). In addition a specimen of *S. montevidensis* was found growing on the sandy, muddy, tidal shore of Rancocas Creek, a tributary of the Delaware River, at Centerton, Burlington County (17 Oct 1973, *Ferren 1343*). Here it was associated with numerous aquatics, some of which are restricted to the fresh intertidal zone, including *Cyperus brevifolius* (Rottb.) Hassk. and *Scirpus smithii,* or are found in the fresh to slightly brackish intertidal zone, including *Eriocaulon parkeri* Robins. and *Isoëtes riparia* Engelm. ex A. Br. Plants of *S. montevidensis* growing in the Delaware River system in Bucks County, Pennsylvania, and Burlington County, New Jersey, apparently occur under similar conditions and with many of the same plants of the fresh intertidal zone as Muenscher (1937) found along the Hudson River at Kingston, Ulster County, New York. Collections from these two rivers represent the most accurate records of *S. montevidensis* from fresh tidal shores and marshes in the northeastern United States and adjacent Canadian provinces.

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[1] All specimens cited herein are in the herbarium of the Academy of Natural Sciences of Philadelphia.

Specimens of *S. montevidensis* collected at Bristol are the first definite record of the plant from Pennsylvania. An herbarium sheet containing specimens of *Sagittaria subulata* originally from the Charles E. Smith Herbarium also contains several specimens of *S. montevidensis.* Smith's blue label, reading "tidal mud, Aug 20," resembles others with more complete data which record his intertidal collections made in the 1860's at Tinicum, Delaware County, and Penrose, Philadelphia County, Pennsylvania. Other than this questionable collection, there is apparently no other record of *S. montevidensis* from Pennsylvania.

The range for *S. montevidensis* has also been extended to new brackish stations along tributaries of the Delaware River in southern New Jersey and Delaware. It was collected in New Jersey towards the upper tidal limit of flats in the Salem River system (along Mannington Creek below Pointers Auburn Road ca 3 mi NE of Salem, 15 Aug 1972, *Ferren 1023*); on tidal mud-covered gravels along a tributary to Alloway Creek (ca .5 mi SW of Quinton W of Perry Road, 16 Oct 1972, *Ferren 1187*); and on soft mud of open flats along Cohansey Creek (mouth of Rocaps Run ca .7 mi S of Bridgeton, 18 Oct 1972, *Ferren 1039*). In New Castle County, Delaware, *S. montevidensis* has been found along the tidal shores of Tom Creek (firm clayey flats, 3.5 mi SW of New Castle, 27 Oct 1972, *Ferren 1209*); Duck Creek (soft open mud of an abandoned boat camp at Smyrna Landing, 28 Jun 1973, *Ferren 1226*); and the Appoquinimink River system near Odessa. In the latter system it occurs on the muddy slope from a marsh along Drawyer Creek at Rt. 13, about one mile north of Odessa (3 Oct 1973, *Ferren 1314*); an open mud flat below Silver Lake along Deep Run (3 Oct 1973, *Ferren 1305*); and along the Appoquinimink River between Noxontown Pond (open mud-covered sandy shore below dam, 3 Oct 1973, *Ferren 1310b*) and Odessa (soft mud of marsh, 3 Oct 1973, *Ferren 1301;* sandy shore, 3 Oct 1973, *Ferren 1299*). In Kent County, Delaware, *S. montevidensis* has been collected from soft muddy areas of a tidal marsh along Swan Creek, just west of Mispillion River about 1.2 miles northeast of Milford City Limit (28 Jun 1973, *Ferren 1223*); and from soft mud at the edge of a marsh along Beaver Dam Branch, about 1 mile from Mispillion River and 3.3 miles northeast of Milford (28 Jun 1973, *Ferren 1224*). In the brackish environment of these tributaries, *S. montevidensis* commonly grows in open, muddy marshes and flats often associated with *Peltandra, Pontederia,* and *Pluchea purpurascens* var. *succulenta* Fern., and occasionally on muddy, sandy, gravelly shores with *Spartina alterniflora, Scirpus pungens,* and *Peltandra.* When a population of *S. montevidensis* extends into the more species rich high tide limits of brackish areas, it has been collected in association with *Juncus acuminatus* Michx., *Acnida cannabina* L., *Eleocharis ambigens* Fern., and *Cyperus rivularis,* an association similar to one along the Delaware River reported by Fogg (1933).

In the fresh conditions, *S. montevidensis* is associated with many of the same plants (e.g. *Scirpus pungens, Peltandra* and *Pontederia*) with which it grows in the brackish conditions. However, other plants of brackish shores and marshes, such as *Spartina alterniflora, Pluchea purpurascens* var. *succulenta,* and *Eleocharis ambigens,* are not associated with *S. montevidensis* along fresh portions of the

Delaware River. Instead, plants which are scarce or absent at brackish localities of *S. montevidensis,* such as *Cyperus brevifolius, Eleocharis erythropoda, Eleocharis diandra, Heteranthera reniformis, Sagittaria graminea, Sagittaria subulata,* and *Scirpus smithii* occur.

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A PRELIMINARY STUDY OF THE CHEMOSYSTEMATICS OF AMERICAN OAKS: PHENOLIC CHARACTERS OF LEAVES

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The oak genus *Quercus* has been systematically treated by Oersted (1871), Schwarz (1936) and Camus (1936-1938). In Schwarz's treatment, the subgenera *Macrobalanus* (a group of large-fruited white oaks) and *Erythrobalanus* (black and red oaks) of Oersted were raised to the generic rank. However, this treatment has been much criticized (e.g. Muller 1942a) and it is generally not being accepted by systematists.

American species of oaks have been critically reviewed by Engelmann (1876-1878) and Sargent (1895, 1918), but no attempts at grouping them into series or sections were made by these authors. Trelease (1924) treated the North American and Central American species and classified them into series, with indications of the supposed relationships between the latter. Since then, there have appeared several regional studies of the oak species of the United States, such as West (1948) on the oaks of Florida and Muller (1951) on the oaks of Texas. In Muller's treatment, the species are also arranged into series.

The anatomical characters of oak woods have been studied by various authors with the aim of correlating these with taxonomy based on external morphology of the plants. Among these are the works of Abromeit (1884), Bailey (1910), Williams (1939, 1942), and Tillson and Muller (1942). Tillson and Muller studied the wood anatomy of 104 species of American oaks. They found that the red oaks (*Erythrobalanus*) are characterized by rounded summerwood vessels with thick walls (over 3μ in thickness). In the white oaks (*Lepidobalanus*), about half of the species examined possess angular summerwood vessels with thin walls (less than 3μ in thickness) while the remaining species exhibit characters similar to those of the red oaks. Their conclusions are that anatomical characters of oak woods do not constitute a basis for subgeneric divisions and indicate only roughly the possibility of division into sections in the white oak subgenus.

As chemical characters have been increasingly employed by systematists in recent times, an attempt is here being made to investigate the implication of the phenolic characters of the leaves of American oaks on their systematics based on external morphology.

MATERIALS AND METHODS

Leaf specimens of forty-nine species belonging to twenty-eight series (Trelease 1924) and two hybrids have been studied chromatographically. The methods used generally follow those of Mabry *et al.* (1970) and Hsiao (1973). Freshly dried leaf specimens were either collected directly from the Michaux Quercetum collection of the Morris Arboretum or through correspondents from other institutions. The Michaux Quercetum is a collection of living specimens of oak species hardy to this region. The program is sponsored by the Morris Arboretum and the U.S. Forest Service, and was begun in 1953 (Schramm & Schreiner 1954, Li 1958).

Voucher specimens were deposited in the herbarium of the Morris Arboretum. Depending on availability, one to four samples were studied for each species. Ground leaf specimens were extracted with aqueous methanol. Two-dimensional paper chromatograms were obtained by using TBA (tertiary butanol : acetic acid : water = 3 : 1 : 1) and HOAc (15% acetic acid) as solvents. The chromatograms were observed under UV light alone and also in the presence of ammonia vapor. The colors and Rf values of each spot were recorded. The species studied, together with the number of samples used for each species and the occurrences of the spots in each of the species, are tabulated in Table 1. The spots with similar appearances and Rf values are assumed to be of the same compound. A composite chromatographic diagram for all species studied is shown in Figure 1.

Several major spots were extracted from the chromatograms of various species. Six UV spectra (Mabry *et al.* 1970) were obtained for each extract by using a Beckman DB-G spectrophotometer. UV spectral data were used to deduce the structure of those spots extracted.

RESULTS AND DISCUSSIONS

Based on UV spectral data, spots 41 and 43 are believed to be glycosides of kaempferol while spots 21, 26 and 54 are glycosides of quercetin. UV spectra of spot 47 matched well with those of kaempferol 3 (*p*-coumaroylglucoside) (Hsiao 1972) and spot 43 is probably a flavanone. Spot 16 is usually found to consist of two spots, a and b. However, these two spots are so close together and so similar in appearances that in many instances it is difficult to distinguish them. These two spots are thus treated as one in the following discussion.

Among the subgenera *Lepidobalanus* (white oaks), *Protobalanus* (intermediate oaks) and *Erythrobalanus* (black oaks), no spot was found to be present exclusively in all members of one subgenus while absent in others. However, several spots were found to be present in one subgenus more often and/or in larger quantities. For example, spots 5, 7, 17, 26, 38, 40 and 56 are present more often in the chromatograms of the black oaks. Spots 6, 8, and 47 are present more often in the white and intermediate oaks. Spot 54 is present exclusively in 9 members of the white oaks while spots 18 and 37 are present only in 7 members of the black oaks. Similar to the findings from the wood anatomy of oak species, the phenolic characters of oak leaves do not constitute a basis for subgeneric division although there are some tendencies that certain spots be found more often in one of the subgenera. Many spots are present in all or nearly all of species examined. Spots 13, 21, 39, 41 and 57 are found in all species, while spots 16, 19, 45, 48, 50 and 52 are found in most of the species studied. These data indicate the coherence of the oak species as a group.

TABLE I.

List of species studied and the occurrence of spots. (Concentration of spots: from 0-5. Abbreviations for colors: B=blue; Br.=brown; d=dark; f=florescent; G=green; I=invisible; l=light; O=orange; Pk=pink; Y=yellow.)

Series	Species	Number of specimens studied	Color	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
			UV	lO	d	I	I	B	OY	B	d	d	I	I	d	O	YB	d	d	d	I	d	I	d	I	d	YB	d	d	B	d	d	B	O
			UV/NH₃	lYG	dBG	[illegible]	O	fYO	Y	fYO	PkO	YO	lBY	fGY	GY	O	YB	PkO	YO	GY	dB	GY	B	GY	fdB	GY	B	YO	YG	B	YG	dG	B	O
White Oaks:																																		
Virentes	Q. virginiana	3		1-3	-	-	-	-	-	1	-	-	-	-	-	1-2	-	-	3	-	-	1-3	3-5	5	-	-	-	-	-	-	1	1	-	-
	Q. minima	1		2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	3	2	-	-	4	5	-	-	-	-	-	-	1	1	-	-
Stellatae	Q. stellata	4		2	1	-	-	-	1	-	-	-	-	-	-	1	-	-	2	-	-	1-2	1	5	-	-	-	-	-	0-2	-	0-1	0-1	-
Albae	Q. alba	4		1-2	0-1	0-1	-	-	-	0-2	-	-	0-1	-	-	1-2	-	-	3	-	-	2	0-1	4-5	-	-	-	-	1	-	-	1	0-1	-
Lyratae	Q. lyrata	3		1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	3	-	-	1	1-2	4	-	-	-	-	-	-	-	0-1	-	-
Macrocarpae	Q. macrocarpa	3		1-2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	2-3	-	-	1	0-2	5	-	-	-	-	-	-	-	1	-	-
	Q. bicolor	2		0-1	-	-	-	-	-	0-1	0-1	-	-	-	1	1	-	1	2	-	-	3-4	-	4	-	-	-	-	1-3	-	-	1	-	-
Prinoideae	Q. prinus	3		0-1	-	0-1	-	1-4	-	4-5	-	-	-	-	-	1-2	-	-	2-3	-	-	1	-	4-5	-	-	-	-	1-2	-	-	-	-	-
	Q. muehlenbergii	2		1-2	0-1	-	-	4-5	-	4-5	-	-	-	-	-	1	-	-	-	-	-	0-2	-	3-5	3	-	3-4	-	1	-	-	-	-	-
	Q. prinoides	1		1	-	-	-	4	-	4	-	-	-	-	-	2	-	-	1	-	-	-	-	5	1	-	-	-	-	-	-	-	-	-
Dumosae	Q. dumosa	2		2-3	0-1	1	-	-	1-2	1	-	-	-	1	-	2	-	-	4	-	-	2-3	0-1	5	-	-	1	-	1	-	-	0-1	-	-
	Q. turbinella ssp california	1		3	-	1	-	-	1	-	-	-	-	1	-	2	-	-	4	-	-	3	-	5	-	-	-	-	1	-	-	1	1	1
Douglasieae	Q. douglasii	2		2	-	1	-	-	0-1	-	0-1	-	-	-	-	1	-	-	3	-	-	3	-	5	-	-	-	-	-	0-2	-	-	-	-
Sadlerianae	Q. sadleriana	1		2	-	1	1	-	4	-	-	-	-	1	-	1	-	-	-	-	-	2	2	5	-	-	-	-	-	-	-	-	2	-
Lobatae	Q. lobata	2		3-4	-	-	-	-	1	-	0-1	-	-	-	-	1-2	1-2	-	3	-	-	1-2	-	5	-	-	-	-	-	-	1-2	1	0-1	-
	Q. garryana	1		3	1	-	-	-	1	-	-	-	-	-	-	2	-	-	4	-	-	2	-	5	-	3	1	-	-	-	-	1	-	-
Undulatae	Q. toumeyi	1		3	2	-	-	1	-	-	-	-	-	-	-	2	-	-	4	-	-	2	-	5	-	-	-	-	-	-	-	-	-	-
Gambeliae	Q. gambelii	1		2	2	-	-	-	-	-	1	-	-	-	-	1	-	-	4	-	-	3	-	5	-	1	-	-	-	-	-	-	1	-
Oblongifoliae	Q. engelmannii	1		2	-	1	-	1	-	1	1	-	-	1	-	1	-	-	4	-	-	3	2	5	-	-	-	-	1	-	-	-	-	-
	Q. oblongifolia	1		3	-	1	-	1	-	1	1	-	-	-	-	1	-	-	4	-	-	1	-	5	-	-	-	-	1	-	-	-	1	-
Griseae	Q. grisea	1		2	1	1	-	-	1	-	-	-	-	-	-	1	-	-	4	-	-	2	1	5	-	-	-	-	-	-	-	1	1	2
Arizonicae	Q. arizonica	1		2	-	-	-	-	-	-	1	-	-	-	-	1	-	-	3	1	-	-	-	5	-	-	-	-	-	-	-	1	1	-
Reticulatae	Q. reticulata	1		2	-	-	-	-	-	-	1	-	-	-	-	1	-	-	4	1	-	-	-	5	-	-	-	-	-	1	-	-	-	-
Intermediate Oaks:																																		
Chrysolepides	Q. chrysolepis	3		2	0-1	-	-	-	1	-	-	-	-	-	-	1-2	-	-	3-4	-	-	1-3	1-2	4-5	-	-	-	-	1-2	-	-	1-2	-	1-2
	Q. palmeri	1		2	1	-	-	-	-	-	1	-	-	-	-	1	-	-	4	-	-	3	-	5	-	-	-	-	-	-	-	-	-	-
	Q. vaccinifolia	1		-	-	1	-	-	1	-	-	-	-	-	-	1	-	-	4	-	-	3	1	5	-	-	-	-	1-2	-	1	1	-	-
Red Oaks:																																		
Agrifoliae	Q. kelloggii	2		1	1	1	-	-	-	1-3	-	1	-	-	1	1-2	-	1-2	5	-	2	-	-	4	-	-	-	-	-	-	-	-	0-1	-
	Q. wislizenii	1		1-2	1-2	-	1	-	1-2	-	-	-	-	-	-	1	-	1	4-5	-	-	2	-	5	-	-	-	-	2	-	-	-	1-2	-
	Q. agrifolia	2		1-2	1	-	0-2	-	-	-	-	-	-	1-2	-	1	-	1	4	-	0-1	2	-	5	-	-	-	-	1	-	-	-	2	-
Durifoliae	Q. emoryi	2		2	2	-	-	-	-	4-5	-	-	-	-	-	1	-	1	4	-	-	1	-	5	-	-	-	-	-	-	-	0-1	3	-
Hypoleucae	Q. hypoleucoides	2		2-3	1	-	-	5	-	5	-	1	-	-	-	1	-	1	4-5	-	-	2-3	-	5	-	-	-	-	2	0-1	-	2	1	-
Laurifoliae	Q. imbricaria	3		0-2	-	0-1	-	3-5	-	1-2	-	-	-	1	-	1	-	-	0-1	-	-	1	-	4	-	-	-	-	1-2	-	-	0-1	-	-
	Q. laurifolia	3		1	-	-	-	2-3	-	3-4	-	-	0-2	0-1	-	1	-	-	2-4	-	0-1	1-2	1-3	5	-	-	-	0-1	-	-	-	-	1-2	-
	Q. myrtifolia	1		-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	4	-	-	-	3	5	-	-	-	-	-	3	-	-	-	-
	Q. phellos	3		-	-	-	-	-	-	-	-	-	-	-	1-2	1	1-2	-	3	-	-	2	2-3	3	-	-	-	-	1	-	-	-	-	-
	Q. incana	1		1	-	1	-	3	-	1	-	-	3	-	-	1	-	-	3	-	-	1	2	5	-	-	-	-	1	-	-	-	-	-
Nigrae	Q. nigra	3		-	-	-	-	-	-	1-2	-	-	1-2	-	-	1	0-1	-	4	-	-	2	1	4-5	-	-	-	-	1	2-3	-	-	-	-
Palustres	Q. palustris	3		1	-	-	-	3-4	-	2-3	-	-	-	-	-	1-2	-	-	1-2	-	-	2-3	-	5	-	-	-	-	1	0-2	-	-	1	-
Marilandicae	Q. marilandica	3		2-3	1	0-1	-	0-1	-	-	-	-	-	-	-	1	-	-	2-3	-	-	-	4	3-4	-	-	-	-	0-1	1	-	-	-	-
	Q. laevis	1		1	-	-	-	-	-	1	-	-	-	-	-	1	-	-	4	-	-	1	4	5	-	-	-	3	1	-	-	-	2	-
	Q. arkansana	1		3	-	1	-	5	-	4	-	3	-	-	-	2	-	-	4	-	2	1	-	5	-	-	-	-	1	-	-	-	1	-
Pagodaefoliae	Q. falcata	4		1-2	1	0-1	-	-	-	1-3	-	0-1	-	-	-	1	-	-	4	-	0-1	1	1	4-5	-	-	-	-	-	-	1	1	-	-
Coccineae	Q. shumardii	3		0-1	-	0-1	-	1	-	-	-	-	-	1	-	1	-	-	-	-	0-2	0-3	-	5	-	-	-	-	0-1	-	-	-	-	-
	Q. borealis	3		-	-	1-3	-	4	-	4	-	-	-	-	-	2-3	-	0-1	4	-	-	2	-	3-4	-	-	-	-	1	-	-	1	-	-
	Q. coccinea	2		4-5	0-1	-	-	-	-	-	-	-	-	-	-	1-2	-	-	4	-	0-1	0-1	-	4	-	-	-	-	-	-	-	-	-	-
	Q. ellipsoidalis	1		2	1	-	-	2	-	3	-	-	-	-	-	1	-	-	2	-	-	3	-	5	-	2	-	-	2	-	-	2	-	-
	Q. nuttallii	1		2	-	-	-	3	-	2	-	2	-	-	-	2	-	-	2	-	-	1	1	5	-	-	-	-	3	-	-	-	1	-
Ilicifoliae	Q. ilicifolia	1		2	-	-	-	-	-	1	-	-	-	-	1	1	-	1	5	-	-	2	3	4	-	-	-	-	-	-	-	1	-	-
Velutinae	Q. velutina	2		-	-	-	-	3	-	4	-	-	0-3	-	-	1	-	-	1	-	-	-	-	3	1	-	1-3	-	1	-	-	1	-	-
Hybrids:																																		
	Q. x bebbiana	1		2	1	-	-	-	-	1	-	-	-	-	-	1	-	-	3	-	-	1	1	5	-	-	-	-	-	-	-	1	-	-
	Q. x comptonae	1		1	1	-	-	-	-	-	-	-	-	-	-	1	-	-	3	-	-	2	2	5	-	-	-	-	-	-	-	-	-	-

Series	Species	Color	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
		UV	fO	d	O	d	d	I	d	d	lB	d	I	d	B	B	d	d	B	YB	B	I	B	d	d	I	B	B	lB	B	I	B	B
		UV/NH₃	lY	d	O	Y	GY	B	BrO	d	B	G	B	dG	B	B	YG	dG	B	YB	B	fY	B	GY	Y	fGY	B	fGY	fBY	B	fYO	YB	B
White Oaks:																																	
Virentes	Q. virginiana		-	-	-	1	-	-	-	1-2	0-1	1-2	-	1	-	-	-	1	2-4	-	1-2	-	1	-	3	-	-	0-1	-	-	-	-	0-1
	Q. minima		-	-	-	1	-	-	-	4	-	1	-	-	-	1	-	1	4	-	2	-	-	-	-	-	1	1	-	1	-	1	2
Stellatae	Q. stellata		-	1	-	0-1	-	-	-	1-2	-	2-3	-	0-1	-	0-1	0-1	0-1	2-3	-	2-3	-	-	-	1-3	-	-	2	-	2-3	-	0-1	0-2
Albae	Q. alba		-	1	-	1	-	-	-	1-2	-	4	-	1	-	-	-	1-3	1-3	-	1-3	-	0-3	-	1-3	-	-	1-2	0-1	0-3	-	-	-
Lyratae	Q. lyrata		-	-	-	2	0-1	-	1-2	1	-	3	-	3	-	-	5	0-1	2-4	-	2	-	2-4	-	-	-	-	2	0-1	-	-	-	1-3
Macrocarpae	Q. macrocarpa		-	-	-	-	2-3	-	0-2	1-2	-	2-3	-	-	-	1	0-2	-	1	-	1-3	-	3	-	2-4	-	-	1	0-1	0-2	-	0-1	-
	Q. bicolor		-	1	-	0-1	1	-	5	2	-	4	-	1-2	-	0-1	-	1-2	1	-	1-2	-	2-4	-	-	-	-	2	0-1	-	-	-	-
Prinoideae	Q. prinus		-	-	-	1-3	2-4	-	-	1	0-1	3-4	-	1-2	-	0-1	-	0-1	1-3	-	1-2	-	1-2	-	-	-	-	4-5	-	-	-	-	-
	Q. muehlenbergii		-	-	-	2	4-5	-	-	2	-	2	-	2	-	0-2	-	-	-	-	2	1-4	2	-	-	-	-	5	3	-	1-2	-	-
	Q. prinoides		-	-	-	3	4	-	-	1	-	2	-	2	-	1	-	-	2	2	2	-	-	-	-	-	-	5	2	3	2	-	-
Dumosae	Q. dumosa		-	-	-	0-2	2	-	-	2	-	2	-	0-1	-	0-1	-	0-1	3-4	-	3	-	1	0-1	-	-	-	1	-	3	-	2-4	2-3
	Q. turbinella ssp california		-	-	-	2	2	-	-	2	-	3	-	1	-	-	-	1	1	-	2	-	-	-	2	-	-	2	1	3	-	1	3
Douglasieae	Q. douglasii		-	-	1	-	2-3	-	-	1-2	0-1	2	-	-	-	1	-	-	3-5	-	-	-	1-3	-	-	-	-	2	-	-	-	2-3	2
Sadlerianae	Q. sadleriana		-	-	-	-	-	-	-	1	1	3	-	-	-	-	1	1	1	-	2	-	3	-	3	-	-	1	-	-	-	-	-
Lobatae	Q. lobata		-	-	1	-	1-2	-	-	1	-	2-3	-	-	-	1	-	-	4-5	-	1	-	2	-	-	-	-	0-1	-	0-1	-	1-2	-
	Q. garryana		-	-	1	-	2	-	-	1	-	3	-	-	-	1	-	1	1	-	1	-	1	1	2	-	-	1	-	2	-	1	-
Undulatae	Q. toumeyi		-	-	-	1	-	-	-	3	-	1	-	-	-	1	-	-	-	2	1	-	-	-	-	-	-	1	-	1	-	2	-
Gambeliae	Q. gambelii		-	-	3	-	2	-	-	1	-	2	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	1	1	1	-	-	-
Oblongifoliae	Q. engelmannii		-	1	1	-	2	-	-	2	-	2	-	-	-	1	-	-	2	-	1	-	2	-	-	-	-	1	-	2	1	-	-
	Q. oblongifolia		-	-	-	-	-	-	-	2	-	2	-	-	-	1	-	-	1	1	1	-	1	-	-	-	-	2	1	3	-	-	-
Griseae	Q. grisea		-	-	-	1	2	-	-	1	-	3	-	1	-	1	-	1	2	-	2	-	1	1	-	-	-	1	-	3	-	-	-
Arizonicae	Q. arizonica		-	1	-	-	-	-	-	2	-	3	-	-	-	1	-	1	1	1	1	-	-	-	-	-	-	2	1	4	-	-	-
Reticulatae	Q. reticulata		-	1	-	-	-	-	-	2	-	1	-	-	-	1	-	-	4	-	1	-	-	-	-	-	-	2	1	4	-	-	-
Intermediate Oaks:																																	
Chrysolepides	Q. chrysolepis		-	-	-	-	3-4	-	-	1	-	2-3	-	-	-	0-1	-	1-2	4-5	-	1-2	-	1-2	-	-	-	-	1-2	-	-	-	-	3-4
	Q. palmeri		-	-	-	-	-	-	-	1	-	1	-	-	-	1	-	-	1	1	2	-	-	-	-	-	1	1	1	4	-	-	-
	Q. vaccinifolia		-	-	1	1	2	-	-	3	-	3	-	-	-	-	-	1	1	-	1	-	-	-	-	-	-	1	-	1	2	-	1
Red Oaks:																																	
Agrifoliae	Q. kelloggii		-	-	-	1	1	0-1	3	1-2	0-1	3	2-3	-	-	1-2	-	-	1-3	-	1-2	-	-	-	-	-	-	2-3	1	-	-	1-2	2
	Q. wislizenii		-	-	1	-	2	0-1	-	1	-	3-4	-	-	-	1-2	-	-	-	-	2	-	1-2	-	-	-	-	0-1	-	0-2	-	-	-
	Q. agrifolia		-	-	-	-	2	-	-	1	-	3-4	-	-	-	0-1	-	-	1	-	1	-	-	-	-	-	-	1	-	3	-	-	-
Durifoliae	Q. emoryi		-	1	-	-	-	-	3	1-2	-	3	-	-	-	2-3	-	-	1	-	1	-	-	-	-	-	-	5	3	3	1	1	-
Hypoleucae	Q. hypoleucoides		-	-	-	-	-	2-3	-	1	2	2	-	-	-	-	-	-	2	1-2	1-2	-	0-1	-	-	-	2	5	3	3	3	1	-
Laurifoliae	Q. imbricaria		-	-	-	0-1	5	-	-	0-1	2-3	2-4	-	0-1	-	1-4	-	0-2	2-3	-	1	-	1	-	-	-	0-1	4-5	1-2	-	-	1-3	0-2
	Q. laurifolia		-	-	-	0-2	-	-	-	2	0-1	3-4	-	1-3	-	1-4	-	-	2-3	-	2-3	-	1	-	-	-	0-1	3	0-1	3	-	1-3	-
	Q. myrtifolia		-	1	-	-	-	-	-	4	-	2	-	-	-	1	-	-	1	-	2	-	1	-	-	-	3	1	-	3	-	1	-
	Q. phellos		-	-	-	-	-	-	5	1-2	-	4-5	-	-	-	-	-	2-3	0-1	-	1-2	-	1-2	-	-	-	-	1-2	-	-	-	1	1-3
	Q. incana		-	1	-	-	-	-	-	1	2	3	-	-	-	2	-	-	4	-	1	-	1	-	-	-	-	4	-	4	-	2	2
Nigrae	Q. nigra		-	1	-	-	0-1	-	-	1	-	3-5	-	-	-	1	-	-	1	-	2	-	2	-	-	-	2-3	2-3	1	1	-	1	-
Palustres	Q. palustris		-	-	-	-	3-4	-	-	1	0-1	3-4	1	-	-	1	-	-	1-2	0-1	2	-	1	-	-	-	-	5	3	0-2	-	1-2	-
Marilandicae	Q. marilandica		-	1	-	1-3	1-2	-	-	2	-	2-4	-	5	-	1	-	-	2-4	-	1-2	-	-	-	-	-	-	1-3	0-1	3-4	-	1	1-3
	Q. laevis		-	-	-	-	-	-	-	3	-	1	-	-	-	1	-	-	2	-	3	-	1	-	-	-	-	3	-	3	-	1	-
	Q. arkansana		-	-	-	-	-	1	-	1	1	3	-	-	-	1	-	-	1	-	2	1	-	-	-	-	-	5	2	4	-	-	-
Pagodaefoliae	Q. falcata		-	-	-	-	1-3	-	-	1	-	3-4	-	-	0-3	-	-	-	1-3	-	1	-	1	-	-	-	0-1	1-3	1	1-3	-	-	1-3
Coccineae	Q. shumardii		-	-	-	-	4	1	-	1	1	3	-	-	-	4	-	-	1	-	3	0-1	0-1	-	-	-	-	5	2	1	-	1	-
	Q. borealis		-	-	-	-	0-1	-	4	1	1	3-5	-	-	-	1	-	-	-	-	1	-	2-3	-	-	-	-	5	2	2	-	0-1	-
	Q. coccinea		3-4	-	-	-	-	-	5	-	-	3	0-1	-	-	-	-	-	1	-	0-1	-	-	-	-	0-1	1	2-3	0-1	2-3	-	-	-
	Q. ellipsoidalis		-	-	-	3	4	-	1	1	-	4	-	2	-	1	-	-	1	-	1	-	1	-	-	2	-	4	-	-	-	1	2
	Q. nuttallii		-	-	-	-	3	1	-	1	2	2	-	-	-	1	-	-	-	-	2	-	1	-	-	-	-	5	2	2	-	1	-
Ilicifoliae	Q. ilicifolia		-	-	-	-	1	-	4	1	-	4	-	-	-	-	-	-	-	-	-	-	2	-	-	1	1	2	2	-	-	-	2
Velutinae	Q. velutina		-	1	-	3	0-2	-	-	2	-	4-5	-	4-5	-	-	-	-	1	-	1-2	2-3	2-3	-	-	-	-	4-5	2	-	-	0-1	-
Hybrids:																																	
	Q. x bebbiana		-	-	-	-	1	-	-	1	-	3	-	-	-	-	-	1	4	-	2	-	3	-	3	-	-	2	-	-	-	-	3
	Q. x comptonae		-	-	-	1	-	-	-	3	-	1	-	2	-	-	-	-	5	-	3	-	3	-	2	-	-	1	-	-	-	-	4

Based on the phenolic characters of leaves, the relationships between oak species are discussed according to each of the series (Trelease 1924) and following the sequence as given in Table 1.

White Oaks

Virentes — Although the leaf chromatographic patterns of *Q. virginiana* and *Q. minima* appear in general similar to each other, there exist some significant differences between these two. For example, spot 17 is found in *Q. minima* but absent from *Q. virginiana,* while spots 19 and 54 are present in *Q. virginiana* but undetectable in *Q. minima.* Schwarz (1936) grouped the series Virentes, Arizonicae and Reticulatae of Trelease into the section Prinopsis. However, no special relationship has been found between the leaf chromatographic patterns of Virentes and Reticulatae or Virentes and Arizonicae.

Stellatae — The chromatographic pattern of *Q. stellata* is relatively variable between specimens especially in regard to spots 27, 54 and 62. One specimen of *Q. stellata* var. *margaretta* has also been studied chromatographically. The chromatographic pattern of this variety generally falls within the variation of *Q. stellata.* No significant difference has been found between the species proper and the variety.

Albae — *Quercus alba* is also relatively variable in its leaf chromatographic pattern. Spots 7, 52 and 59 are quite variable within the species. Schwarz (1936) treated the series Albae, Macrocarpae, Lyratae, and Prinoideae as members of the section Prinus Loud. Although series Albae, Macrocarpae and Lyratae are to some extent similar to each other, the series Prinoideae is very different from these three series in their chromatographic patterns.

Lyratae — *Quercus lyrata* is treated by Trelease (1924) as the only member constituting this series. Muller (1951) combined the series Macrocarpae, which includes *Q. macrocarpa* and *Q. bicolor,* with the series Lyratae. However, leaf chromatographic patterns do not indicate close relationship between *Q. lyrata, Q. macrocarpa* and *Q. bicolor.*

Macrocarpae — Although *Q. macrocarpa* and *Q. bicolor* are treated as members of a series by both Trelease (1924, as series Macrocarpae) and Muller (1951, as series Lyratae), the chromatographic patterns of these two species are quite different — having 15 spots present exclusively in one of the two species. Based on the chromatographic evidence it is probably more appropriate to separate them into different series.

Prinoideae — In the leaf phenolic characters, series Prinoideae of the white oaks is similar to red oaks in some respects. It is interesting to note the presence of large amounts of spots 5, 7 and 57 in this series. These three spots are present in large quantities in many red oak species while either completely absent or present only in small amounts in the white oak species. This series is not only different from the other series of the section Prinus; it is a rather distinct one among white oak species.

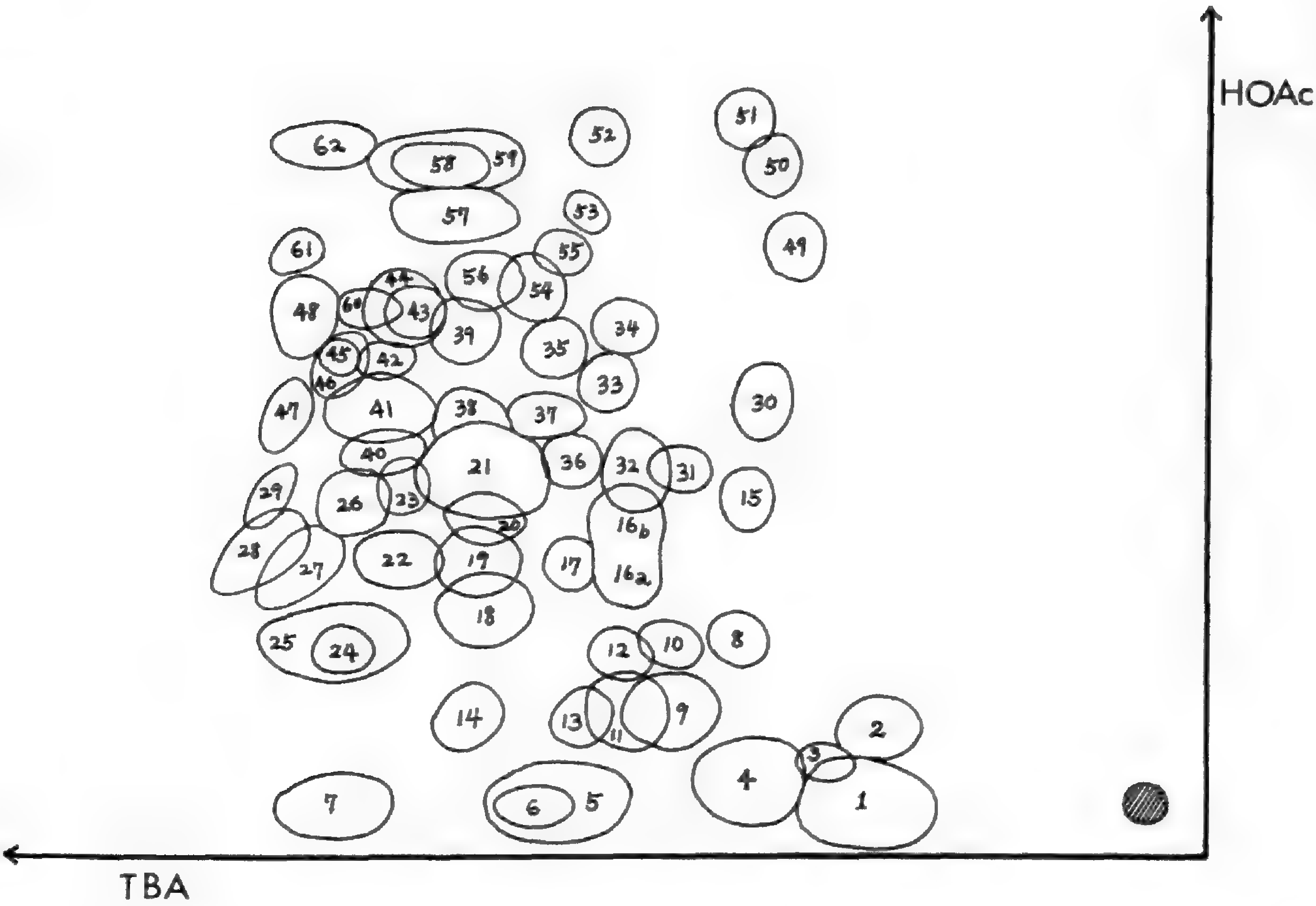

FIG. 1. — A composite chromatographic diagram of the leaves of American oak species.

Dumosae — Except for a few minor differences, the chromatographic pattern of *Q. dumosa* is rather similar to that of *Q. turbinella* ssp. *californica.* Muller (1951) combined *Q. turbinella,* together with part of the series Undulata (e.g. *Q. toumeyi*), into a new series Turbinellae. In the chromatographic patterns, *Q. dumosa, Q. turbinella* ssp. *californica* and *Q. toumeyi* are all similar to each other.

Douglasiae — Schwarz (1936) included series Stellatae, Lobatae, Douglasiae and Gambelliae as members of the subsection Pseudoprinus of the section Dascia Schwz. Chemical studies present no evidence against this treatment.

Sadlerianae — *Quercus sadleriana* was treated as constituting a series of its own and this treatment received some support from chemical evidence. Spot 16, which is believed to be flavonoid glycoside, is completely absent in this species. This condition is uncommon among oak species. Furthermore, spot 6 is present in *Q. sadleriana* in unusually large quantities.

Lobatae — Although the general patterns of *Q. garryana* and *Q. lobata* of the series Lobatae are similar to each other, there are some differences. The most noteworthy differences are the presence of spots 23 and 54 in *Q. garryana* and spots 14 and 28 in *Q. lobata.* A sample of *Q. garryana* var. *breweri* has also been studied chromatographically. No major difference has been found between this variety and the species proper.

Undulatae — *Quercus toumeyi* of the series Undulata Trel. was transferred to the series Turbinellae by Muller (1951). No material of *Q. undulata* was available for this study.

Gambelieae — It is uncertain whether *Q. gambelii* deserves a series of its own as treated by Trelease (1924). Muller (1951) combined *Q. undulata* with this series. No material of *Q. undulata* was available for this study.

Oblongifoliae — Although there are differences between several of the minor spots of *Q. oblongifolia* and *Q. engelmannii,* the two species generally have similar chromatographic patterns. It is probably justifiable to treat these two species in one series.

Griseae — Herbarium specimens were used for leaf chromatographic studies of *Q. grisea.* Muller (1951) treated *Q. arizonica* as a member of this series. This treatment is not supported by the present study as the leaf chromatographic patterns of these two species are found to be rather different.

Arizonicae — *Quercus arizonica* was treated as a member of the series Arizonicae by Trelease (1924), but included as a member of the series Griseae by Muller (1951). As noted above, Muller's treatment does not seem to be supported by chromatographic data.

Reticulatae — *Quercus reticulata* was treated as a member of the series Reticulatae by both Trelease (1924) and Muller (1951). However, *Q. reticulata* is so similar to *Q. arizonica* in their chromatographic patterns that it is probably more appropriate to combine these two species into one series. Schwarz (1936) combined series Reticulatae, Arizonicae and Virentes into a section called Prinopsis. While species of the first two series studied herein are rather similar in their chromatographic patterns, species of series Virentes possess relatively different patterns.

Intermediate Oaks

Chrysolepides — All of the three species studied within this series exhibit similar chromatographic patterns. It is difficult to compare the intermediate oaks with the other two subgenera because of the large number of species examined. However, in the leaf chromatographic patterns, the intermediate oaks seem in general more similar to the white oaks than to the black oaks. The intermediate oaks also show similarities in the chromatographic patterns to some series of the black oaks, especially series Agrifoliae.

Black Oaks

Agrifoliae — There are many similarities between the chromatographic patterns of *Q. wislizenii* and *Q. agrifolia.* However, the leaf chromatogram of *Q. kelloggii* is so different from these two species that it probably should not be included in the series. Muller's system (1938) is preferred because he excluded *Q. kelloggii* from the series Agrifoliae, pairing it with another species, *Q. morebus,* as a distinct series he called Californicae.

Durifoliae — Muller (1951) combined several Mexican series of Trelease into this series. These series are beyond the scope of the present study.

Hypoleucae — Muller (1951) noted that *Q. hypoleucoides* is not closely related morphologically to any other species in the United States or adjacent Mexico. Chemical evidences corroborate his morphological findings. This species is characterized by a very large rectangular blue spot, which probably consists of spots 5 and 7, on the lower portion of the leaf chromatogram.

Laurifoliae — All five species of the series Laurifoliae (Trelease 1924) are available for the present study. Among these five species, *Q. phellos* is rather different from the other species in their chromatographic patterns. Spot 38, which is believed to be a flavonoid glycoside, is the largest spot in the leaf chromatogram of *Q. phellos* while it is completely absent in the other members of the series. The complete absence of spots 5 and 7 in *Q. phellos* is also unusual in the series. Based on the phenolic characters, *Q. phellos* should probably be excluded from the series.

Nigrae — *Quercus nigra* of the series Nigrae of Trelease (1924) was transferred into series Laurifoliae by Muller (1951). This treatment receives some support from the phenolic data. The chromatographic pattern of *Q. nigra* is generally similar to that of *Q. myrtifolia* of the series Laurifoliae.

Palustres — The leaf chromatogram of *Q. palustres* is characterized by the presence in large quantities of spots 5, 7, 36 and 57. These spots are also found in many species of the series Prinoideae of the white oaks and series Coccineae of the black oaks. There is no close relationship between Palustres and Prinoideae morphologically. However, in external morphology Palustres is rather similar to Coccineae.

Marilandicae — Despite their similarity in morphology, the leaf chromatograms of *Q. marilandica* and *Q. laevis* are rather different. The leaf chromatogram of *Q. laevis* is characterized by the presence in large quantities of spot 25 which is found in trace amounts in *Q. laurifolia,* but not in any of the other species studied. On morphological grounds *Q. arkansana* should belong to this series. The chromatographic pattern of this species is relatively close to *Q. marilandica.*

Pagodaefoliae — Spot 44 is found only in *Q. falcata.* It is also interesting to note that, while other spots are found to be rather constant for all the samples of this species examined, spot 52 and spot 66 are present in large quantity in two samples but completely undetectable in the other two samples studied. This seems to be a good example of chemical polymorphism.

Coccineae — Despite the similarity in morphology, the variation in the chromatographic patterns in this series is rather great. *Quercus coccinea* is especially distinct from the other species of the series. In this species, spots 5 and 7 are completely absent while spot 1 is present in an unusually large quantity. *Quercus shumardii* is characterized by the absence of spots 7 and 16. Although *Q. nuttallii* was treated as a form of *Q. shumardii* by Muller (1942b), the chromatographic patterns of these two taxa are, to a certain extent, quite different.

Ilicifoliae — In spite of the distinct morphological characters, *Q. ilicifolia* does not possess a chromatographic pattern that is noteworthily distinct.

Velutinae — Trelease (1924) treated *Q. velutina* as the sole member of the series while Muller (1951) transferred this species to the series Marilandicae. The present study does not indicate any close relationship in the leaf chromatographic patterns between *Q. velutina* and species of the series Marilandicae.

Chromatographic studies on putative hybrids

Q. × bebbiana — The chromatographic pattern of a sample of *Q. × bebbiana* (Morris Arboretum #163) supports the general belief that *Q. alba* and *Q. macrocarpa* are the two parent species. *Quercus × bebbiana* possesses most of the spots, except for a few minor ones, found in these two putative parent species.

Q. × comptonae — The leaf chromatogram of a sample of *Q. × comptonae* (collected by Dr. Baldwin of the College of William and Mary, Virginia) does not support the belief that *Q. lyrata* is one of the parent species. Spot 46, which is believed to be a flavonoid glycoside, is the largest spot in the leaf chromatograms of *Q. lyrata*. However, this spot is completely absent in the chromatograms of *Q. × comptonae*. The chromatogram of *Q. × comptonae* is in general similar to that of *Q. virginiana*. It is believed that *Q. virginiana* might be one of the parent species of *Q. × comptonae*.

CONCLUSIONS

Phenolic characters of oak species of America as revealed by chromatographic studies of their leaves are found to be indicative in many instances of relationships among the species, and are especially helpful in the grouping of species into series. These characters in general do not seem to constitute a basis for subgeneric division.

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THE INTRODUCTION AND DISTRIBUTION OF *NYMPHOIDES PELTATUM* (MENYANTHACEAE) IN NORTH AMERICA[1]

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Nymphoides peltatum (S. G. Gmelin) O. Kuntze, the yellow floating heart of the Menyanthaceae (or Gentianaceae of some authors), is a species native to southern Europe and Asia Minor. Tutin (1972) gives its range as most of Europe, northwards to England, the Baltic, and northcentral Russia. The plants grow in colonies, are entirely aquatic with alternate floating suborbicular leaves, and when blooming have one or more umbels of 5-merous fringed-petaled bright yellow flowers about 2-4 cm. in diameter. In central United States blooming begins about June and continues throughout the summer until October (Stover, 1932). The plant is illustrated in figure 1. Equivalent names for *Nymphoides peltatum* (S. G. Gmelin) O. Kuntze as used in American botanical literature are *Menyanthes nymphoides* L., *Limnanthemum nymphoides* (L.) Hoffmansegg & Link, *Limnanthemum peltatum* S. G. Gmelin, *Nymphoides nymphoides* (L.) Britton, and *Nymphoides peltatum* (S. G. Gmelin) Britten & Rendle.

Nymphoides peltatum has been introduced into North America where it is planted and cultivated as an ornamental in artificial pools, ponds, and outdoor aquaria. The plants are easily propagated vegetatively, as new plants form readily at the flowering nodes and are easily separated (Dress, 1954). In Canada, the species is known only from cultivation, but in the United States, the plants have escaped and have been found in widely scattered areas in quiet waters of rivers, slow streams, and in still water along wet sandy shores of artificial lakes. Because of the species' sporadic occurrences, either temporarily or permanently, in various localites, most of the common and some of the more recent manuals do not give an adequate description of its distribution in the United States (Fassett, 1940; Muenscher, 1944; Fernald, 1950; Gleason, 1952; Gleason and Cronquist, 1963; Steyermark, 1963; Correll and Johnston, 1970; and Correll and Correll, 1972). This paper brings together data from the literature and herbarium specimens to illustrate the history of *Nymphoides peltatum* in North America. A distribution map (figure 2) based on these sources is presented, and all known herbarium specimens and specimen records seen are cited.

Regional floras and manuals of North America previous to 1890 (for example, Gray, 1867; Gray, 1878; Gray, Watson, and Coulter, 1889 [1890]), do not report *Nymphoides peltatum*. One of the earliest known records of the species

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FIG. 1. — *Nymphoides peltatum.* Reprinted from Walter Conrad Muenscher: AQUATIC PLANTS OF THE UNITED STATES (fig. 137, p. 304). Copyright 1944 by Comstock Publishing Company, Inc. Used by permission of Cornell University Press.

in North America is based on a report by Mr. E. B. Southwick, who showed beautifully preserved specimens that had been grown in New York City's Central Park Terrace Pond in 1886 (Anonymous, 1887). The earliest known herbarium specimen is dated 1882 and comes from Winchester, Massachusetts (*Perkins s.n.*, NY). Another early herbarium specimen is from a fish pond in Washington, D.C., where it was collected in 1890 (*Seaman s.n.*, Herb. F. S. Earle, NY). Later herbarium records dated 1894 and 1895 also from Washington, D.C., are apparently the basis for the report by Pollard (1896), who noted that the plants had become so thoroughly naturalized in ponds of the United States Fish Commission in Washington, D.C., that they covered the surface of their ponds and were spreading into several adjacent ponds. Just how or when the species was brought into the District of Columbia is not known. Further, *Nymphoides peltatum* evidently did not survive because Hitchcock and Stanley (1919) did not report the species for the *Flora of the District of Columbia and Vicinity,* and Metcalf (1922) stated that it was extirpated from the locality cited by Pollard. A year later following Pollard's report, Britton and Brown (1897) in their *Illustrated Flora* noted that *Nymphoides peltatum* was "Naturalized in ponds, District of Columbia." Britton (1901), Robinson and Fernald (1908), and Britton and Brown (1913) continued to carry the same distributional information as did the first edition of Britton and Brown (1897), although the species had been found earlier in Newton County, Missouri, in 1893, Gretna, Louisiana, in 1899, in a pond near St. Louis, Missouri, in 1904, and in a pond in Reading, Pennsylvania, in 1905. The occurrence of *Nymphoides peltatum* in eastern Pennsylvania was first reported by Leibelsperger (1907) who noted that the species was rare in a small pond near Moselm in Berks County, but he was unable to ascertain how it came there. Specimens are also known from that location in 1915. The floating heart has been known from specimens obtained at Keans Lake (also called Elmer's Pond) near Elmer, Salem County, New Jersey, from 1940 through 1955. The species is still present covering a large portion of the lake (Fairbrothers, 1973).

Muenscher (1933) was the first to report *Nymphoides peltatum* from New York state where it was "locally abundant in water to a depth of 2 meters in several places in the Hudson River between Mechanicville and Schuylerville," and where it "apparently . . . [had] been introduced within recent years." Here the plants were "spreading both by seeds and by long narrow rhizomes which root at the nodes." Later, Muenscher (1935) stated that the plants were forming dense beds in shallow water of the Hudson River farther down river between Waterford and North Troy. The earliest record dates from specimens obtained at Waterford on 2 September 1929 by William H. Barker (Muenscher, 1933), and subsequently discussed in greater detail by House (1937). The latter noted that the plants formed wide stretching colonies thickly covered with yellow flowers when he saw them during August of 1936 in the quiet backwaters of the Hudson River, as well as on occasional shallow bars in the main stream itself between Stillwater and Schuylerville. Its origin in the Hudson River, according to House, was unknown, but probably represented "an escape from some artificial or natural

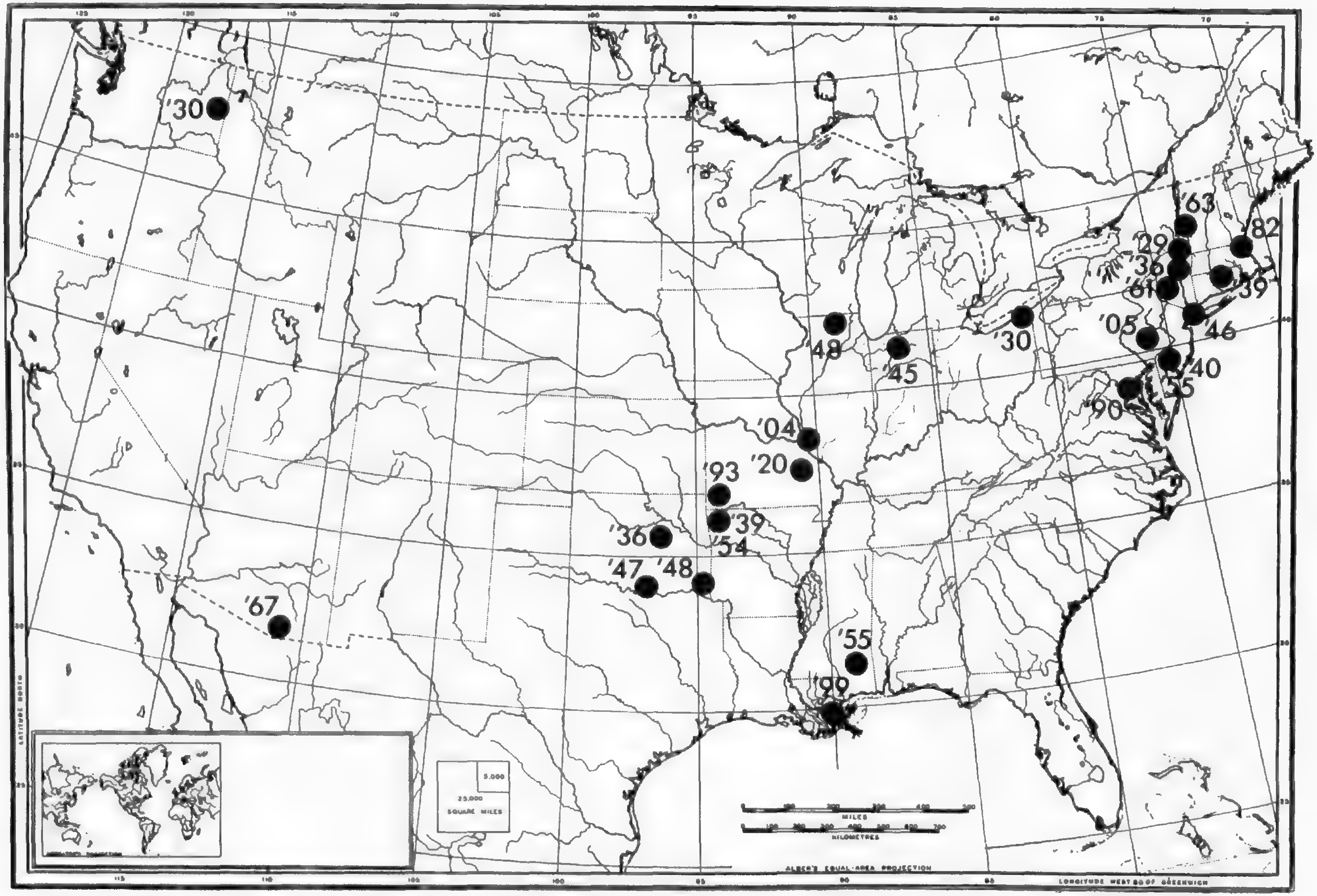

FIG. 2. — Known distribution of *Nymphoides peltatum* (yellow floating heart) in the United States based on herbarium specimens and literature records cited in this paper. The numbers are the last two digits for the year(s) in which plants were collected.

water garden or pool, in which situation it is not infrequently seen in cultivation." McVaugh (1958) further noted its occurrence along the Hudson River at Nutten Hook, Columbia County, in 1936. Herbarium records of the species' occurrence in the Hudson River date from 1929 to 1953. Today, "the plants in the Mohawk-Hudson River area at Waterford . . . cover a large area, are flourishing, and show strong, weedy tendencies" (Ogden, 1973). Outside the Hudson River proper, *Nymphoides peltatum* was observed by House in 1932 in a pond east of East Poestenkill, Rensselaer County, where it was evidently planted (note in Herb. NYS), and was obtained by Dunbar and Smiley in 1961 from a small lake covering about one acre at Mohonk Mountain, Ulster County. In the New York City area, a collection made by Monachino in 1946 confirmed its occurrence in Central Park, and he also noted its occurrence in a swamp in Prospect Park, Brooklyn, 1957 (Monachino, 1958).

In the midwest, *Nymphoides peltatum* was known as early as 1893 and 1904 from two locations in Missouri. Other early records based on specimens date from 1920 in Missouri (Metcalf, 1922), 1930 in Ohio (Schaffner, 1934), 1945 in Indiana (Deam, Kriebel, Yuncker, and Friesner, 1945), and 1948 in Illinois (Fuller, Fell, and Fell, 1949). The Ohio record was originally published as *Brasenia schreberi* Gmel. For some unknown reason, the Illinois record was not reported in the floras of Illinois by Jones and Fuller (1955) or Jones (1950, 1963). In the late 1920's and early 1930's Stover (1932) had plants in cultivation on the campus at Eastern Illinois State Teachers College (now Eastern Illinois University), Charleston, but apparently the plants were never recorded as having ever escaped from cultivation. Mason and Iltis (1965) stated that the yellow floating heart should be looked for in Wisconsin. Steyermark (1963) noted it as naturalized in St. Louis, Iron, and Newton counties in southern and central Missouri, apparently based on the above mentioned records.

In southwestern United States, *Nymphoides peltatum* was first noticed in Oklahoma in October 1935, and first collected in the same month a year later, and then reported by Clark (1938). The plants were growing in a small protected estuary of the then newly created Messina Lake in the wooded park west of Bristow in Creek County. By October 1937, the plants had completely covered the entire estuary and had spread about 100 yards in the shallow waters along the shore across the lake opposite the mouth of the estuary. How the plant was introduced is not definitely known, but Clark suggested three possibilities: (1) The park attendant believed it was planted along with other water plants to provide a spawning ground for fish but had no idea whence the plant had been obtained, (2) the plant was introduced when the lake was stocked with fish, but not known from where, and (3) the possibility of introduction by water fowl because of the light weight of the seeds whose margins have hooked hairs. Steyermark (1963) noted that the plants are sometimes eaten by wildfowl: Additional records for Oklahoma come from Bryan County at Lake Texoma in 1947 (Stratton, 1948) and from McCurtain County at a pond six miles north of Broken Bow in 1948 (Waterfall, 1950). The species is listed for both counties by Waterfall

(1960). In Arkansas, Moyle, Nielsen, and Younge (1946) reported the species from Lake Wedington, near Fayetteville in Washington County. Two years after this lake began to fill, 39 species of aquatic and wet soil plants had become established, among which was *Nymphoides peltatum*. Specimens from this lake and vicinity are dated 1939 and 1954. In Arizona the plant was first found in 1967 at Guevavi Ranch Pond, River Road, 3.7 miles west of Arizona highway 82, Santa Cruz County (Pinkava, Lehto, and Keil, 1969). Correll and Johnston (1970) and Correll and Correll (1972) report it from north central Texas, but no specimens or other reports have been seen.

Isolated occurrences of *Nymphoides peltatum* are further known from the states of Washington at Long Lake, Spokane County, in 1930 (Ornduff, 1963); Mississippi at a small pond near Hattiesburg, Forrest County, in 1955; Connecticut at College Lake in Storrs, Tolland County, in 1939; and Vermont at Lake Champlain near the town of West Haven, Rutland County, in 1963 (Seymour, 1969a, b). *Nymphoides peltatum* has apparently not become established in Canada, not being reported by Boivin (1966-1967), although records are known of its cultivation at St. Vallier, Quebec; Sudbury and Turkey Point, Ontario; and Hope, British Columbia (Gillett, 1963).

An analysis of the documented distribution and history of *Nymphoides peltatum* in North America suggests that the species was separately introduced into many widely scattered localities. Its establishment has been either temporary as in the Fish Commission ponds in the District of Columbia, or permanently as in the Hudson River, New York, or Elmer Pond, New Jersey, for examples. Unfortunately, recent herbarium specimens or literature records from many of the formerly reported localities are not known, and so one must wonder if the species still occurs at these locations.

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Lake Wedington, Oct 1939, *E. L. Nielsen & O. R. Younge A56* (ILL, MINN), 15 Jun 1954, *R. F. Thorne 15521* (NSC); very common in small pond near lake, Lake Wedington area, 14 mi w Fayetteville, Oct 1954, *H. H. Iltis s.n.* (GH). CONNECTICUT: TOLLAND CO.: Naturalized in College Lake, Storrs, 17 Sep 1939, *Travis 1913* (PENN). DISTRICT OF COLUMBIA: Fish Pond near Monument, May 1890, *Seaman s.n.* Herb. F. S. Earle (NY); pond, 7 Aug 1894, *J. W. Fredholm 637* (US); abundantly naturalized in ponds of U.S. Fish Commission, B Street N.W., 27 Sep 1895, *C. L. Pollard 710* (US); abundantly naturalized in two ponds just w U.S. Fish Commission ponds, 23 Sep 1895, *C. L. Pollard 710* (US); pond, 22 Jun 1896, *E. S. Steele s.n.* (MO, NY, US); pond, 26 Jun 1896, *E. S. Steele s.n.* (MINN); U.S. Fish Comm[ission] Ponds, 24 Sep 1896, *D. L. Topping s.n.* (ILL, MINN); sink near [Washington] Monument, 24 Sep 1896, *D. L. Topping s.n.* (US); one of the Fish Ponds, 8 Jul 1902, *G. H. Shull 11* (US); Washington, D.C., Jun 1905, *I. Tidestrom s.n.* (US). ILLINOIS: WINNEBAGO CO.: Cultivated, Kent Creek bottom, w Rockford, 30 Jul 1948, *E. W. & G. B. Fell R48-212* (ILL). INDIANA: MARSHALL CO.: Pond of Maxinkuckee Conservation Club n side highway 10, ca. 2 mi n w Culver, 13 Oct 1945, *W. E. Ricker s.n.* (IND). LOUISIANA: [JEFFERSON PARISH]: Gretna, 12 May 1899, *C. R. Ball 378* (US), cited by Metcalf (1922). MASSACHUSETTS: [MIDDLESEX CO.]: Winchester, 16 Sep 1882, *C. E. Perkins s.n.* (NY). MISSISSIPPI: FORREST CO.: Abundant in small pond, 2 mi s e Hattiesburg, 20 Jun 1955, *J. D. Ray, Jr. 6198* (GH, Univ. Mississippi). MISSOURI: [IRON CO.]: "Abundant in a small pond" (Metcalf, 1922), Ironton, 9 Aug 1920, *F. P. Metcalf 826* (US). NEWTON CO.: Without locality, 15 Jul 1893, *B. F. Bush s.n.* (MO). [ST. LOUIS CO.]: Pond near St. Louis, 21 Aug 1904, *M. W. Lyon, Jr. s.n.* (F, GH, NY, US). NEW JERSEY: SALEM CO.: Floating in shallow water, Elmer Pond, e Elmer, 25 Jul 1940, *B. Long 54872* (PH); dense beds choking large areas on surface of Keans Lake [Elmer Pond], Elmer, 17 Aug 1952, *F. M. Uhler s.n.* (US); floating in mucky pond on route 40, Elmer, 10 Sep 1955, *F. H. Sargent 7349* (GA, NSC). NEW YORK: COLUMBIA CO.: N of Nutton Hook, 13 Sep 1936, *R. McVaugh 4512* (NYS). MANHATTAN CO.: A pest in ponds, Central Park, 12 Aug 1946, *J. Monachino 442* (PENN). RENSSELAER CO.: In 1-3 ft water, Hudson River below Mechanicville, 28 Aug 1932, *W. C. Muenscher & A. A. Lindsey 3541* (CU, F, GH, MINN, US). SARATOGA CO.: Hudson River at Waterford, 2 Sep 1929, *W. H. Barker s.n.* (GH, NYS); well established in Hudson River at Waterford, 15 Sep 1930, *W. H. Barker s.n.* (NY); where the Mohawk enters the Hudson River at Waterford, 22 Aug 1934, *W. C. Muenscher & R. T. Clausen 4548* (CU, MO, PH, US); in Hudson River, Mechanicville, 7 Aug 1938, *W. C. Muenscher & O. L. Justice s.n.* (BH, CU, F, FLAS, GH, ILL, IND, MICH, MO, NCU, NSC, NY, NYS, PENN, PH, US); Mechanicville, 1 Sep 1946, *W. Manning s.n.* (NSC); Coreville, 20 Jul 1948, *D. G. Huttleston s.n.* (NYS); moving backwaters of the Hudson, 14 Jul 1953, *G. R. Cooley 1914* (GA). ULSTER CO.: Small lake, Mohonk Mountain, 4 Oct 1961, *H. F. Dunbar & D. Smiley 1309* (NYS). WASHINGTON CO.: In the Hudson River along the e shore below Schuylerville, 27 Jun 1932, *W. C. Muenscher & A. A. Lindsey 3540* (CU, GH, NYS, US); Hudson River above Stillwater, town of Easton, 26 Aug 1936, *H. D. House 23947* (CU, GH, NY, NYS, PENN, SYR); above Stillwater, 19 Jul 1948, *S. J. Smith & D. G. Huttleston 4500* (NYS). OHIO: ASHTABULA CO.: Mouth of Conneaut River, 15 Jul 1930, *L. E. Hicks s.n.* (OS). OKLAHOMA: BRYAN CO.: On sandy loam shore of Lake Texoma, Sandy Point Homesite, 13.7 mi s w Durant, 19 Aug 1947, *W. T. Nailon s.n.* (GH); sandy loam, shore of Lake Texoma, s Sandy Point Home Site, 11 mi s w Durant, 20 Oct 1947, *R. Stratton 6730* (GH). McCURTAIN CO.: In pond, 6 mi n Broken Bow, 9 Aug 1948, *U. T. Waterfall 8503* (OKL), cited by Waterfall (1950); small muddy pond, 5 mi n Broken Bow, 13 Oct 1957, *W. R. King 124* (NCU). PENNSYLVANIA: BERKS CO.: In a pond, Reading, 23 Aug 1905, Herb. H. L. Fisher *s.n.* (PH); abundantly naturalized in a small pond 1 mi e Moselem, 4-6 Jul 1915, *B. Long 12761* (PH); near Moselem, 25 Jul 1915, *W. H. Leibelsperger 394* (PH). VERMONT: RUTLAND CO.: Shallow water, Lake Champlain, near channel marker 21, e shore, Maple Bend, town of West

Haven, 5 Sep 1963, *W. D. Countryman s.n.* (NEBC). WASHINGTON: SPOKANE CO.: Long Lake, 12 Oct 1930, *W. H. Ransom s.n.* (US).

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SUBSTRATE CONDITIONS, COMMUNITY STRUCTURE AND SUCCESSION IN A PORTION OF THE FLOODPLAIN OF WISSAHICKON CREEK

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In the fall of 1971 an intensive analysis was made on the Wissahickon Creek floodplain in the Penllyn Nature Area, Montgomery County, Pennsylvania, to determine interrelationships among the substrate conditions, community structure, and succession in the floodplain environment. Wissahickon Creek rises east of Lansdale, Pennsylvania and flows southwesterly, approximately twenty-two miles, into the Schuylkill River in Philadelphia. The Penllyn Nature Area is a seventeen acre portion of the Wissahickon Creek floodplain located about eight miles from the headwaters of the stream. The history of the area is one of disturbance. About 1700, large portions of this floodplain were cleared and used for agricultural purposes. The present composition of the vegetation indicates the area has been cut for timber several times since then.

METHODS

Field work, conducted from August 1971 to February 1972, began with ground reconnaissance of the area. In late August, Ektachrome and flase-color infrared aerial photographs were taken of the site from altitudes of 800 and 2000 feet to aid in the field work and to provide the foundation of a base map. The area was surveyed for elevation using a hand level and rod, and the information was used to construct a detailed topographic map.

The first phase of the vegetation study consisted of a qualitative determination of the communities present based on the occurrence and frequency of dominant canopy and sub-canopy species. The names of the various stands are based on both canopy species and new growth to facilitate the explanation of the succession at Penllyn. No quantitative work was done in the shrub, vine, or herb strata. Estimates on the abundance of these species were based on frequency (Phillips, 1959).

A grid at a scale of 10 × $10m^2$ was superimposed on the aerial photographs. Points on this grid were selected from a random numbers table for each community, and these points formed the southwest corners of 44 sampling quadrats. Sampling was terminated when the number of species encountered in the quadrats included all those listed in the qualitative survey for that community.

All woody species were grouped into three diameter classes. Stems less than or equal to .96 inches dbh (diameter at breast height) make up the small diameter class (sdc); the medium diameter class (mdc) includes all stems between .96 and 3.96 inches dbh; and the large diameter class (ldc) refers to stems greater than or equal to 3.96 inches dbh. Ten × $10m^2$ quadrats were used for all specimens greater than .96 inches dbh, and 1 × 4m^2 nested quadrats were used for specimens in the sdc. The number and dbh were recorded for specimens in the mdc and ldc. Only the number of specimens in the sdc was recorded. These data were used to compute density, frequency, basal area, relative density, relative frequency, relative basal area, and importance values for each species in each diameter class for each community (Curtis, 1956). Importance values for specimens less than .96 inches dbh were computed by adding relative frequency to relative density and dividing the sum by two.

In November 1971, the ground at Penllyn was bored at each quadrat location to determine horizon structure, color, and texture of the profile to a depth of 3 feet. Depth to seasonal high water table was also recorded. A composite sample of the soil was mixed at each quadrat by taking 4 separate samples from the top 4 inches of soil inside the boundaries of the 10 × 10m^2 area. Each of these quadrat composite soils was analyzed at the Merkle Laboratory of the Pennsylvania State University for pH, cation exchange capacity (CEC), milliequivalents of available magnesium (Mg), potassium (K), calcium (Ca), and pounds per acre of phosphorous (P). Pounds per acre units were converted to milliequivalents per 100 grams. Composites were also made of the soils for each plant community. Equal amounts of soil were taken from each quadrat in a community, mixed, and analyzed for pH, CEC, milliequivalents of Mg, K, Ca, pounds per acre of P, and percent organic matter content. In addition these composite soil samples from each community were subjected to a mechanical analysis (Bouyoucos, 1951), and the percentage of sand, silt, and clay of each was determined.

The Spearman Rank Correlation Coefficient (rho) (Yamane, 1967) was computed for all relationships with a 10% or less level of significance (Olds, 1938, 1949). This test allows discovery of both statistically significant relationships and the direction of covariability between two variables with as few as four observations.

Rank order correlations were calculated between importance value of all tree species in each community for each diameter class and community composite soils data. The basal area for each species within a quadrat was then rank ordered with values for pH, Ca, Mg, P and K, CEC and depth to water table in that quadrat. Basal area was computed in part from measured dbh values. To obtain a more accurate estimate of the total basal area of any given species, an average value of .375 inches diameter was assigned to all specimens occurring in the sdc.

COMMUNITY DESCRIPTIONS

The qualitative survey revealed eight distinct forest communities (Figure 1). Several of these communities are found in more than one location in the Penllyn nature area. Quantitative methods, carried out for seven of the eight communities, provided results that substantiated the qualitative survey results. Table 1 gives the importance values for woody species in the entire area and in each community. A more complete listing of vegetation data is given in Sollers (1972).

Swamp white oak — This community has widely-spaced canopy species with dense weed growth in the clearings. The area closely resembles a savannah in

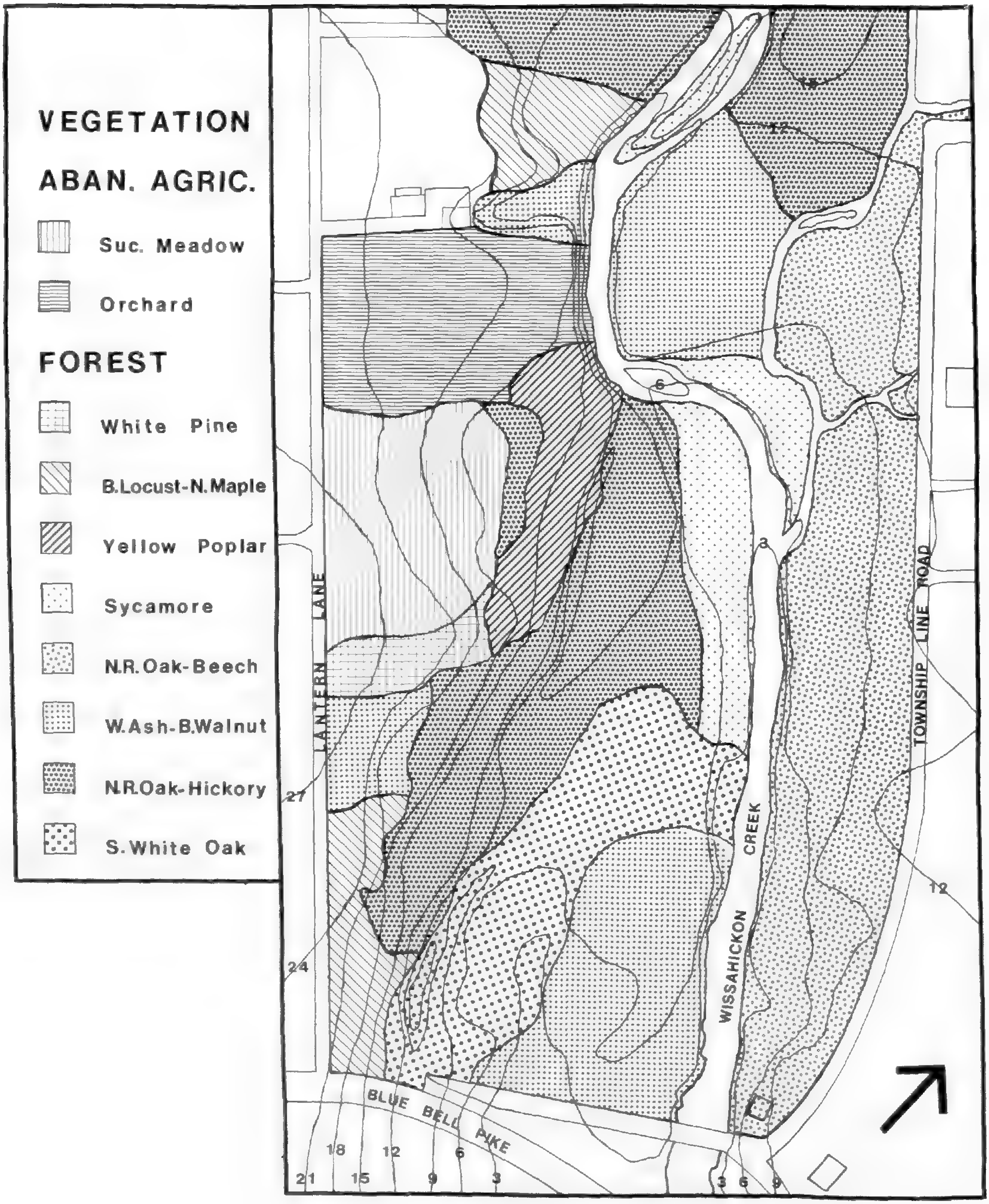

FIG. 1. — Vegetation of the Penllyn Nature Area.

appearance. Because of the open nature of the community, no quantitative sampling was done. Associated with the swamp white oak (*Quercus bicolor*) are slippery elm (*Ulmus rubra*), black walnut (*Juglans nigra*), and white oak (*Quercus alba*). Several mdc plants of the associated species are present but are scattered and infrequent. Lianas such as grape vine (*Vitis sp.*), wild cucumber (*Echinocystis lobata*), and bur cucumber (*Sicyos angulatus*) flourish. The herbaceous layer is dominated by giant ragweed (*Ambrosia trifida*), growing to heights of 10 feet in late summer, with scattered plants of dock (*Rumex sp.*).

Red oak-hickory — This community is found in three locations on the site. Northern red oak (*Quercus borealis*) is the dominant canopy species followed by white ash (*Fraxinus americana*). Shagbark hickory (*Carya ovata*) and shellbark hickory (*Carya laciniosa*) combined are third in importance in the largest diameter class. Red maple (*Acer rubrum*) is a major associated species in the community.

N. red oak is well represented in the mdc; however, no small size specimens were encountered in the sampling quadrats. Both species of hickory are successfully competing in the sdc. Norway maple (*Acer platanoides*) occurs as a minor associated species in the two largest diameter classes, but it is the dominant species in the sdc. These sdc specimens, however, appear in dense clumps when encountered in the 1 × $4m^2$ nested quadrats. Several specimens of ironwood (*Ostrya virginiana*) and flowering dogwood (*Cornus florida*) were found in the mdc. Throughout this community spice bush (*Lindera benzoin*) is abundant. Japanese honeysuckle (*Lonicera japonica*) is encountered occasionally.

White ash-black walnut — This community exists in four separate locations. White ash is the dominant canopy species and is well represented in the smaller diameter classes. Black walnut, planted in the 1800's when Blue Bell Pike was used as a mill road (Isodore C. Mineo, personal communication), is second in dominance to white ash in the canopy strata. Black walnut is not reproducing successfully. Several mdc specimens were found in this region in the qualitative survey but none in the sampling quadrats. Red maple and slippery elm are the major associated species. Several specimens of yellow poplar (*Liriodendron tulipifera*), beech (*Fagus grandifolia*), norway maple, wild black cherry (*Prunus serotina*), and hickory occur and may be considered minor associated species for the ash-walnut community. Many n. red oak and hickory sdc specimens were found in these locations but neither is well represented in the larger diameter classes. A clone of hawthorn (*Crataegus sp.*) was found in the stand that borders the southwestern bank of the stream. The hawthorn occurred only in the mdc and sdc. Japanese honeysuckle is very abundant throughout the stands with occasional specimens of spice bush and rare occurrences of sumac (*Rhus copallinum*).

N. red oak-beech — This community is located along the eastern side of the nature area. N. red oak is the dominant canopy species. White ash and yellow poplar species have higher importance values than beech; however, the ash and poplar are widely scattered and fewer in number. The high importance values therefore must be due to the large basal area of the specimens encountered. Yellow poplar is present only in the canopy and no evidence of new growth of

TABLE 1.— Importance Values for Woody Species in the Penllyn Nature Area.

	Entire Area			Oak-Hickory			Ash-Walnut			Oak-Beech		
Species	ldc	mdc	sdc	ldc	mdc	sdc	ldc	mdc	sdc	ldc	mdc	sdc
Fraxinus americana	22.12	7.23	4.19	20.15	15.86	5.69	54.16	7.72	4.61	16.74		12.85
Quercus borealis	11.31	5.42	5.60	28.62	12.92				9.16	22.02		17.69
Liriodendron tulipifera	10.07	.84	.60	4.77			3.87	3.71		16.30		
Ulmus rubra	8.33	10.37	3.78	6.67	7.96	2.31	9.55	23.56	14.52	2.55	5.67	
Acer rubrum	8.29	19.96	1.83	10.95	20.00	2.31	10.31	9.42		9.27	31.79	5.05
Robinia pseudoacacia	6.40			2.30								
Acer platanoides	6.32	14.23	56.25	3.25	2.98	44.36	2.80	9.14	22.34			15.79
Platanus occidentalis	6.06											
Prunus serotina	3.48	7.04	7.12	3.37	6.48	14.91	2.59	14.90	20.58			2.26
Carya laciniosa	3.16	1.19	3.93	6.15		15.68		3.23	1.70			6.85
Fagus grandifolia	2.96	7.01	2.91			3.37	3.00	3.13		12.68	28.52	17.84
Carya ovata	2.73	7.67	5.41	7.73	10.17	6.87	2.31	9.44	8.37		2.76	6.50
Quercus alba	2.48	.51	.46	4.26	2.10					8.85		2.44
Juglans nigra	1.88						11.40					
Pinus strobus	1.50											
Cornus florida	.80	6.57	1.84		3.31					5.08	20.51	10.45
Carya tomentosa	.61									3.69		
Ulmus americana	.50	.68		1.79				3.03				
Prunus virginiana	.45	1.31	.45		5.12					2.77		
Sassafras albidum	.40	3.41	.60					3.11	3.21		3.00	
Ostrya virginiana		2.97	1.90		9.83				7.98		3.29	
Vibernum prunifolium		1.52	2.60		3.13	4.46		3.28	4.97			2.26
Crataegus		1.43	.53					6.32	2.44			
Prunus pennsylvanicus		.84									4.45	
Acer negundo		.66										

TABLE 1 (*Continued*). — Importance Values for Woody Species in the Penllyn Nature Area.

Species	Sycamore			Yellow Poplar			Locust-Maple			White Pine		
	ldc	mdc	sdc	ldc	mdc	sdc	ldc	mdc	sdc	ldc	mdc	sdc
Fraxinus americana	19.65			9.41	17.46	8.95	11.45	4.55	4.36	13.52		10.24
Quercus borealis	3.87		22.97		27.70	18.67					7.32	
Liriodendron tulipifera	8.26			70.78		14.12						
Ulmus rubra	7.89			9.50			16.36	9.27	4.17	8.15	13.63	
Acer rubrum	10.20	42.43		10.30	11.42	5.00	2.53	13.96			15.48	
Robinia pseudoacacia							32.91					
Acer platanoides		8.31	38.52		16.94	18.67	24.38	62.87	82.74	8.00	22.64	57.56
Platanus occidentalis	38.00											
Prunus serotina	3.00	29.91	22.97		7.43		4.50			12.76		10.24
Carya laciniosa	5.97						5.58	4.55	8.73			
Fagus grandifolia	3.16	8.31										
Carya ovata			7.78		19.02	19.07		4.77		8.12	6.73	21.96
Quercus alba												
Juglans nigra												
Pinus strobus										41.38		
Cornus florida											7.96	
Carya tomentosa												
Ulmus americana												
Prunus virginiana			7.78									
Sassafras albidum										8.04	26.24	
Ostrya virginiana						9.56						
Vibernum prunifolium						6.19						
Crataegus												
Prunus pennsylvanicus												
Acer negundo		11.04										

poplar was recorded. Beech has the greatest success reproducing itself, followed closely by n. red oak and white ash. Numerous specimens of flowering dogwood were found in the sub-canopy strata. Flowering dogwood is well represented in all diameter classes. White oak is an associated species and is reproducing in the sdc.

The shrub strata for the community is dense and diverse. Spice bush is the most abundant, followed closely in occurrence by privet (*Ligustrum vulgare*). Arrow-wood (*Viburnum dentatum*) and black haw (*Viburnum prunifolium*) are frequently present, and sumac is occasional. As expected in an oak-beech community the litter is quite deep (3 to 6 inches). The herbaceous layer is very open in contrast to other communities.

Sycamore — This community is found in three locations at Penllyn. Sycamore (*Platanus occidentalis*) has taken firm root and grown to large size trees (example: 35 inches dbh, 30 feet tall) on these sites. Major associated species are white ash and red maple. Minor associated species include yellow poplar, slippery elm, shellbark hickory, n. red oak, beech, and wild black cherry. All three of the sites for this community have sparse canopies. There are only a few plants of red maple, beech, wild black cherry, and norway maple present in the mdc and even fewer in the sdc. Sycamore, white ash, yellow poplar, slippery elm, and shellbark hickory are not reproducing at all. N. red oak, wild black cherry, norway maple, shagbark hickory, and choke-cherry (*Prunus virginiana*) are represented in the sdc but are few and widely spaced. The three sites are all scoured by flooding waters and have no significant number of shrubs or herbs.

Yellow poplar — This community exists adjacent to the n. red oak-hickory stand that borders the meadow. Yellow poplar completely dominates the canopy. Sub-canopy species include red maple, slippery elm, and white ash. There are no yellow poplars in the mdc. N. red oak and shagbark hickory dominate this size class. Yellow poplar appears in the sdc but is competing with shagbark hickory, n. red oak and norway maple. Specimens in the sdc are very numerous and widely dispersed in the stand. Spice bush is an abundant shrub throughout the stand and Japanese honeysuckle is a frequent vine.

Black locust-norway maple — This community is found in two locations on the site. The stand in the southwest corner of Penllyn can be divided into two halves based upon the occurrence of spice bush. Norway maple seedlings (specimens less than 1 inch dbh and less than 1 foot in height) form a virtual carpet in the shrubless southern half of this stand. This half has the oldest locust (*Robinia pseudoacacia*) specimens, each averaging about 100 feet in height and 20 inches dbh. The norway maples in this half are much younger than the locust. They average 50 feet in height and 10 inches dbh.

The northern half has a dense omnipresent shrub layer of spice bush. Associated with spice bush is Japanese honeysuckle. Here, the black locusts are younger relative to those in the southern part. These specimens average 75 feet in height and 13 inches in diameter. The norway maples in this half are infrequent, scattered and younger relative to the maple specimens encountered in the southern portion.

The second stand of this community, located in the northern portion of the floodplain bordering the west stream bank, is dominated by norway maple. There are no overstory specimens of black locust remaining, although the qualitative survey revealed that there are several locust seedlings in this stand.

Associated species in both stands of this community are slippery elm, white ash, shellbark hickory, wild black cherry, and red maple. All except wild black cherry seem to be reproducing. Norway maple dominates the mdc and sdc. Only scattered specimens of other species occur.

White pine — This community borders Lantern Lane and is adjacent to the southern side of the goldenrod (*Solidago sp.*) meadow (Fig. 1). Eastern white pine (*Pinus strobus*) dominates the canopy, averaging 55 feet in height and 26 inches in diameter. The largest specimen is 67 feet tall and 23 inches dbh. Associated species are white ash, wild black cherry, slippery elm, shagbark hickory, sassafras (*Sassafras albidum*) and norway maple. The understory also includes some flowering dogwood and white oak, both in the mdc. All of these associated species are reproducing in this stand, but the pine has no representatives in the two smaller diameter classes. The ground is heavily matted with pine needles and herbaceous species are very sparse. Poison ivy (*Rhus radicans*) vines cling to most of the pine specimens and have grown to impressive diameters (3 inches). Virginia creeper (*Parthenocissus quinquefolia*) is common throughout the stand.

Field results from all 44 quadrats show that ash is the single most important canopy species present with major associated species including n. red oak, yellow poplar, slippery elm, and red maple. Several other species exist in the largest diameter class but are failing to reproduce themselves (Table 1). These include black locust, sycamore, black walnut, eastern white pine, and mockernut hickory (*Carya tomentosa*). Only one boxelder (*Acer negundo*) specimen was encountered in any of the 44 quadrats. This specimen has a dbh of 2.5 inches.

The mdc is dominated by red maple and norway maple. The sdc is heavily dominated by norway maple. Although this maple does not exhibit a high survival rate in the larger diameter classes, its effective replacement of seedlings of other species is carried out by sheer numbers alone.

Throughout the floodplain the dominant shrub is spice bush with scattered specimens of arrow-wood, blackhaw, privet, and japanese barberry (*Berberis Thunbergii*). The most abundant lianas are poison ivy, grape vines, japanese honeysuckle, wild cucumber, and bur-cucumber respectively. There are numerous herbaceous species found throughout the floodplain, the most conspicuous of which are giant ragweed, jewelweed (*Impatiens sp.*), garlic (*Allium sp.*), and May-apple (*Podophyllum peltatum*).

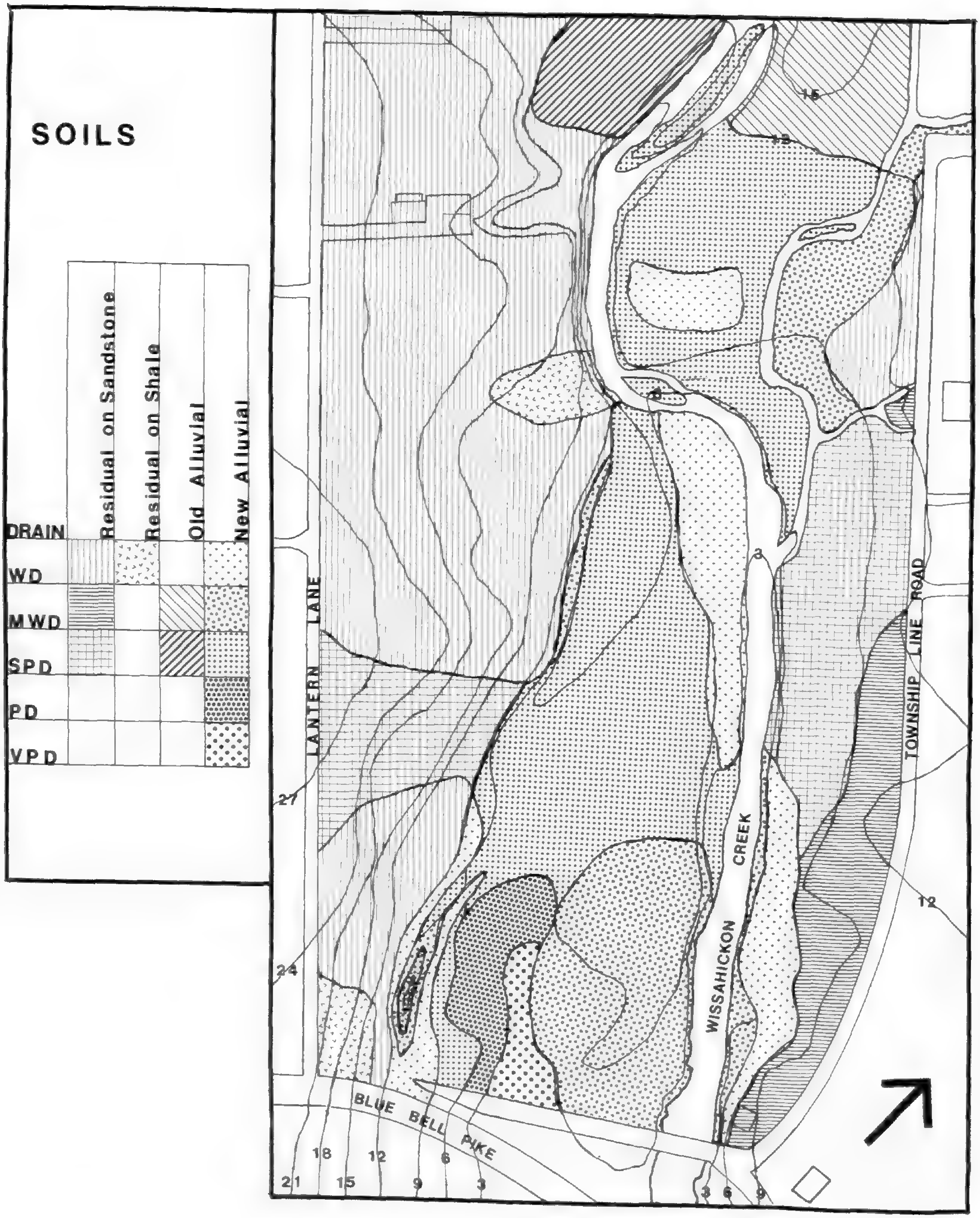

FIG. 2.—Soils of the Penllyn Nature Area. WD = well drained; MWD = moderately well drained; SPD = somewhat poorly drained; PD = poorly drained; VPD = very poorly drained.

SOIL DESCRIPTIONS

There are two major categories of soils in the Penllyn Nature Area (Fig. 2). The first is residual soil overlying bedrock, and the second is alluvial soil. Residual soils are found on terraces or abandoned floodplains. These soils are further defined by the type of bedrock associated with the soil. In Penllyn both sandstone and red shale are present; however, shale is confined to two small areas in the floodplain. These soils are also classified by drainage. Well drained (seasonal high water table greater than 3 feet) residual soils in the Penllyn area have profiles that closely approximate those described in the Soil Survey of Montgomery County for the Lansdale series (U.S.D.A. 1967). Moderately well drained (seasonal high water table between 2 and 3 feet) residual soils fall in the Lawrenceville series, and finally, somewhat poorly drained (seasonal high water table between 1 and 2 feet) are in the Chalfont series.

Older alluvial soils have ceased to be directly acted upon by the stream and show some pedogenic soil horizons. Old alluvial soils will evolve into terraces as more sediment is deposited and the stream continues to cut into its bed unless the meander pattern or migration direction of the stream is altered. New alluvial soils are presently being acted upon by the stream, are inundated at recurrent flooding intervals, and show only stratigraphic sedimentary layering. The SCS also describes alluvial soils on the basis of drainage and profile (U.S.D.A. 1967). The well drained alluvium is in the Bermudian series, moderately well drained in the Rowland series and somewhat poorly to very poorly drained (seasonal high water table between 6 inches and the surface) in the Bowmansville series.

The tests for chemical and particle size distribution made on the soils samples produced results in general agreement with similar analyses done elsewhere (Hanks, 1972). No excessive nutrient concentrations were found. The general pattern is that nutrient concentrations are moderate in shallow, moderately well drained soils and deficient in deep, well drained soils. Fig. 3 graphically illustrates the results of the analyses of the community composite soils samples. Results of the chemical analysis of quadrat composite soils, averaged by community, compared closely with the community composite soils results (Sollers, 1972).

Results of the mechanical analysis of the community composite samples revealed that silt loam is the dominant soils configuration found in the swamp white oak, oak-hickory, ash-walnut, and oak-beech communities. These communities occupy the majority of area in Penllyn. Loamy soils were found for the sycamore, yellow poplar and locust-maple communities, with sandy loams being found in the white pine stand. In general, larger sized grains of material were found in the natural levees and the terraces with finer grained materials making up the remaining alluvial soils. This lateral stratification is fairly typical for the floodplain environment (Lindsey, 1961).

RANK ORDER ANALYSIS

Table 2 lists the results for the rank order analysis between importance values

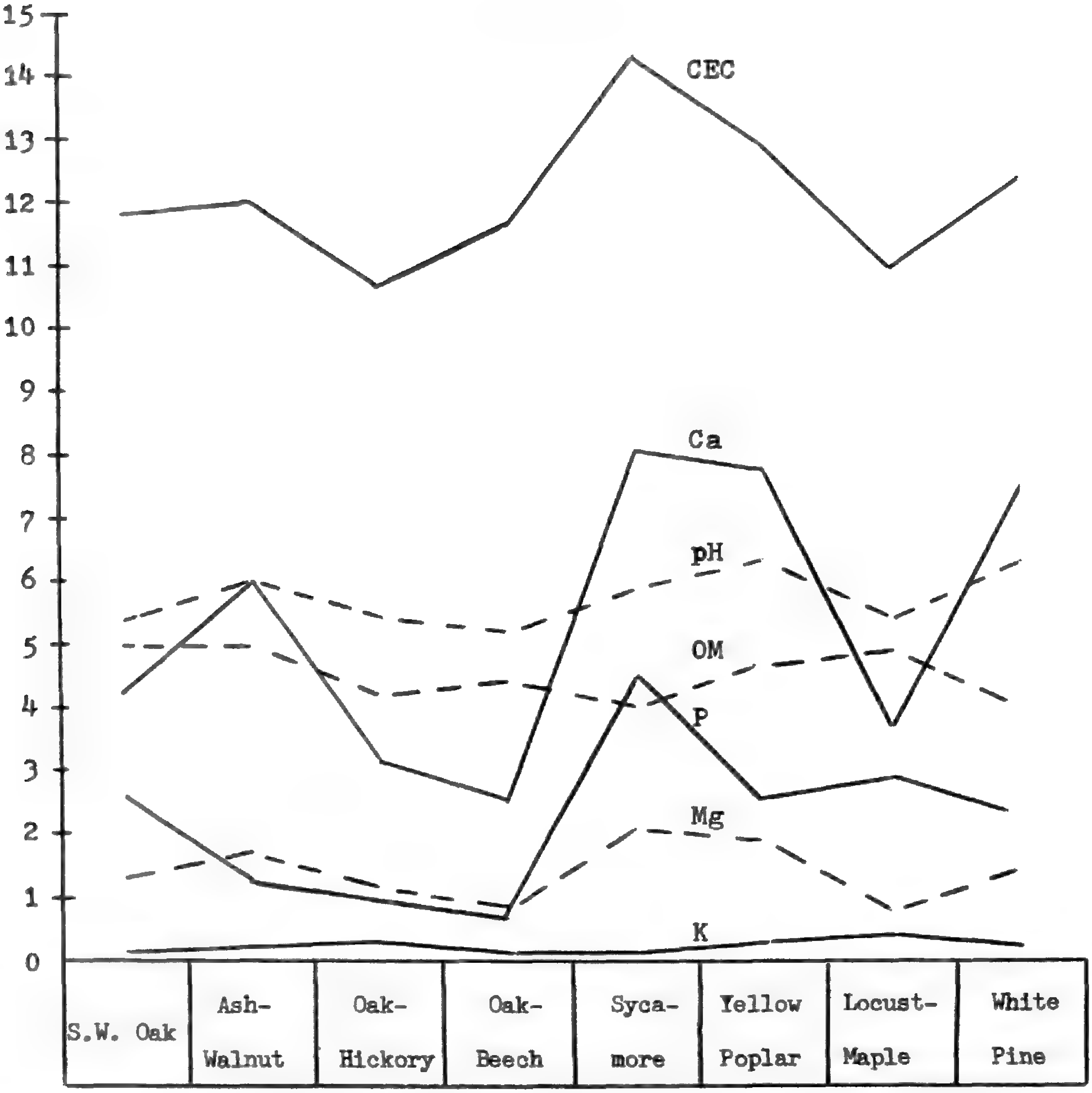

FIG. 3. — Community composite soils nutrient levels. Units on the calibrated ordinate vary for the different soil parameters: the values for Mg, K, Ca, P and CEC are expressed in milliequivalents per 100 grams; the level of OM content is expressed as a percentage; and the pH of the soil is the logarithm of the reciprocal of the H ion concentration.

for the three diameter classes and community composite soils samples data. It became evident that more relationships existed between species in the sdc than in the larger diameter classes. All the variables tested for in the chemical analysis were correlated with at least one species in the floodplain. Slippery elm and blackhaw appear to be affected by more variables in the soil than any of the other species. Rank ordering using the results of the mechanical analysis revealed no relationships.

TABLE 2. — Rank Order Results of Importance Values and Community Soil Data

Species	Diameter Class	Variable	Rho Coefficient
Acer platanoides	— sdc	K	.82
Ulmus rubra	— mdc	pH	.85
		Mg	.85
		Ca	.90
	— ldc	OM	.51
Prunus serotina	— sdc	Mg	.90
	— mdc	K	— 1.00
Carya laciniosa	— sdc	CEC	— 1.00
Acer rubrum	— mdc	pH	— .57
		OM	— .61
Carya ovata	— sdc	pH	.97
	— mdc	Mg	.80
Viburnum prunifolium	— sdc	pH	1.00
		P	1.00
		Mg	1.00
		Ca	1.00
Fraxinus americana	— sdc	OM	— .66

Many more relationships were revealed between quadrat composite soils data and basal area values (Table 3) than for importance value and community soils data. All variables tested in the quadrat soils data were related to at least two species in the floodplain. In this test, flowering dogwood, sycamore, white and red oak, and wild black cherry are affected by more parameters than other species in the floodplain.

In general, it is evident that no one physical or chemical factor is limiting for the occurrence or growth of vegetation in the floodplain.

STREAM MIGRATION

Fig. 4 depicts the location of the old stream course and the direction of stream migration in the Penllyn Nature Area. At present, the stream is lengthening its course by further developing its meander pattern. The stream is migrating to the west in the northern section of Penllyn by constantly undercutting the west bank, thereby improving internal drainage. In the southern half the stream is depositing gravelly material on the west bank and is undercutting the east bank. This present migration pattern was probably initiated when the stream cut through sandstone deposits into more resistant shale.

Soil borings performed in the new alluvium reveal that soil deposited when the stream exceeded bankfull stage is now several feet thick and overlies a gravelly substrate that in the past served as a stream bed. Tracing the present migration pattern back across this alluvium to the terrace marks the pathway of the old stream course.

TABLE 3. — Rank Order Results of Basal Area and Quadrat Soil Data

Species	Variable	Rho Coefficient
Robinia pseudoacacia	pH	— .68
	Mg	— .71
Carya laciniosa	Mg	.46
Ostrya virginiana	Ca	— .85
Cornus florida	P	— .83
	K	— .63
	Ca	— .94
	WT *	— 1.00
Platanus occidentalis	pH	.90
	P	1.00
	Mg	.90
	Ca	.90
Liriodendron tulipifera	CEC	.56
Quercus alba	K	.70
	Mg	.75
	CEC	.85
Fagus grandifolia	K	— .51
	WT	.76
Prunus serotina	pH	.42
	P	.63
	K	.56
	Mg	.39
Ulmus rubra	P	.59
Quercus borealis	pH	— .43
	Mg	— .58
	Ca	— .45
	WT	— .56
Acer rubrum	P	.37
	WT	— .60
Acer platanoides	P	.57
	K	.58

* WT = Depth to seasonal high water table

Relationships Between Vegetation And Substrate Conditions

Norway maple — The total basal area of all size classes and importance value of the sdc specimens vary directly with the concentration of K. Of those communities that have norway maple, the oak-beech community, where K concentrations are the lowest, supports the fewest number of their seedlings. Conversely, norway maple is most abundant in the locust-maple community, where the rapidly decomposing black locust litter provides the highest K concentrations found in the floodplain. However, in sections of this community, spice bush forms a thicket that prevents the introduction of norway maple seedlings. I suspect that a slight variation in moisture conditions has created a more favorable site for spice bush

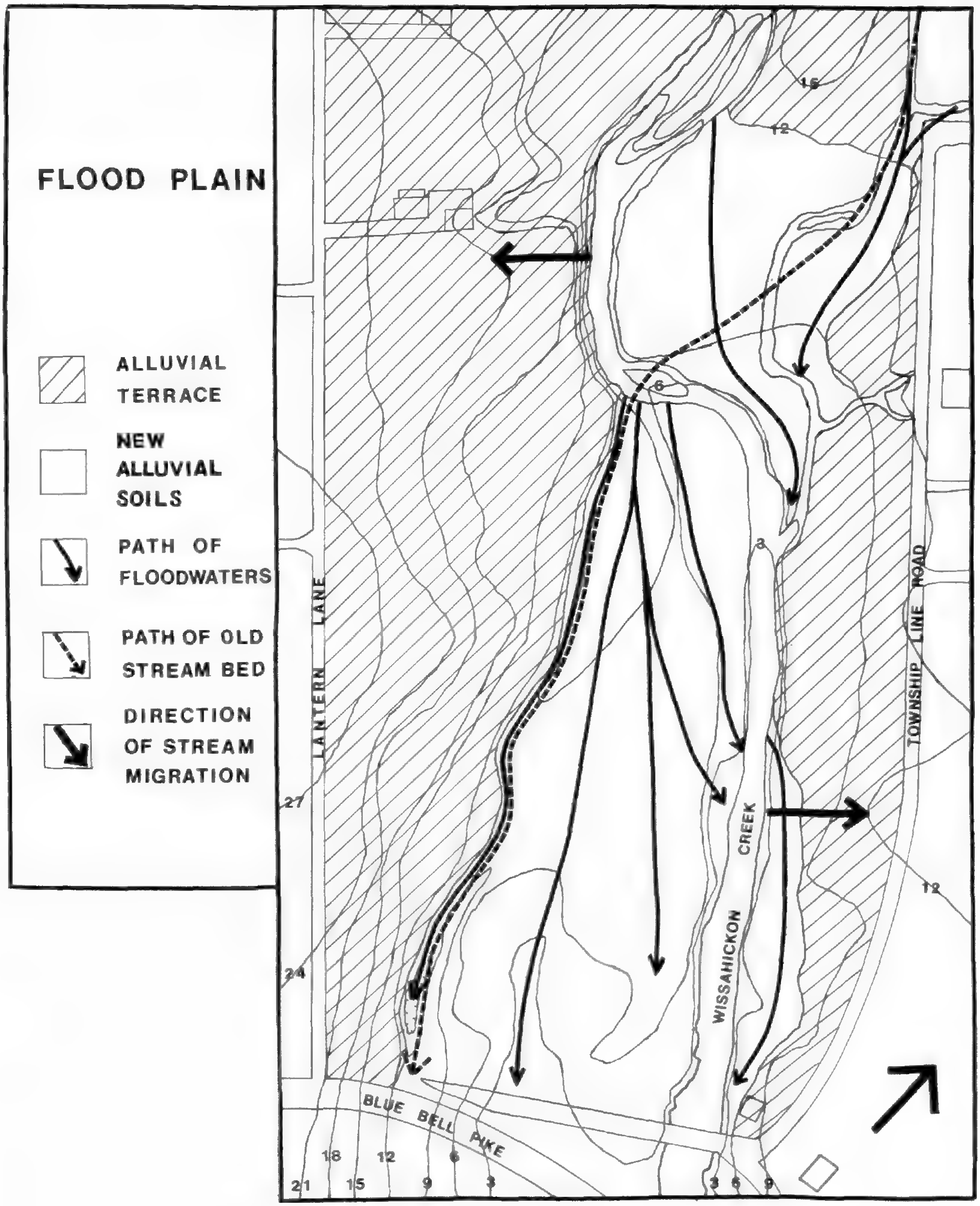

FIG. 4. — Floodplain of the Penllyn Nature Area.

than for norway maple. Therefore, moisture and availability of K in the soil both appear to be guiding factors for the site selection of norway maple.

Slippery elm — The relationships found for slippery elm indicate that this species favors sites with rich alkaline soils that are high in organic matter content. Slippery elm is generally considered to favor moist rich soils of lower slopes and stream banks (Fowells, 1965). As organic matter increases, so does the moisture holding capacity of a given soil; therefore, since elm prefers soils high in moisture, it follows that it would do best on sites with greater organic matter content.

Shellbark hickory — Specimens in the sdc are negatively correlated with CEC. Since CEC and pH vary directly (Buckman and Brady, 1969), an increase in acidity would induce an improvement in the importance value of shellbark hickory. Also, its basal area values are positively correlated with Mg concentrations, indicating that hickory prefers rich soils. Results from another site preference study (Fowells, 1965) indicate that shellbark hickory prefers neutral or alkaline soils; but the soils tested at Penllyn are slightly to moderately acidic, demonstrating the tolerance of this species to variations in pH.

Red maple — The basal areas of red maple are negatively correlated with depth to water table, indicating that this species favors bottomland soils with a high water table. The quantitative survey reveals that red maple does well in the moist red oak-hickory, ash-walnut, and swamp white oak soils. It is also reproducing in the well drained sycamore and yellow poplar communities. However, red maple is doing best overall in the nutritionally poor soils of the oak-beech community where moisture conditions are becoming dryer due to improved internal drainage. The results of the rank ordering indicate that red maple prefers slightly acidic soils and tolerates low concentrations of nutrients. Red maple provides much litter, but because this species takes up a dearth of nutrients for normal growth its litter is low in nutrients (Fowells, 1965). The deep litter layer from red maple and the oaks, providing the deep mat which oak seeds require for germination, is no impediment to the red maple seeds. These factors account for the high association of red maple with the n. red oak-hickory community.

N. red oak — This species also prefers moist areas, slightly acidic conditions, and tolerates low nutrient concentrations. Although n. red oak has high overall importance values (Table 1), its occurrence is restricted. Tree sized specimens exist mostly in the oak-hickory and oak-beech communities. Specimens of n. red oak in the sdc are being inhibited by the more prolific red maple in the oak-beech communities but have done well in the oak-hickory stands. N. red oak is invading the yellow poplar community with such success that as edaphic conditions continue to vary, it should emerge as a dominant in the resultant stand.

American beech — This species is positively correlated with the depth to seasonal high water table and tolerates low concentrations of K. Beech appears to be best suited to the well drained loam soils of the alluvial terrace. It is best represented in the well drained oak-beech community where sucker growth represents the greater faction of its reproduction. Beech seedlings are present in the northeastern stand of the oak-hickory community but are not maturing successfully due to present soil conditions. Beech will invade this sector of the nature area as soils evolve to drier and better drained conditions resulting from stream migration. Although mdc beech specimens exist in the ash-walnut community, there is no evidence to suggest that beech will continue to invade this stand. These specimens are probably sucker growth from the mature individuals, and no seedlings were recorded in the ash-walnut stand in the qualitative or quantitative vegetation surveys.

White oak — The basal area of white oak is positively correlated with K, Mg, and CEC. An increase in CEC signifies a decrease in the H^+ ion availability. These H^+ ions are being adsorbed on the colloidal surfaces of soil particles, thereby releasing K and Mg for their eventual uptake by white oak. White oak is found in the nutritionally poor soils of the oak-beech community but its seedlings are most successful in the nutritionally richer oak-hickory community.

Flowering dogwood — This species was found to be negatively correlated with the depth to water table. A negative rho normally would mean that as the water table rises indefinitely, a species would be even more successful in that site. However, in this case, the negative rho applies to a certain range of water table levels. Dogwood specimens were found only on somewhat poorly to well drained soil conditions; therefore the negative rho does not pertain to poorly or very poorly drained soils. This test, then, means that dogwood favors the somewhat poorly drained soils rather than well drained soils. Observations by Oosting (1942), on the other hand, specify that dogwood reproduces best in well drained soils.

Flowering dogwood also is negatively correlated with P, K, and Ca. The negative rho suggests that dogwood can tolerate nutritionally poor soils even though it has some reputation for requiring good soils (Coile, 1940). In fact, dogwood is growing well in the poor soils of the oak-beech community. As dogwood multiplies in the understory the nutrients in the soil should also increase since dogwood litter is very rich in nutrients and decomposes rapidly.

Sycamore — The basal area of sycamore varies directly with an increase of P, Mg, Ca, and pH. Sycamore stands are located on well drained sites adjacent to the river and the flooding waters provide periodic enrichment of the soil with these nutrients. Sycamore, therefore, depends on both physical and chemical site conditions for its survival.

Yellow poplar — The basal area of yellow poplar is directly related to the CEC of the soil. Yellow poplar, therefore, prefers alkaline soils and high nutrient concentrations. Previous work by Auten (1945), however, concludes that yellow poplar can survive in a wide range of nutrient concentrations. McAlpine (1961) showed that yellow poplar cannot tolerate submersion for more than four days and is, therefore, excluded from new alluvium even though these sites are nutritionally rich. It is evident that yellow poplar is mostly constrained by physical rather than chemical factors.

White ash — The importance values of sdc specimens were found to be inversely related to organic matter content. The availability of organic matter, however, does not appear to be a critical parameter for white ash success since white ash is common to all sites in the floodplain.

Black haw — Finally, the only tree sized shrub that had any direct correlation with pH or the nutrients was black haw. The correlation coefficients are extremely high (rho = 1.0 in all cases). It seems evident that prominent occurrence of black haw is an indicator of slightly acidic, rich soils. Black haw is least important in the oak-beech community with low nutrient values and most important in the yellow poplar community with high nutrient values.

General relationships — In analysis of the relationships between importance values and soil properties, more relationships occur for the smaller sized diameter classes of species than for the largest. This trend indicates that a change in soil conditions will have a greater effect on the introduction or elimination of seedlings and saplings of these species than on mature specimens.

Also, many more relationships are found between basal area of species and nutrients than between importance value of species and nutrients. This may be due to the inherent ambiguity in an importance value index. Since importance value involves three separate relative measures, it seems reasonable to expect fewer well defined relationships between it and soil properties compared to an absolute index such as basal area. The advantage of using importance value, however, is that it allows an inspection of the relative overall success of specimens within three different diameter classes. This advantage provides the means to discover which diameter classes are more strongly affected by changes in nutrient levels. Basal area values could be separated into three diameter classes also but an analysis using just this parameter would not include an impression of frequency or density. Basal area, as defined here, pools together all diameter classes and gives but one impression of the relative success of a species.

SUCCESSION

The successional development at Penllyn is controlled by both autogenic and allogenic forces. In the initial stages of development physical factors dominate, and once forests evolve, biotic factors appear to more directly control succession. The physical processes operating on the plants are controlled by the stream. Sites for the invasion of primary species are being created as the stream migrates, depositing gravel and sand sized materials that have been carried down from further upstream. These coarse grained materials eventually have finer-grained sediment deposited on them as flooding continues and migration of the meander pattern develops.

The pioneer vegetation is typically a variety of annual weeds that remain as long as flooding waters destroy any emergent perennial or woody vegetation. The swamp white oak community exemplifies this type of condition. Only scattered tree species have survived seedling growth as ragweed provides cover for most of the ground. This community will remain stable until the stream migrates away, permitting drier soil conditions.

The new sites that can sustain woody vegetation are invaded by silver maple (*Acer saccharinum*) and sycamore. Seedlings of both species can tolerate submersion and grow well until subsiding flood waters have deposited enough soil to allow drier conditions. The fact that sycamore and silver maple are no longer reproducing indicates that the soil conditions in the sycamore community sites were at one time much wetter.

The ash-walnut community represents the next stage of successional development. This community is dominated by ash, elm, red maple, black walnut and spice bush. Black walnut is not reproducing and should remain simply as scattered canopy specimens. The remaining co-dominants all favor the moist soils of new alluvium and can be expected to remain until changing soil acidity and moisture conditions allow the penetration of the more tolerant red oak and shellbark hickory.

The oak-hickory stands in Penllyn are on the transitional zones between new alluvium and the alluvial terraces (Fig. 4). This zone is characterized by changing soil conditions that have been favorable for the maturation of n. red oak and hickory. The oak-hickory stands are still transitional at Penllyn since the canopy is shared by ash, elm, and red maple, but oak and hickory are reproducing at a faster rate (Table 1) and are successfully maturing more often than the other seedlings. The trend, therefore, is toward a vegetation type better adapted to the slightly drier and more acidic soils. Once mature, the oak-hickory community at Penllyn will remain stable as long as these soil conditions remain the same or as long as the stand is not damaged by wind-throws, timbering or fire.

Should openings appear in the oak-hickory canopy, yellow poplar seedlings that favor these soil conditions would respond with rapid growth, resulting in a stand similar to the yellow poplar community at Penllyn. As the canopy is closed, the yellow poplar seedlings are shaded out. An inspection of Table 1 reveals that yellow poplar has previously reached its prime and that this stand should return to a stable oak-hickory community.

As the red oak-hickory stands remain undisturbed but moisture conditions become drier, shade tolerant norway maple invades. The ash-walnut and white pine communities will both eventually be dominated by norway maple since neither the pine nor the walnut are reproducing successfully (Table 1). Pearson (1972) remarks on the growing naturalization of norway maple along other reaches of the Wissahickon and expects the composition of those stands to be significantly influenced by the proliferation of norway maple.

American beech can also be expected to invade the oak-hickory stands as soils become drier. The pattern of development for the oak-hickory community in the northeastern section of the nature area (Fig. 1) is being affected by the successful invasion of beech. As the stream migrates to the west and soil conditions become drier, beech will successfully reach the larger diameter classes and will co-dominate with oak and norway maple in the resultant stand.

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Editor's Note

In September, 1973 the Club received $1,000.00 from the estate of Edna E. Benner, who died on August 22, 1972. Mrs. Benner was the widow of Dr. Walter M. Benner who served as the club's president from 1928-1931 and 1962-1967. Bartonia No. 41 contains an account of Dr. Benner's life.

LETTERS

On page 70 of our latest Bartonia No. 41 will be found a record of a collection made on June 21, 1971 of the *Arethusa bulbosa f. albiflora* at Quaker Bridge, New Jersey. The author quotes Fernald (1950) as stating that it is rapidly becoming extinct south of Newfoundland and Canada. He does not state that he took the last one at Quaker Bridge but we regret to say we think he did. A diligent search this year failed to uncover the other known specimen.

If you will read the report I wrote of the 1966 field trips in Bartonia No. 36 you will note at the bottom of page 26 that club members on that day saw the specimen which now lies dried on a herbarium sheet.

I did not mean to infer that Brooks discovered it for the first time that day. We had known it since 1958. However, each year it was a delight to find it still there and doubly so in 1966 as that year Dr. Wherry was with us and could properly name it.

I would like to quote Professor David Fables in Caesarian Flora and Fauna No. 5 — 1959. "At present the active Pine Barren Conservationists is the most informed group on the Pine Barrens. It is attempting to record photographically the beauty of this wilderness preserve. Messrs. Chaney, Fort, Gill, Hawkins, Evert, Hand and Starkey and the Mrs. Allen and Evert are all endeavoring to do justice pictorially to this unique region. It is to be hoped that the acquisition of the heart of the Pine Barrens (The Wharton Tract) by the State will be followed by wise allocation of its various sectors to the use for which it is best suited." You will note records were to be made photographically. Quaker Bridge was the first area we recommended to protect from all disturbances. The State has recognized its botanically historic value and allows NO collecting.

It is extremely distressing to the Pine Barren Conservationists that this violation has taken place. Any of our members would have been glad to give photographic specimens to the Herbarium had it been requested. I understand this is now accepted practice for rare species.

We wish to request that The Philadelphia Botanical Club discuss this desecration and emphasize to erring scientists a fact they should all know only too well — you do not collect a specimen of ANYTHING if it endangers the plant colony.

MRS. W. BROOKS EVERT, *Chairman*
Pine Barren Conservationists

The point of view espoused by the Conservationists is somewhat narrow; they disregard the value of the documentation of species' distributions by collection. A good example of the value of documentation can be found in the same issue of *Bartonia* (Sipple, 1972) for the exact same species. How many contemporaneous humans, even botanists, would have ever imagined the one-time existence of *Arethusa bulbosa* in the now severely degraded Hackensack Meadows if it hadn't been for the collected specimens cited by Torrey, et al. (1819) and Britton (1889)? The Conservationists stated that they have known of *A. bulbosa albiflora* being present at Quaker Bridge since 1958. Since the particular specimen that I collected probably would have died naturally within a few years should the documentation of its existence have been invested in only the memories of a few finite lifetimes? I've been traveling through the Pine Barrens for years and know most of the Conservationists, but became aware of this specimen only through my own investigations.

Secondly, I did not take the last specimen of *A. bulbosa* at Quaker Bridge nor would I consider the collection of *one* specimen of forma *albiflora* to have "endangered the plant colony."

Thirdly, I am quite disappointed with what I feel is an unwarranted stigma placed on my head. Language like "violation," "desecration," and "erring scientists" is certainly emotional. In turn, it bothers me emotionally since the stigma relates to two areas close to my heart: 1) the New Jersey Pine Barrens and 2) wetlands in general. I truly love and respect the N.J. Pine Barrens and have traveled and botanized through it for the greater part of my outdoor career. There is no ecosystem on earth that I admire more and I would certainly like to see it managed well. Wetlands are where my second main interest lies. For the last two years in Maryland my direct participation in the Department of Natural Resources wetland's program has been instrumental in the wise protection and management of wetland areas. Literally hundreds of acres of ecologically valuable wetlands have been saved from destruction. In fact, during my involvement at Maryland I've had close interaction with the Chesapeake Bay Foundation, the Worcester County Environmental Trust and other conservation organizations in relation to wetland cases.

If I had to start over the only thing that might possibly stop me from collecting it again would be the fact that Mr. & Mrs. Evert and possibly others have been capturing it photographically, a fact that I became aware of subsequent to my collecting it.

WILLIAM S. SIPPLE
Maryland Dept. of Natural Resources

No. 43 1974-1975

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A CHECK-LIST OF THE FLORA OF BUCKS COUNTY, PENNSYLVANIA

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Check-lists of the floras of three southeastern Pennsylvania border counties have been published in recent issues of Bartonia — Delaware in No. 37, Philadelphia in No. 38, and Montgomery in No. 41. A similar treatment of the easternmost, Bucks, seems appropriate.

An excellent Flora of Bucks County was prepared as a doctoral dissertation at the University of Pennsylvania by Walter M. Benner and published by him privately in 1932, but it is now out of print. Moreover the nomenclature used was Britonian, no longer favored, and in the subsequent 40 years several hundred additional taxa have been found here, so publication of a revised and expanded listing in Bartonia is worthwhile. This has been compiled from the Pennsylvania Flora card file now stored at the Morris Arboretum of the University of Pennsylvania.

As in preceding county check-lists the plant families are arranged in standard systematic sequence, with the genera and species in alphabetical order under them. Subspecies, varieties, and forms are placed in parentheses, and introduced taxa in brackets.

This summary indicates that about 2500 major taxa occur in Bucks County, of which some 700 are introduced.

PTERIDOPHYTES

LYCOPODIACEAE: *Lycopodium appressum, clavatum, flabelliforme, lucidulum, obscurum* (typ. & v. *dendroideum*), *tristachyum.*

SELAGINELLACEAE: *Selaginella apoda, rupestris.*

ISOETACEAE: *Isoetes dodgei, engelmannii, riparia.*

EQUISETACEAE: *Equisetum arvense,* × *ferrissii, fluviatile, hyemale,* × *litorale, sylvaticum.*

OPHIOGLOSSACEAE: *Botrychium dissectum, matricariifolium, multifidum* (v. *intermedium*), *obliquum, oneidense, simplex* (typ., v. *laxifolium* & v. *tenebrosum*), *virginianum. Ophioglossum vulgatum* (v. *pseudopodum*).

OSMUNDACEAE: *Osmunda cinnamomea, claytoniana, regalis* (v. *spectabilis*).

SCHIZAEACEAE: *Lygodium palmatum.*

POLYPODIACEAE: *Adiantum pedatum. Asplenium* × *ebenoides, platyneuron* (typ. & f. *hortonae*), *ruta-muraria, trichomanes. Athyrium angustum* (typ., v. *elatius* & v. *rubellum*), *asplenioides, pycnocarpon, thelypterioides. Camptosorus rhizophyllus. Cheilanthes lanosa. Cystopteris bulbifera, fragilis* (v. *mackayi*), *protrusa. Dennstaedtia punctilobula. Dryopteris* × *boottii, carthusiana* (synonym *spinulosa*), × *celsa,* × *clintoniana, cristata, goldiana, intermedia, marginalis,* × *slossonae,* × *triploidea,* × *uliginosa. Matteuccia pensylvanica. Onoclea sensibilis* (typ. & f. *obtusilobata*). *Pellaea atropurpurea, glabella. Phegopteris connectilis, hexagonoptera. Polypodium virginianum. Polystichum acrostichoides. Pteridium aquilinum* (v. *latiusculum*). *Thelypteris noveboracensis, palustris* (v. *pubescens*). *Woodsia ilvensis, obtusa. Woodwardia areolata, virginica.*

GYMNOSPERMS

GINKGOACEAE: [*Ginkgo biloba*].

PINACEAE: *Pinus echinata, rigida, strobus,* [*sylvestris*], *virginiana. Tsuga canadensis.*

CUPRESSACEAE: *Chamaecyparis thyoides. Juniperus communis, virginiana.*

TAXACEAE: *Taxus canadensis.*

MONOCOTYLEDONS, REDUCED

TYPHACEAE: *Typha angustifolia, latifolia.*

SPARGANIACEAE: *Sparganium americanum, androcladum, eurycarpum.*

NAJADACEAE: *Najas flexilis, gracillima.*

ZOSTERACEAE: *Potamogeton alpinus* (v. *tenuifolius*), *amplifolius, berchtoldii* (v. *lacunatus*), *bicupulatus,* [*crispus*], *diversifolius, epihydrus* (typ. & v. *nuttallii*), *foliosus* (v. *macellus*), *nodosus, oakesianus, pectinatus, perfoliatus* (v. *bupleuroides*), *pulcher, robbinsii, spirillus. Zannichellia palustris.*

ALISMACEAE: *Alisma subcordatum. Sagittaria australis, eatonii, graminea, latifolia* (typ., formae, & v. *pubescens*), *montevidensis, rigida* (typ. & formae), *subulata* (typ. & v. *gracillima*).

HYDROCHARITACEAE: *Elodea* (synonym *Anacharis*) *canadensis, nuttalli. Vallisneria americana.*

MONOCOTYLEDONS

GRAMINEAE: [*Agropyron repens*]. *Agrostis* [*alba*], *hyemalis,* [*palustris*], *perennans, scabra,* [*tenuis*]. [*Aira praecox*]. *Alopecurus aequalis,* [*pratensis*]. *Andro-*

pogon elliottii, gerardii, glomeratus (synonym *virginicus* v. *abbreviatus*), *scoparius* (typ. & vars.), *virginicus* (typ.). [*Anthoxanthum odoratum*]. *Aristida dichotoma, longespica* (typ. & v. *geniculata*), *oligantha, purpurascens.* [*Arrhenatherum elatius*]. [*Avena fatua*], [*sativa*]. *Brachyelytrum erectum. Bromus* [*commutatus*], [*inermis*], [*japonicus* (v. *porrectus*)], *kalmii,* [*mollis*], *pubescens* (synonym *purgans*), *purgans* (synonym *latiglumis*), [*racemosus*], [*secalinus*], [*sterilis*], [*tectorum*]. *Calamagrostis canadensis, cinnoides. Cenchrus pauciflorus* (synonym *longispinus*), [*tribuloides*]. *Cinna arundinacea.* [*Cynodon dactylon*]. [*Cynosurus cristatus*]. [*Dactylis glomerata*]. *Danthonia compressa, spicata. Deschampsia caespitosa, flexuosa. Digitaria filiformis,* [*ischaemum*], [*sanguinalis*]. *Echinochloa* [*crus-galli*], *pungens, walteri.* [*Eleusine indica*]. *Elymus canadensis, riparius, villosus, virginicus* (typ. & v. *hirsutiglumis*). *Eragrostis capillaris,* [*cilianensis* (synonym *megastachya*]), *frankii, hypnoides,* [*multicaulis*], *pectinacea,* [*pilosa*], [*poaeoides*], *spectabilis* (typ. & v. *sparsihirsuta*). *Erianthus saccharoides* (synonym *giganteus*). *Festuca* [*capillata*], [*myurus*], *obtusa, octoflora* v. *tenella,* [*ovina*], [*pratensis* (synonym *elatius*]), *rubra* (incl. vars.). *Glyceria acutiflora, canadensis, grandis, melicaria, pallida, septentrionalis, striata.* [*Heleochloa schoenoides*]. [*Holcus lanatus*]. *Hordeum jubatum,* [*vulgare*]. *Hystrix patula* (typ. & v. *bigeloviana*). *Leersia oryzoides, virginica.* [*Leptochloa filiformis*]. [*Lolium multiflorum*], [*perenne*], [*temulentum*]. [*Microstegium* (synonym *Eulalia*) *vimineum*]. [*Miscanthus sinensis*]. *Muhlenbergia frondosa, glomerata* (incl. vars.), *mexicana, schreberi, sobolifera, sylvatica, tenuiflora. Oryzopsis racemosa. Panicum agrostoides, amarulum, anceps, annulum, boscii* (typ. & v. *molle*), *capillare* (typ. & v. *occidentale*), *clandestinum, columbianum, commutatum* (typ. & v. *ashei*), *depauperatum* (typ. & v. *psilophyllum*), *dichotomiflorum, dichotomum, flexile, gattingeri, implicatum, latifolium, lindheimeri, linearifolium* (typ. & v. *werneri*), *longifolium, lucidum, longiligulatum, meridionale, microcarpon,* [*miliaceum*], *philadelphicum, polyanthes, scoparium, scribnerianum, spinaerocarpon, spretum, stipitatum, verrucosum, virgatum* (incl. vars.), *xanthophysum. Paspalum laeve* (typ., v. *circulare,* & v. *pilosum*), *psammophilum, pubescens* (synonym *ciliatifolium* v. *muhlenbergi*), *setaceum. Phalaris arundinacea,* [*canariensis*]. [*Phleum pratense*]. *Phragmites australis* (synonym *communis*). *Poa* [*annua*], [*compressa*], *autumnalis, cuspidata, palustris,* [*pratensis*], *sylvestris,* [*trivialis*]. [*Secale cereale*]. *Setaria* [*faberi*], *geniculata,* [*italica*], [*lutescens*], *verticillata,* [*viridis,* (typ. & v. *major*)]. *Sorghastrum nutans.* [*Sorgum halepense*], [*sudanense*], [*vulgare*]. *Spartina pectinata. Sphenopholis intermedia, nitida, obtusata* (typ. & v. *pubescens*). *Sporobolus asper, neglectus, vaginiflorus. Stipa avenacea. Triodia flava* (typ. & f. *cuprea*). *Triplasis purpurea. Trisetum pensylvanicum.* [*Triticum aestivum*]. *Uniola laxa.* [*Zea mays*]. *Zizania aquatica.*

Cyperaceae: *Bulbostylis capillaris* (incl. "v. *crebra*"). *Carex abdita, abscondita, aggregata, alata, albolutescens, albursina, amphibola* (typ., v. *rigida* & v. *turgida*), *angustior, annectens* (typ. & v. *xanthocarpa*), *artitecta, bicknellii, blanda, brevior, bromoides, bullata, bushii, buxbaumii, canescens* (v. *disjuncta*), *carolini-*

ana, cephalantha, cephaloidea, cephalophora, communis, comosa, conjuncta, conoidea, convoluta, crinita, cristatella, davisii, debilis, digitalis, emmonsii, emoryi, festucacea, foena, folliculata, frankii, glaucescens, glaucodea, gracillima, granularis, grayi (typ. & v. *hispidula*), *gynandra, haydenii, hirsutella, hirtifolia, hitchcockiana, howei, hystericina, incomperta, interior, intumescens, jamesii, lacustris, laevivaginata, lanuginosa, lasiocarpa, laxiculmis, laxiflora, leavenworthii, leptalea, limosa, longii, lupulina, lurida, meadii, mesochorea, molesta, muhlenbergii, nigromarginata, normalis, oligocarpa, pallescens* (v. *neogaea*), *pedunculata, pensylvanica* (typ. & v. *lucorum*), *plana, plantaginea, platyphylla, prasina, projecta, radiata, retroflexa, rosea, rostrata, scabrata, scoparia, seorsa, sparganioides, spicata, sprengelii, squarrosa, sterilis, stipata, straminea, stricta, strictior, styloflexa, swanii, tetanica, tonsa, torta, tribuloides, trichocarpa, umbellata, vesicaria, vestita, virescens, vulpinoidea, willdenowii. Cyperus aristatus, dentatus, diandrus, erythrorhizos, esculentus, filiculmis* (incl. v. *macilentus*), *flavescens, lancastriensis, odoratus, ovularis, rivularis, strigosus, tenuifolius. Dulichium arundinaceum. Eleocharis acicularis, calva, diandra, engelmannii, intermedia, obtusa, olivacea, smallii, tenuis* (typ., v. *pseudoptera* & v. *verrucosa*). *Eriophorum gracile, virginicum. Fimbristylis autumnalis. Rhynchospora alba, capitellata, globularis. Scirpus americanus, atrovirens, cyperinus* (typ. & relative *rubricosus*), *expansus, fluviatilis, georgianus, hattorianus, microcarpus, pendulus* (synonym *lineatus*), *polyphyllus, purshianus, smithii, validus* (v. *creber*), *verecundus* (synonym *planifolius*). *Scleria muhlenbergii, pauciflora, tricostata.*

ARACEAE: *Acorus americana. Arisaema dracontium, pusillum* (synonym *triphyllum*), *triphyllum* (synonym *atrorubens*). *Orontium aquaticum. Peltandra virginica. Symplocarpus foetidus.*

LEMNACEAE: *Lemna minor, perpusilla, trisculca, valdiviana. Spirodela polyrhiza. Wolffia columbiana.*

XYRIDACEAE: *Xyris difformis* (synonym *caroliniana*), *torta.*

ERIOCAULACEAE: *Eriocaulon parkeri.*

COMMELINACEAE: [*Commelina communis* (typ. & v. *ludens*)]. *Tradescantia virginiana.*

PONTEDERIACEAE: *Heteranthera dubia, reniformis. Pontederia cordata.*

JUNCACEAE: *Juncus acuminatus, bufonius, canadensis, debilis, dichotomus, dudleyi, effusus* (v. *costulatus, pylaei,* & *solutus*), *longii, marginatus, nodosus, platyphyllus, scirpoides, secundus, subcaudatus, tenuis. Luzula acuminata, bulbosa, echinata, multiflora.*

LILIACEAE: *Aletris farinosa. Allium canadense,* [*cepa*], [*oleraceum*], [*sativum*], *tricoccum,* [*vineale*]. *Amianthium muscaetoxicum.* [*Asparagus officinalis*]. *Chamaelirium luteum.* [*Convallaria majalis*]. *Erythronium americanum.* [*Hemerocallis fulva*]. [*Hosta lancifolia, ventricosa*]. *Lilium canadense, philadelphicum, superbum,* [*tigrinum*]. *Maianthemum canadense. Medeola virginiana. Melanthium hybridum, virginicum.* [*Muscari botryoides*]. [*Ornithogalum umbellatum*]. *Polygonatum biflorum, commutatum* (synonym *canaliculatum*), *pubescens. Smila-*

cina racemosa (typ. & v. *cylindrata*), *stellata. Smilax glauca* (v. *leurophylla*), *herbacea, hispida* (synonym *tamnoides* v. *hispida*), *pulverulenta, rotundifolia. Trillium cernuum* (typ. & v. *macranthum*), *erectum.* [*Tulipa sylvestris*]. *Uvularia perfoliata, sessilifolia. Veratrum viride.* [*Yucca smalliana*].

AMARYLLIDACEAE: *Hypoxis hirsuta.* [*Narcissus poeticus*], [*pseudo-narcissus*].

DIOSCOREACEAE: *Dioscorea* [*batatas*], *villosa.*

IRIDACEAE: [*Belamcanda chinensis*]. *Iris* [*germanica*], *prismatica,* [*pseudacorus*], *versicolor. Sisyrinchium angustifolium, atlanticum, mucronatum.*

CANNACEAE: [*Canna generalis*].

ORCHIDACEAE: *Aplectrum hyemale. Calopogon pulchellus. Corallorhiza maculata, odontorhiza. Cypripedium acaule.* [*Epipactis helleborine*]. *Goodyera pubescens. Habenaria* (synonym *Platanthera*) *ciliaris, clavellata, flava* (v. *herbiola*), *psycodes. Isotria verticillata. Liparis lilifolia, loeselii. Malaxis unifolia. Orchis spectabilis. Pogonia ophioglossoides. Spiranthes cernua, gracilis, gracilis-lacera intermediate, lucida, tuberosa* (synonyms *beckii, grayi*). *Triphora trianthophora.*

DICOTYLEDONS: ZERO & FREE-PETAL SUBCLASS

SAURURACEAE: *Saururus cernuus.*

SALICACEAE: *Populus* [*alba*], [*canescens*], *deltoides,* [× *gileadensis*], *grandidentata,* [*nigra* (typ. & v. *italica*)], *tremuloides. Salix* [*alba*], [*babylonica*], *bebbiana,* [*caprea*], *discolor,* [*fragilis*], *gracilis* (v. *textoris*), *humilis* (typ. & v. *rigidiuscula*), *interior, lucida,* [× *myricoides*], *nigra,* [*purpurea*], *rigida,* [× *rubens*], *sericea, tristis* (synonym *humilis* v. *microphylla*).

MYRICACEAE: *Comptonia peregrina. Myrica heterophylla, pensylvanica.*

JUGLANDACEAE: *Carya cordiformis, glabra, laciniosa, ovata, tomentosa. Juglans cinerea, nigra.*

BETULACEAE: *Alnus* [*glutinosa*], *serrulata. Betula lenta, nigra, populifolia.*

CORYLACEAE: *Carpinus caroliniana* (v. *virginiana*). *Corylus americana, cornuta. Ostrya virginiana.*

FAGACEAE: *Castanea dentata,* [*pumila*]. *Fagus grandifolia. Quercus alba, bicolor, coccinea, falcata,* × *heterophylla, ilicifolia, marilandica, muhlenbergii, palustris, phellos, prinoides, prinus, rubra* (synonym *borealis* v. *maxima*), × *rudkinii, stellata, velutina.*

ULMACEAE: *Celtis carina* (synonym *occidentalis* v. *canina*), *georgiana* (syonym *tenuifolia* v. *georgiana*), *occidentalis, tenuifolia. Ulmus americana, rubra.*

MORACEAE: [*Broussonetia papyrifera*]. [*Maclura pomifera*]. *Morus* [*alba* (typ. & red-fruited f.)], *rubra.*

CANNABINACEAE: [*Cannabis sativa*]. *Humulus* [*japonicus*], *lupulus.*

URTICACEAE: *Boehmeria cylindrica* (typ. & v. *drummondiana*). *Laportea canadensis. Parietaria pensylvanica. Pilea pumila. Urtica* [*dioica*], *procera,* [*urens*].

ARISTOLOCHIACEAE: *Aristolochia serpentaria. Asarum canadense* (typ., v. *acuminatum* & v. *reflexum*).

Loranthaceae: *Phoradendron serotinum* (synonym *flavescens*).

Santalaceae: *Comandra umbellata.*

Polygonaceae: [*Fagopyrum sagittatum*]. *Polygonum arifolium* (v. *pubescens*), [*aviculare* (typ. & v. *vegetum*)], [*caespitosum* (v. *longisetum*)], *cilinode, coccineum* (incl. formae), [*convolvulus* (typ. & v. *subalatum*)], *cristatum,* [*cuspidatum*], *erectum,* [*hydropiper*], *hydropiperoides, lapathifolium* (typ. & [v. *prostratum*]), *opelousanum* (typ. & v. *adenocalyx*), [*orientale*], *pensylvanicum* (typ. & v. *laevigatum*), [*persicaria*], *punctatum* (typ. & v. *confertiflorum* (synonym *leptostachyum*)), *robustius,* [*sachalinense*], *sagittatum, scandens, tenue.* [*Rheum rhaponticum*]. *Rumex* [*acetosella*], [*altissimus*], [*crispus*], [*obtusifolius*], *orbiculatus,* [*patientia*], [*pulcher*]. *Tovara virginiana.*

Chenopodiaceae: *Atriplex hastata, patula.* [*Beta vulgaris*]. *Chenopodium* [*album* (typ. & v. *lanceolatum*)], [*ambrosioides* (typ. & v. *chilense*)], [*berlandieri* v. *zschackeyi*], [*botrys*], *bushianum* (syn. *paganum*), *capitatum,* [*carinatum*], *gigantospermum* (synonym *hybridum*), [*glaucum*], [*hybridum*], *missouriense,* [*murale*], [*serotinum*], *standleyanum* (synonyms *boscianum* & *hybridum* v. *standleyanum*), *strictum* v. *glauphyllum,* [*urbicum*]. [*Kochia scoparia* (cv. Culta)]. [*Salsola kali* v. *tenuifolia*].

Amaranthaceae: *Amaranthus albus, cannabinus* (synonym *Acnida*), [*caudatus*], [*graecizans*], [*hybridus*], [*lividus*], [*powellii*], [*retroflexus*], [*spinosus*]. [*Celosia argentea*]. [*Froelichia gracilis*].

Nyctaginaceae: [*Oxybaphus* (synonym *Mirabilis*) *nyctagineus*].

Phytolaccaceae: *Phytolacca americana.*

Molluginaceae: [*Mollugo verticillata*].

Portulacaceae: *Claytonia virginica* (typ., f. *lutea* & f. *robusta*). [*Portulaca grandiflora, oleracea*].

Caryophyllaceae: [*Agrostemma githago*]. *Arenaria* [*serpyllifolia*], *stricta. Cerastium arvense* (typ. & v. *villosum*), [*glomeratum* (synonym *viscosum*)], [*holosteoides* (synonym *vulgatum*)], *nutans.* [*Dianthus armeria*], [*barbatus*]. [*Lychnis alba* (synonym *Silene*)], [*coronaria*]. *Moehringia* (synonym *Arenaria*) *lateriflora.* [*Myosoton aquaticum*]. *Paronychia canadensis, fastigiata. Sagina decumbens,* [*procumbens*]. [*Saponaria officinalis*]. [*Scleranthus annuus*]. *Silene antirrhina,* [*armeria*], [*noctiflora*], *stellata,* [*vulgaris* (synonym *cucubalus*)]. *Stellaria alsine,* [*graminea*], *longifolia,* [*media*], *pubera.* [*Vaccaria pyramidata* (synonym *Saponaria vaccaria*)].

Nymphaeaceae: *Brasenia schreberi.* [*Cabomba caroliniana*]. *Nuphar advena* (ssp. *macrophyllum*), *luteum* (ssp. *pumilum;* synonym *N. microphyllum*). *Nymphaea odorata.*

Ceratophyllaceae: *Ceratophyllum demersum, echinatum.*

Ranunculaceae: *Actaea alba* (synonym *pachypoda*). *Anemone quinquefolia, virginiana. Anemonella* (synonym *Thalictrum*) *thalictroides. Aquilegia canadensis,* [*vulgaris*]. *Caltha palustris. Cimicifuga racemosa. Clematis* [*dioscoreifolia*], *occidentalis* (synonym *verticillaris*), *virginiana.* [*Delphinium* (synonym *Consolida*) *ajacis*]. [*Helleborus viridis*]. *Hepatica americana. Hydrastis canadensis.* [*Paeonia lactiflora*]. *Ranunculus arbortivus* (typ. & v. *acrolasius*), [*acris*], *amigens*, [*bulbosus*], [*ficaria*], *flabellaris, hispidus* (typ. & v. *falsus*), *longirostris, micranthus* (v. *delitescens*), *pensylvanicus, pusillus, recurvatus*, [*repens* (typ. & v. *pleniflorus*)], [*sceleratus*], *septentrionalis. Thalictrum dioicum, polygamum, revolutum. Trollius laxus.*

BERBERIDACEAE: [*Berberis thunbergii, vulgaris*]. *Caulophyllum thalictroides. Jeffersonia diphylla. Podophyllum peltatum.*

MENISPERMACEAE: *Menispermum canadense.*

MAGNOLIACEAE: *Liriodendron tulipifera. Magnolia* [*tripetala*], *virginiana.*

ANONACEAE: *Asimina triloba.*

LAURACEAE: *Lindera benzoin. Sassafras albidum* (typ. & v. *molle*).

PAPAVERACEAE: [*Argemone mexicana*]. [*Chelidonium majus*]. [*Macleaya cordata*]. [*Papaver orientale, rhoeas, somniferum*]. *Sanguinaria canadensis.*

FUMARIACEAE: *Adlumia fungosa. Corydalis flavula, sempervirens. Dicentra canadensis, cucullaria.* [*Fumaria officinalis*].

CRUCIFERAE: [*Alliaria petiolata*]. [*Arabidopsis thaliana*]. *Arabis canadensis*, [*glabra*], *laevigata, lyrata, perstellata.* [*Armoracia rusticana*]. [*Barbarea verna, vulgaris* (typ., v. *arcuata* & v. *sylvestris*]. [*Brassica campestris, hirta, kaber* (v. *pinnatifida*), *nigra, oleracea*]. [*Camelina microcarpa*]. [*Capsella bursa-pastoris*]. *Cardamine bulbosa*, [*hirsuta*], [*impatiens*], *parviflora* v. *arenicola, pensylvanica, rotundifolia.* [*Conringia orientalis*]. *Dentaria diphylla, heterophylla, laciniata.* [*Draba reptans, verna*]. [*Erucastrum gallicum*]. [*Erysimum cheiranthoides*]. [*Hesperis matronalis*]. *Lepidium* [*camprestre*], [*densiflorum*], *virginicum.* [*Lobularia maritima*]. [*Lunaria annua*]. [*Nasturtium officinale*]. [*Raphanus raphanistrum, sativus*]. *Rorippa* [*islandica* typ.], *islandica* v. *fernaldiana* & *hispida*, [*sylvestris*]. [*Sisymbrium altissimum, officinale* (typ. & v. *leiocarpum*]. [*Thlaspi arvense*].

CAPPARACEAE: [*Cleome houtteana* (synonym *spinosa*)].

RESEDACEAE: [*Reseda luteola*].

DROSERACEAE: *Drosera intermedia, rotundifolia.*

PODOSTEMACEAE: *Podostemon ceratophyllum.*

CRASSULACEAE: *Sedum* [*acre*], [*alboroseum*], [*album*], *rosea*, [*sarmentosum*], [*telephium* v. *purpureum*], *ternatum. Tillaea aquatica.*

SAXIFRAGACEAE: *Chrysoplenium americanum.* [*Deutzia scabra*]. *Heuchera americana. Hydrangea arborescens* (typ., [v. *grandiflora* & *paniculata*]. *Mitella diphylla. Parnassia glauca.* [*Philadelphicus coronarius, pubescens*]. *Ribes americanum*, [*grossularia*], *hirtellum*, [*odoratum*], *rotundifolium*, [*rubrum*].

HAMAMELIDACEAE: *Hamamelis virginiana. Liquidambar styraciflua.*

PLATANACEAE: *Platanus occidentalis.*

ROSACEAE: *Agrimonia gryposepala, microcarpa, parviflora, pubescens, rostellata, striata. Amelanchier arborea, canadensis, laevis, stolonifera. Aronia* (synonym *Pyrus*) *arbutifolia, melanocarpa, prunifolia. Crataegus canbyi, intricata, pruinosa, punctata, uniflora* (& others). [*Duchesnea indica*]. *Filipendula rubra.*

Fragaria [*vesca* typ.], *vesca* (v. *americana*), *virginiana* (typ. & v. *illinoensis*). *Geum aleppicum* (v. *strictum*), *canadense, laciniatum* (typ. & v. *trichocarpum*), *vernum, virginianum. Gillenia trifoliata. Malus coronaria,* [*domestica* (synonym *Pyrus malus*)]. *Physocarpus opulifolius. Potentilla* [*argentea*], *arguta, canadensis,* [*intermedia*], *norvegica,* [*recta*], [*reptans*], *simplex. Prunus allegheniensis, americana,* [*avium*], [*cerasus*], *depressa,* [*domestica*], *maritima, pensylvanica,* [*persica*], *serotina, virginiana.* [*Pyrus communis*]. [*Rhodotypos scandens*]. *Rosa blanda,* [*canina*], *carolina,* [*centifolia*], [*cinnamomea*], [*gallica*], [*multiflora*], *palustris,* [*rubiginosa*], [*setigera*], *virginiana. Rubus allegheniensis, baileyanus, cuneifolius, enslenii, flagellaris, frondosus, hispidus,* [*laciniatus*], *occidentalis, odoratus, pergratus,* [*phoenicolasius*], *pubescens, roribaccus, semisetosus* (synonym *benneri*), (& others). *Sanguisorba canadensis,* [*minor*]. *Spiraea alba,* [*billardii*], [*japonica*], *latifolia,* [*prunifolia*], *tomentosa. Waldsteinia fragarioides.*

LEGUMINOSAE: [*Amorpha fruticosa*]. *Amphicarpa bracteata, comosa. Apios americana. Baptisia tinctoria. Cassia fasciculata, hebecarpa, nicticans. Cercis canadensis.* [*Coronilla varia*]. *Crotalaria sagittalis. Desmodium canadense, canescens, ciliare, dillenii* (synonym *perplexum*), *glutinosum, humifusum, laevigatum, marilandicum, nudiflorum, nuttallii, paniculatum, rigidum, rotundifolium. Gleditsia triacanthos.* [*Glycine max*]. [*Gymnocladus dioica*]. *Lathyrus* [*latifolius*], *palustris* (v. *myrtifolius*). [*Lens esculenta*]. *Lespedeza capitata* (typ. & v. *vulgaris*), [*cuneata*], *hirta, intermedia, nuttallii, procumbens, repens,* [*stipulacea*], [*striata*], *stuevei, violacea, virginica.* [*Lotus corniculatus*]. *Lupinus perennis.* [*Medicago hispida, lupulina, sativa*]. [*Melilotus alba, officinalis*]. *Phaseolus polystachios,* [*vulgaris*]. [*Pisum sativum*]. *Robinia pseudo-acacia,* [*viscosa*]. *Strophostyles helvola,* [*leiocarpa*], *umbellata. Tephrosia virginiana.* [*Trifolium arvense, aureum* (synonym *agrarium*), *campestre* (synonym *procumbens*), *dubium, hybridum, incarnatum, pratense, repens*]. *Vicia americana,* [*angustifolia*], *caroliniana,* [*cracca*], [*dasycarpa*], [*tetrasperma*], [*villosa*]. [*Wisteria frutescens*].

GERANIACEAE: [*Erodium cicutarium*]. *Geranium carolinianum,* [*columbinum*], *maculatum,* [*molle*], [*pusillum*], *robertianum,* [*striatum*].

OXALIDACEAE: *Oxalis europaea, filipe, stricta, violacea.*

LINACEAE: *Linum intercursum, medium* (v. *texanum*), *striatum,* [*usatatissimum*], *virginianum.*

ZYGOPHYLLACEAE: [*Tribulus terrestris*].

RUTACEAE: [*Poncirus trifoliata*]. *Ptelea trifoliata. Zanthoxylum americanum.*

SIMARUBACEAE: [*Ailanthus altissima*].

POLYGALACEAE: *Polygala cruciata* (v. *aquilonia*), *lutea, nuttallii, paucifolia, sanguinea, senega, verticillata* (typ., v. *ambigua,* & v. *isocycla*).

EUPHORBIACEAE: *Acalypha gracilens, rhomboidea, virginica. Crotonopsis elliptica. Euphorbia corollata,* [*cyparissias*], [*helioscopia*], *ipecacuanhae,* [*lathyris*], [*marginata*], *nutans,* (synonym *maculata*), *supina, vermiculata.*

CALLITRICHACEAE: *Callitriche austinii* (synonym *deflexa* v.), *heterophylla, palustris,* [*stagnalis*].

LIMNANTHACEAE: *Floerkea proserpinacoides.*

ANACARDIACEAE: *Rhus* [*aromatica*], *copallina* (v. *latifolia*), *glabra, radicans, typhina, vernix.*

AQUIFOLIACEAE: *Ilex glabra, laevigata, opaca, verticillata.*

CELASTRACEAE: *Celastrus* [*orbiculatus*], *scandens. Euonymus* [*alatus*] (typ. & v. *apterus*)], *americanus, atropurpureus,* [*europaeus*].

STAPHYLACEAE: *Staphylea trifolia.*

ACERACEAE: *Acer* [*campestre*], *negundo, pensylvanicum,* [*platanoides*], [*pseudoplatanus*], *rubrum* (typ. & v. *tridens*), *saccharinum, saccharum* (typ. & v. *rugelii*), *spicatum.*

HIPPOCASTANACEAE: [*Aesculus hippocastanum, octandra*].

BALSAMINACEAE: *Impatiens* [*balsamina*], *capensis, pallida.*

RHAMNACEAE: *Celastrus americanus.* [*Rhamnus cathartica, frangula*].

VITACEAE: *Parthenocissus quinquefolia,* [*tricuspidata*]. *Vitis aestivalis* (typ. & v. *argentifolia*), *labrusca,* [*labruscana*], *riparia,* [*vinifera*], *vulpina.*

TILIACEAE: *Tilia americana* (typ. & v. *neglecta*).

MALVACEAE: [*Abutilon theophrasti*]. [*Althaea rosea*]. [*Anoda cristata*]. [*Callirhoe involucrata*]. *Hibiscus moscheutos,* [*syriacus*], [*trionum*]. [*Malva moschata, neglecta, sylvestris, verticillata*]. [*Sida spinosa*].

GUTTIFERAE: *Ascyrum hypericoides, stans. Hypericum adpressum, boreale, canadense, denticulatum* v. *ovalfolium, dissimulatum, ellipticum, gentianoides, multilum,* [*perforatum*], *punctatum, pyramidatum, spathulatum* (synonym *prolificum*). *Triadenum virginicum.*

ELATINACEAE: *Elatine americana, minima.*

CISTACEAE: *Helianthemum bicknellii, canadense, propinquum. Lechea leggettii, minor, racemulosa, villosa.*

VIOLACEAE: *Hybanthus concolor. Viola affinis,* [*arvensis*], *blanda, brittoniana, canadensis, conspersa, cucullata,* × *emarginata, fimbriatula, hirsutula, lanceolata, pallens, pedata* (typ. & v. "*lineariloba*"), *pensylvanica,* × *porteriana, primufolia,* [cv. Priceana], *pubescens, rafinesquii* (not "*kitaibeliana*"), *rostrata, rotundifolia, sagittata, sororia* (including "*papilionacea*"), *stoneana, striata,* [*tricolor*], *triloba.*

CACTACEAE: *Opuntia compressa.*

THYMELEACEAE: *Dirca palustris.*

LYTHRACEAE: *Cuphea petiolata. Decodon verticillatus. Lythrum alatum, hyssopifolia,* [*salicaria*].

NYSSACEAE: *Nyssa sylvatica* (typ. & v. *caroliniana*).

MELASTOMACEAE: *Rhexia mariana, virginica.*

ONAGRACEAE: *Circaea lutetiana* (synonym *quadrisulcata*) (v. *canadensis*). *Epilobium angustifolium, coloratum, glandulosum* (v. *adenocaulon*), *leptophyllum, strictum. Gaura biennis. Jussiaea repens* (v. *glabrescens*). *Ludwigia alternifolia, palustris* (v. *americana*), *sphaerocarpa. Oenothera biennis, fruticosa, laciniata, perennis,* [*speciosa*], *tetragona* (typ., v. *brevistipata* & v. *longistipata*).

HALORAGACEAE: *Myriophyllum* [*brasiliense* (synonym *proserpinacoides*)], *heterophyllum,* [*spicatum*] (not *exalbescens*). *Proserpinaca intermedia, palustris, pectinata.*

Araliaceae: *Aralia hispida, nudicaulis, racemosa,* [*spinosa*]. [*Hedera helix*]. *Panax quinquefolius, trifolius* (not *-um*).

Umbelliferae: [*Aegopodium podagraria*]. [*Anethum graveolens*]. *Angelica venenosa* (synonym *villosa*). [*Apium graveolens*]. [*Bupleurum rotundifolium*]. [*Carum carvi*]. *Chaerophyllum procumbens. Cicuta bulbifera, maculata.* [*Conium maculatum*]. *Cryptotaenia canadensis.* [*Daucus carota*]. *Eryngium aquaticum. Heracleum maximum. Hydrocotyle americana,* [*sibthorpioides*], *umbellata. Osmorhiza claytonii, longistylis* (typ. & v. *villicaulis*). *Oxypolis rigidior.* [*Pastinaca sativa*]. [*Pimpinella magna, saxifraga*]. *Ptilimnium capillaceum. Sanicula canadensis, gregaria, marilandica, trifoliata. Sium suave. Taenidia integerrima. Thaspium trifoliatum. Zizia aptera, aurea.*

Cornaceae: *Cornus alternifolia, amomom, florida* (typ. & f. *rbura*), *racemosa, rugosa,* [*sanguinea*].

DICOTYLEDONS: UNITED-PETAL SUBCLASS

Clethraceae: *Clethra alnifolia.*

Ericaceae, *sens. lat.*: *Chimaphila maculata, umbellata* (v. *cisatlantica*). *Epigaea repens. Gaultheria procumbens. Gaylussacia baccata* (typ. & f. *glaucocarpa*), *frondosa. Kalmia angustifolia, latifolia. Leucothoe racemosa. Lyonia ligustrina, mariana. Monotropa hypopithys, uniflora. Pyrola elliptica, rotundifolia* (v. *americana*), *virens* (synonym *chlorantha*) (v. *convoluta*). *Rhododendron maximum, pemiclymenoides* (typ. & v. *eglandulosum* (synonyms *nudiflorum* v. *glandiferum* & typ.), *viscosum* (typ. & v. *glaucum*). *Vaccinium angustifolium* (incl. "v. *hypolasium*"), *atrococcum, caesariense, caesium, corymbosum* (typ. & v. *glabrum*), *lamarckii, macrocarpon, stamineum* (typ., v. *interius* & v. *neglectum*), *vacillans* (incl. "v. *crinitum*").

Primulaceae: [*Anagallis arvens*]. *Hottonia inflata. Lysimachia ciliata,* [*clethroides*], *hybrida,* [*nummularia*], × *producta,* [*punctata*], *quadrifolia, terrestris. Samolus parviflorus. Trientalis borealis.*

Ebenaceae: *Diospyros virginiana.*

Styracaceae: [*Halesia carolina*].

Oleaceae: *Chionanthus virginicus. Fraxinus americana* (typ. v. *biltmoreana,* f. *iodocarpa,* & v. *juglandifolia*), *nigra, pennsylvanica* (typ., v. *austinii* & *subintegerrima*). [*Ligustrum amurense, obtusifolium, ovalifolium, vulgare*]. [*Syringa vulgaris*].

Loganiaceae: [*Buddleia davidii*].

Gentianaceae: *Bartonia paniculata, virginica. Gentiana alba* (synonym *flavida*), *andrewsii, clausa, crinita, quinquefolia, saponaria. Menyanthes trifoliata* (v. *minor*). *Nymphoides cordata. Obolaria virginica. Sabatia angularis, campanulata, stellaris.*

Apocynaceae: *Apocynum androsaemifolium, cannabinum* (typ., v. *glaberrimum* & v. *pubescens*), × *medium, sibiricum.* [*Vinca minor*].

Asclepiadaceae: *Asclepias amplexicaulis, exaltata, incarnata* (typ. & v. *pulchra*), *purpurascens, quadrifolia, syriaca, tuberosa, variegata, verticillata, viridiflora* (synonym *Acerates*) (typ. & v. *lanceolata*).

Convolvulaceae: *Calystegia* (synonym *Convolvulus*) [*pubescens* (synonym *pellitus* v. *anestius*)], *sepium, spithamaea.* [*Convolvulus arvensis*]. *Cuscuta campestris, compacta, gronovii* (typ. & v. *latiflora*), *pentagona. Ipomoea* [*batatas*], [*coccinea*], [*hederacea*], lacunosa, pandurata, [*purpurea*], [*quamoclit*].

Polemoniaceae: *Phlox* [*divaricata* (typ., f. *coulltri* & ssp. *laphamii*], *maculata,* [*paniculata*], *pilosa* (typ. & v. *canescens*), *subulata. Polemonium reptans.*

Hydrophyllaceae: *Ellisia nyctelea. Hydrophyllum canadense, virginianum.*

Boraginaceae: *Cynoglossum* [*officinale*], *virginianum.* [*Echium vulgare*]. *Hackelia virginiana.* [*Lappula echinata*]. [*Lithospermum arvense*]. *Mertensia virginica. Myosotis laxa,* [*scorpioides*], *verna.* [*Symphytim officinale*].

Verbenaceae: *Verbena* [*bracteata*], × *engelmannii, hastata, simplex, urticifolia* (typ. & v. *leiocarpa*).

Labiatae: *Agastache nepetoides, scrophulariifolia* (typ. & v. *mollis*). *Collinsonia canadensis. Cunila origanoides.* [*Glechoma hederacea*]. *Hedeoma pulegioides.* [*Hyssopus officinalis*]. [*Lamium album, amplexicaule, maculatum, purpureum*]. [*Leonurus cardiaca*]. *Lycopus americanus* (typ. & v. *longii*), [*europaeus*], *rubellus,* × *sherardii, uniflorus, virginicus.* [*Marrubium vulgare*]. [*Melissa officinalis*]. *Mentha* [*alopecuroides*], [*aquatica*], *arvensis* (typ. & v. *villosa*), [*cardiaca*], [*gentilis*], [*longifolia*], [*piperita*], [*rotundifolia*], [*sativa*], [*spicata*]. *Monarda clinopodia, didyma, fistulosa* (typ. & v. *mollis*), [*media*]. [*Nepeta cataria*]. [*Perilla frutescens*]. *Physostegia virginiana. Prunella vulgaris* ([typ.] & v. *lanceolata*). *Pycnanthemum clinopodioides, incanum, muticum, pycnanthemoides, tenuifolium, torrei, verticillatum, virginianum. Salvia lyrata,* [*officinalis*], [*verticillata*]. *Satureja vulgaris* (v. *neogaea*). *Scutellaria elliptica, epilobiifolia, integrifolia, lateriflora, nervosa, parvula* (v. *leonardii*). *Stachys hyssopifolia* (typ. & v. *ambigua*), [*palustris* (typ.)], *tenuifolia* (v. *platyphylla*). *Teucrium canadense* (v. *virginicun*). [*Thymus serpyllum*]. *Trichostema brachiata* (synonym *Isanthus*), *dichotomum.*

Solanaceae: [*Capsicum annuum*]. [*Datura innoxia, meteloides, stramonium*]. [*Lycium halimifolium*]. [*Lycopersicum esculentum*]. [*Petunia axillaris, hybrida, violacea*]. *Physalis* [*alkakengii*], *heterophylla* (typ. & v. *ambigua*), [*ixocarpa*], [*pruinosa*], *subglabrata. Solanum carolinense,* [*dulcamara* (typ. & v. *villosissimum*)], *nigrum* v. *americanum,* [*rostratum*], [*tuberosum*].

Scrophulariaceae: *Agalinis* (synonym *Gerardia*) *purpurea, tenuifolia.* [*Antirrhinum majus*]. *Aureolaria* (synonym *Gerardia*) *flava, pedicularia, virginica. Buchnera americana. Castilleja coccinea* (typ. & f. *lutea*). [*Chaenorrhinum minus*]. *Chelone glabra,* [*Cymbalaria muralis*]. *Gratiola aurea* (typ. & v. *obtusa*), *neglecta.* [*Kicksia elatine*]. *Limosella subulata. Linaria canadensis,* [*genistaefolia*], [*vulgaris*]. *Lindernia anagallidea, dubia* (incl. aquatic variants *inundata &*

riparia). [*Mazus reptans*]. *Melampyrum lineare. Micranthemum micranthemoides. Mimulus alatus, ringens. Pedicularis canadensis, lanceolata. Penstemon* [*calycosus*], [*digitalis*], *hirsutus,* [*pallidus*]. *Scrophularia lanceolara, marilandica. Tomanthera* (synonym *Gerardia*) *auriculata.* [*Verbascun blattaria, lychnitis, phlomoides, thapsus*]. *Veronica americana,* [*anagallis-aquatica,* (typ. & f. *anagalliformis*)], [*arvensis*], [*chamaedrys*], [*filiformis*], [*hederaefolia*], [*longifoloa*], *officinalis, peregrina* (typ. & v. *xalapensis*), [*persica*], [*polita*], *scutellata,* [*serpyllifolia*]. *Veronicastrum virginicum.*

BIGNONIACEAE: *Campsis radicans.* [*Catalpa bignonioides*]. [*Paulownia tomentosa*] (sometimes placed in preceding family).

MARTYNIACEAE: [*Proboscidea louisianica*].

OROBANCHACEAE: *Conopholis americana. Epifagus virginiana. Orobanche uniflora.*

LENTIBULARIACEAE: *Utricularia fibrosa, gibba, inflata* (v. *minor*), *intermedia, vulgaris.*

PHRYMACEAE: *Phryma leptostachya.*

PLANTAGINACEAE: *Plantago* [*aristata*], [*indica*], [*lanceolata*], [*major*], *rugelii, virginica.*

RUBIACEAE: *Cephalanthus occidentalis. Diodia teres. Galium aparine, asprellum, boreale, circaezans* (typ. & v. *hypomalacum*), *concinnum,* [*erectum*], *lanceolatum,* [*mollugo*], *obtusum, pilosum, tinctorium, triflorum,* [*verum*]. *Hedyotis* (synonym *Houstonia*) *caerulea. Mitchella repens.*

CAPRIFOLIACEAE: *Diervilla lonicera. Lonicera* [× *bella*], *dioica,* [*japonica* (typ. & v. *chinensis*)], [*morrowi*], *sempervirens,* [*standishii*], [*tatarica*]. *Sambucus canadensis, pubens. Symphoricarpos* [*albus* (v. *laevigatus*)], *orbiculatus, Triosteum angustifolium, aurantiacum* (typ. & v. *glaucescens*), *perfoliatum. Viburnum acerifolium, cassinoides, dentatum, lentago, nudum,* [*opulus*], *prunifolium, rafunesquianum, recognitum.*

VALERIANACEAE: [*Valeriana officinalis*]. *Valerianella intermedia,* [*olitoria*], *patellaria.*

DIPSACACEAE: [*Dipsacus sylvestris*].

CUCURBITACEAE: [*Citrullus vulgaris*], [*Cucumis sativus*]. [*Cucurbita pepo*]. *Echinocystis lobata.* [*Lagenaria vulgaris*]. *Sicyos angulatus.*

CAMPANULACEAE: *Campanula americana, aparinoides,* [*glomerata*], [*rapunculoides*], *rotundifolia. Triodanis* (synonym *Specularia*) *perfoliata.*

LOBELIACEAE: *Lobelia cardinalis, inflata, nuttallii, siphilitica, spicata* (typ. & v. *companulata*).

COMPOSITAE: [*Achillea millefolium* (typ. & f. *rosea*)]. *Ambrosia artemisiifolia, trifica* (typ. & f. *integrifolia*). *Anaphalis margaritacea. Antennaria fallax, neglecta, neodioica, parlinii, plantaginifolia. Aster* × *amethystinus, cordifolius, divaricatus, dumosus, ericoides, infirmus, laevis, lateriflorus, linariifolius, lowrieanus, luciculus, macrophyllus, nemoralis, novae-angliae, novi-belgii, patens* (typ. & v. *phlogifolius*), *pilosus* (typ., v. *demotus* & v. *platyphyllus*), *prenanthoides, puniceus* (typ. & v. *calvus*), *radula, sagittifolius, schreberi, simplex* (typ. & v. *ramosissimus*), *spectabilis, umbellatus, undulatus, vimineus* (typ. & v. *subdumosus*). [*Baccharis halimifolia*]. [*Bellis perennis*]. *Bidens bidentoides, bipinnata, cernua, comosa, connata* (typ. & v. *petiolata*), *coronata, discoidea, frondosa* (typ. & v. *anomala*), *laevis, polylepis* (typ. & v. *retrorsa*), *vulgata. Cacalia atriplicifolia.* [*Carduus nutans*]. [*Centaurea calcitrapa, cyanus, jacea, maculosa, nigra* v. *radiata, vochinensis*]. [*Chrysanthemum leucanthemum* (v. *pinnatifidum*), *morifolium, parthenium*]. [*Cichorium endiva, intybus*]. *Cirsium altissimum,* [*arvense* (typ., v. *integrifolium* & v. *vestitum*], *discolor, muticum, pumilum,* [*vulgare*]. *Coreopsis* [*lanceolata* (incl. *grandiflora*)], *rosea,* [*tinctoria*], *tripteris.* [*Cosmos bipinnatus, sulphureus*]. [*Crepis capillaris, tectorum*]. [*Echinops sphaerocephalus*]. *Eclipta alba. Erechtites hieracifolia. Erigeron annuus, canadensis, philadelphicus, pulchellus, strigosus* (typ. & f. *discoideus*). *Eupatorium album, coelestinum, dubium, fistulosum, hyssopifolium* (incl. v. *calcaratum*), *leucolepis, perfoliatum* (typ. & f. *purpureum*), *pilosum, pubescens, purpureum, rotundifolium, rugosum,* [*serotinum*], *sessilifolium.* [*Filago germanica*]. [*Galinsoga ciliata, parviflora*]. *Gnaphalium obtusifolium* (incl. v. *micradenium*), *purpureum, uliginosum. Helenium* [*amarum* (synonym *tenuifolium*)], *autumnale,* [*flexuosum* (synonym *nudiflorum*)]. *Helianthus angustifolius,* [*annuus*], [*debilis* (v. *cucumerifolius*)], *decapetalus, divaricatus, giganteus,* [*laetiflorus*], [*petiolaris*], *strumosus,* [*tuberosus*]. *Heliopsis helianthoides. Heterotheca* (synonym *Chrysopsis*) *mariana. Hieracium* [*aurantiacum*], [*flagellare*], [*florentinum*], *gronovii, paniculatum,* [*pratense*], [*sabaudum*], *scabrum,* [*vulgatum*]. [*Hypochoeris radicata*]. [*Inula helenium*]. [*Ixeris* (synonym *Lactuca*) *stolonifera*]. *Krigia biflora,* virginica. *Lactuca biennis* (synonym *spicata*), *canadensis* (typ., v. *latifolia* & v. *longifolia*), *floridana* (typ. & v. *villosa*), [*sativa*], [*scariola* (typ. & v. *integrata*)]. [*Lapsana communis*]. [*Leontodon autumnalis, nudicaulis*]. *Liatris spicata* (typ. & v. *resinosa*). [*Matricaria chamomilla, matricarioides*]. *Mikania scandens.* [*Petasites vulgaris*]. [*Picris hieracioides*]. *Polymnia canadensis. Prenanthes alba, altissima, serpntaria, trifoliolata.* [*Ratibida pinnata*]. *Rudbeckia fulgida,* [*hirta* v. *pulcherrima*], *laciniata* (typ. & cv. Hortensia), *triloba. Senecio aureus* (v. *gracilis & intercursus*), *obovatus* (typ. & v. *elongatus*), *pauperculus* (typ. & v. *crawfordii*), [*vulgaris*]. *Sericocarpus asteroides, linifolius. Solidago altissima, arguta, bicolor, caesia, canadensis* v. *hargeri, flexicaulia, gigantea* (typ. & v. *leiophylla*), *graminifolia* v. *nuttallii, juncea, nemoralis, patula, puberula, rigida, rugosa* (typ., v. *aspera* & v. *villosa*), *speciosa, squarrosa, tenuifolia, uliginosa, ulmifolia.* [*Sonchus asper, oleraceus, uliginosus*]. [*Tagetes erecta, patula*]. [*Tanacetum vulgare*]. [*Taraxacum erythrospermum* (synonym *laevigatum*), *officinale*]. [*Tragopogon dubius, porrifolius, pratensis*]. [*Tussilago farfara*]. *Verbesina* (synonym *Actinomeris*) *alternifolia. Vernonia noveboracensis. Xanthium chinense, italicum, pensylvanicum.*

A CHECK-LIST OF THE FLORA OF BERKS COUNTY, PENNSYLVANIA

HANS WILKENS

Reading, Pennsylvania

Berks County is located in southeastern Pennsylvania; its principal town is Reading, on the Schuylkill River about 60 miles northwest of Philadelphia. The highest elevation is near the northern border, at about 1600 ft. above sea level; the lowest where the Schuylkill leaves the county, is at about 130 ft. Small areas in the southern and the northwestern parts of the county are in the Susquehanna River drainage, the rest in that of the Delaware.

This list is based largely on specimens preserved in the herbarium of the Academy of Natural Sciences of Philadelphia, collected over a period of about 125 years. The nomenclature is intended to be that of the 8th edition of Gray's Manual (1950). Introduced species are in brackets; those that have probably not persisted are marked with an asterisk. The known flora numbers about 1600 species of vascular plants, nearly one-third of them introduced.

PTERIDOPHYTES

EQUISETACEAE: *Equisetum arvense, fluviatile, hyemale* v. *affine, sylvaticum.*

LYCOPODIACEAE: *Lycopodium clavatum, flabelliforme, lucidulum, obscurum* typ. & v. *dendroideum, tristachyum.*

SELAGINELLACEAE: *Selaginella apoda, rupestris.*

ISOETACEAE: *Isoetes engelmannii.*

OPHIOGLOSSACEAE: *Botrychium dissectum* typ., f. *obliquum* & f. *oneidense, lanceolatum* v. *angustisegmentum, matricariaefolium, simplex, virginianum. Ophioglossum vulgatum* v. *pseudopodum.*

OSMUNDACEAE: *Osmunda cinnamomea, claytoniana, regalis* v. *spectabilis.*

POLYPODIACEAE: *Adiantum pedatum. Asplenium cryptolepis,* × *ebenoides, pinnatifidum, platyneuron, trichomanes. Athyrium filix-femina* v. *asplenoides* & v. *michauxii* f. *rubellum, pycnocarpon, thelypteroides. Camptosorus rhizophyllus. Cheilanthes vestita. Cystopteris bulbifera, fragilis* v. *mackayii* & v. *protrusa,* × *tennesseensis. Dennstaedtia punctilobula. Dryopteris* × *boottii, celsa, cristata* typ. & v. *clintoniana, disjuncta, goldiana, hexagonoptera, marginalis, noveboracensis, phegopteris, simulata, spinulosa* typ. & v. *intermedia, thelypteris* v. *pubescens. Onoclea sensibilis. Pellaea atropurpurea, glabella. Polypodium virginianum. Polystichum acrostichoides. Pteridium aquilinum* v. *latiusculum.* [*Pteretis pensylvanica*]. *Woodsia ilvensis, obtusa. Woodwardia areolata, virginica.*

SPERMATOPHYTES

CONIFERS

Taxaceae: *Taxus canadensis.*

Pinaceae: *Juniperus communis* typ. & v. *depressa, virginiana* v. *crebra. Pinus pungens, rigida, strobus, virginiana. Tsuga canadensis.*

MONOCOTS

Typhaceae: *Typha angustifolia, latifolia.*

Sparganiaceae: *Sparganium americanum, eurycarpum.*

Zosteraceae: *Potamogeton amplifolius, bicupulatus,* [*crispus*], *diversifolius, epihydrus* v. *nuttallii, foliosus* typ. & v. *macellus, nodosus, pectinatus, perfoliatus* v. *bupleuroides. Zannichellia palustris* v. *major.*

Alismataceae: *Alisma subcordatum. Sagittaria australis, graminea, latifolia* typ. & v. *pubescens, rigida.*

Hydrocharitaceae: *Elodea canadensis, nuttallii. Vallisneria americana.*

Gramineae: [*Agropyron repens*]. *Agrostis alba, hyemalis, perennans, scabra.* [*Alopecurus pratensis**]. *Andropogon gerardi, scoparius, virginicus* typ. & v. *abbreviatus.* [*Anthoxanthum odoratum*], [*puellii**]. *Aristida dichotoma, longespica, oligantha. Arrhenatherum elatius.* [*Avena sativa**]. *Brachyelytrum erectum* typ. & v. *septentrionale.* [*Briza media**]. *Bromus* [*brizaeformis**], [*commutatus*], [*inermis*], [*japonicus* v. *porrectus*], *latiglumis, purgans,* [*secalinus*], [*sterilis*], [*tectorum*]. *Calamagrostis canadensis, cinnoides.* [*Cenchrus longispinus*]. *Cinna arundinacea.* [*Cynodon dactylon*]. [*Cynosurus echinatus*]. [*Dactylis glomerata*]. *Danthonia compressa, spicata. Deschampsia caespitosa, flexuosa. Digitaria filiformis,* [*ischaemum*], [*sanguinalis* typ. & v. *ciliaris**]. *Echinochloa* [*crusgalli*], *pungens.* [*Eleusine indica*]. *Elymus canadensis* f. *glaucifolius, riparia, villosus, virginicus. Eragrostis capillaris, frankii, hypnoides,* [*megastachya*], [*multicaulis*], *pectinacea,* [*pilosa*], [*poaeoides*], *spectabilis.* [*Eulalia viminea* v. *variabilis*]. *Festuca* [*arundinacea*], [*elatior*], *obtusa,* [*ovina*], [*rubra*]. *Glyceria canadensis, melicaria, pallida, septentrionalis, striata.* [*Holcus lanatus*]. [*Hordeum jubatum*], [*vulgare**]. *Hystrix patula. Leersia oryzoides, virginica* typ. & v. *ovata.* [*Leptoloma cognatum**]. [*Lolium multiflorum*], [*perenne*]. [*Manisuris altissimus**]. *Melica nitens**. [*Miscanthus sinensis*]. *Muhlenbergia frondosa, glomerata, mexicana, schreberi, sobolifera, sylvatica, tenuiflora. Oryzopsis racemosa. Panicum agrostoides, anceps, angustifolium*,* × *bicknellii, boscii* typ & v. *molle,* × *calliphyllum, capillare* typ. & v. *occidentale, clandestinum, columbianum, commutatum* typ. & v. *ashei, depauperatum* typ. & v. *psilophyllum, dichotomiflorum, dichotomum* typ. & v. *barbulatum, flexile, gattingeri, lanuginosum* v. *fasciculatum,* v. *implicatum,* & v. *lindheimeri, linearifolium* typ. & v. *werneri, longifolium*, meridionale, microcarpon,* [*miliaceum*], *philadelphicum, polyanthes, sphaerocarpon, stipitatum, verrucosum, villosissimum, virgatum. Paspalum ciliatifolium* v. *muhlenbergii, laeve* v. *circulare, setaceum.* [*Pennisetum alopecuroides**]. *Phalaris arundinacea,* [*canariensis**]. [*Phleum pra-*

tense]. [*Phragmites communis* v. *berlandieri*]. *Poa alsodes*, [*annua*], *autumnalis**, [*compressa*], *cuspidata, nemoralis, paludigena, palustris, pratensis, sylvestris, trivialis.* [*Pseudosasa japonica**]. [*Secale cereale**]. *Setaria* [*faberii*], *geniculata*, [*glauca*], [*verticillata*], [*viridis*]. *Sorghastrum nutans.* [*Sorgum halepense*], [*vulgare**]. *Spartina pectinacea. Sphenopholis intermedia, nitida, obtusata. Sporobolus asper, cryptandrus, neglectus, vaginiflorus. Stipa avenacea. Triodia flava* typ. & f. *cuprea. Tripsacum dactyloides. Trisetum pensylvanicum.* [*Triticum aestivum**]. *Vulpia* [*myuros*], *octoflora.*

CYPERACEAE: *Bulbostylis capillaris. Carex abdita, aggregata, albolutescens, albursina, amphibola* typ., v. *rigida* & v. *turgida, angustior, annectens, argyrantha, artitecta, blanda, bromoides, bushii, buxbaumii, canescens* v. *disjuncta, caroliniana, cephaloidea, cephalophora, communis, comosa, conjuncta, conoidea, convoluta, crinita* typ. & v. *gynandra, cristatella, davisii, debilis* typ., v. *pubera* & v. *rudgei, digitalis, emmonsii, emoryi, festucacea, flaccosperma* v. *glaucodea, folliculata, frankii, gracilescens, gracillima, granularis, grayii, hirsutella, hirtifolia, hitchcockiana, hystericina, incomperta, interior, intumescens, jamesii, lacustris, laevivaginata, lanuginosa, lasiocarpa* v. *americana, laxiculmis, laxiflora, leavenworthii, leptalea, leptonervia, lupulina, lurida, molesta, muhlenbergii* typ. & v. *enervis, nigromarginata, normalis, oligocarpa, pedunculata, pensylvanica* typ. & v. *lucorum, platyphylla, prairea, prasina, projecta, retroflexa, rosea, scabrata, scoparia, seorsa, sparganoides,* [*spicata*], *squarrosa, sterilis, stipata, straminea, striatula, stricta* typ. & v. *strictior, styloflexa, swanii, tenera, tonsa, torta, tribuloides, trichocarpa, trisperma, umbellata, vestita, virescens, vulpinoidea, willdenowii. Cyperus* [*dentatus*], *erythrorhizos, esculentus, filiculmis, flavescens* v. *poaeformis, inflexus,* [*iria**], [*ovularis**], *rivularis,* [*schweinitzii*], *strigosus. Dulichium arundinaceum. Eleocharis acicularis, calva, engelmannii, intermedia, obtusa, smallii, tenuis* typ. & v. *pseudoptera. Eriophorum gracile, virginicum. Fimbristylis autumnalis. Rynchospora alba, capitellata. Scirpus americanus, atrovirens* typ. & v. *georgianus, cyperinus, expansus, hattorianus, lineatus, polyphyllus, purshianus, rubricosus, validus* v. *creber, verecundus. Scleria pauciflora, triglomerata.*

ARACEAE: *Acorus calamus. Arisaema atrorubens* typ., f. *viride* & f. *zebrinum, dracontium, triphyllum. Orontium aquaticum. Symplocarpus foetidus.*

LEMNACEAE: *Lemna minor, perpusilla, trisulca*. Spirodela polyrhiza. Wolfia columbiana.*

XYRIDACEAE: *Xyris torta.*

COMMELINACEAE: [*Commelina communis* typ. & v. *lugens*].

PONTEDERIACEAE: *Heteranthera dubia, reniformis. Pontederia cordata.*

JUNCACEAE: *Juncus acuminatus, biflorus, bufonius, dudleyi, effusus* [v. *conglomeratus**], v. *pylaei* & v. *solutus, longii, marginatus, platyphyllus, secundus, subcaudatus, tenuis* typ. & v. *anthelatus. Luzula echinata,* [*luzuloides*], *multiflora.*

LILIACEAE: *Aletris farinosa. Allium canadense,* [*sativum**], [*schoenoprasum**], *tricoccum,* [*vineale*]. *Amianthemum muscaetoxicum.* [*Asparagus officinalis*]. *Chamaelirium luteum.* [*Convallaria majalis*]. *Erythronium americanum.* [*Hem-*

erocallis fulva]. [*Hosta ventricosa*]. *Lilium canadense* typ. & f. *rubrum, philadelphicum, superbum,* [*tigrinum*]. *Maianthemum canadense* typ. & v. *interius. Medeola virginiana. Melanthium hybridum, virginicum.* [*Muscari botryoides*], [*racemosum*]. [*Ornithogalum nutans*], [*umbellatum*]. *Polygonatum biflorum, canaliculatum, pubescens.* [*Scilla sibirica*]. *Smilacina racemosa* v. *cylindrata, stellata. Smilax glauca, herbacea, pulverulenta, rotundifolia, tamnoides* v. *hispida. Trillium cernuum, erectum.* [*Tulipa sylvestris*]. *Uvularia perfoliata, sessilifolia. Veratrum viride.* [*Yucca smalliana*].

DIOCOREACEAE: *Dioscorea quaternata, villosa.*

AMARYLLIDACEAE: *Hypoxis hirsuta.* [*Leucojum aestivum*].

IRIDACEAE: [*Belamcanda chinensis*]. *Iris* [*pseudacorus*], *versicolor. Sisyrinchium angustifolium, mucronatum.*

ORCHIDACEAE: *Aplectrum hyemale. Calopogon pulchellus. Corallorhiza maculata, odontorhiza, wisteriana. Cypripedium acaule, calceolus* v. *pubescens.* [*Epipactis helleborine*]. *Goodyera pubescens. Habenaria ciliaris, clavellata, fimbriata, flava* v. *herbiola, lacera, orbiculata, psycodes, viridis* v. *bracteata. Isotria medeoloides**, *verticillata. Liparis liliifolia, loeselii. Malaxis unifolia. Orchis spectabilis. Pogonia ophioglossoides. Spiranthes cernua, gracilis, lacera, lucida**, *tuberosa.*

DICOTS

SALICACEAE: *Populus* [*alba*], [*canescens*], [*deltoides*], [*giliadensis*], *grandidentata,* [*nigra* v. *italica**], *tremuloides. Salix* [*alba*], *bebbiana,* [*capraea*], *discolor,* [*fragilis*], *humilis, lucida, nigra,* [*purpurea*], *rigida, sericea,* [× *rubens*].

MYRICACEAE: *Comptonia peregrina. Myrica pensylvanica.*

JUGLANDACEAE: *Carya cordiformis, glabra, laciniosa, ovata. Juglans cinerea, nigra.*

CORYLACEAE: *Alnus* [*glutinosa*], *rugosa, serrulata. Betula lenta, lutea, nigra, papyrifera,* [*pendula*], *populifolia. Carpinus caroliniana* v. *virginiana. Corylus americana, cornuta. Ostrya virginiana* typ. & f. *glandulosa.*

FAGACEAE: *Castanea dentata. Fagus grandifolia. Quercus alba, bicolor,* × *bushii, coccinea, ilicifolia, marilandica, muehlenbergii, palustris,* [*pedunculata**], *prinoides, prinus, rubra, stellata, velutina.*

ULMACEAE: *Celtis occidentalis* typ. & v. *pumila, tenuifolia. Ulmus americana, rubra.*

MORACEAE: [*Broussonetia papyrifera*]. [*Ficus carica**]. *Maclura pomifera. Morus* [*alba*], *rubra.*

CANNABINACEAE: [*Cannabis sativa**]. [*Humulus japonicus*], [*lupulus*].

URTICACEAE: *Boehmeria cylindrica. Laportea canadensis. Parietaria pensylvanica. Pilea fontana, pumila. Urtica* [*dioica*], *gracilis.*

SANTALACEAE: *Comandra umbellata.*

ARISTOLOCHIACEAE: *Aristolochia serpentaria. Asarum canadense* typ. & v. *reflexum.*

Polygonaceae: [*Fagopyrum sagittatum**]. *Polygonella articulata. Polygonum amphibium* v. *stipulaceum, arifolium* v. *pubescens,* [*aviculare* typ. & v. *vegetum*], *careyi,* [*cespitosum* v. *longisetum*], *coccineum* typ. & f. *natans,* [*convolvulus* typ. & v. *subalatum*], *cristatum,* [*cuspidatum*], *erectum, hydropiper, hydropiperoides, lapathifolium,* [*orientale**], *pensylvanicum* v. *laevigatum,* [*persicaria*], *punctatum* v. *leptostachyum,* [*sachalinense**], *sagittatum, scandens, tenue. Rumex* [*acetosella*], [*altissimus*], [*crispus*], [*domesticus*], [*obtusifolius*], *orbiculatus. Tovara virginiana.*

Chenopodiaceae: *Atriplex* [*patula* typ. & v. *hastata.*] *Chenopodium* [*album*], *ambrosioides, berlandieri,* [*bonus-henricus**], *boscianum,* [*botrys*], [*carinatum*], *hybridum* v. *gigantospermum,* [*glaucum*], [*murale*], [*paganum*], [*urbicum*]. [*Cycloloma atripicifolium*]. [*Kochia scoparia*]. [*Salsola kali* v. *tenuifolia*].

Amaranthaceae: *Amaranthus albus,* [*cruentus**], *graecizans,* [*hybridus*], [*lividus*], [*palmeri*], [*powellii*], *retroflexus,* [*spinosus**]. [*Froelichia gracilis*].

Nyctaginaceae: [*Mirabilis nyctaginea*].

Phytolaccaceae: *Phytolacca americana.*

Aizoaceae: [*Mollugo verticillata*].

Portulacaceae: *Claytonia virginica* typ. & f. *robusta.* [*Portulacca oleracea*].

Caryophyllaceae: [*Agrostemma githago*]. *Arenaria lateriflora,* [*serpyllifolia*], *stricta. Cerastium arvense, nutans,* [*pumilum*], [*viscosum*], [*vulgatum*]. [*Dianthus armeria*], [*prolifer*]. [*Holosteum umbellatum*]. [*Lychnis alba*]. [*Myosoton aquaticum*]. *Paronychia canadensis, fastigiata. Sagina* [*japonica*], *procumbens.* [*Saponaria officinalis*]. [*Scleranthus annuus*]. *Silene antirrhina* typ. & f. *deaneana,* [*armeria**], *carolina* v. *pensylvanica,* [*cserei*], [*cucubalus*], [*dichotoma*], [*noctiflora*], *stellata.* [*Spergula arvensis**]. *Stellaria alsine,* [*graminea*], *longifolia,* [*media*], [*pallida*], *pubera.*

Ceratophyllaceae: *Ceratophyllum demersum, echinatum.*

Nymphaeaceae: *Brasenia schreberi*. Nuphar advena.* [*Nymphaea odorata*].

Ranunculaceae: [*Aconitum fischeri**]. *Actaea pachypoda. Anemone* [*canadensis**], *quinquefolia, virginiana. Anemonella thalictroides. Aquilegia canadensis,* [*vulgaris*]. *Caltha palustris. Cimicifuga racemosa* typ. & [v. *cordifolia**]. *Clematis* [*diocoreifolia*], *verticillaris, virginiana. Coptis groenlandica.* [*Delphinium ajacis**]. [*Helleborus viridis**]. *Hepatica americana. Hydrastis canadensis. Ranunculus abortivus,* [*acris*], *ambigens,* [*bulbosus*], [*ficaria*], *hispidus* v. *falsus, longirostris, pensylvanicus, recurvatus,* [*repens* typ. & v. *pleniflorus*], *sceleratus, septentrionalis, trichophyllus. Thalictrum dioicum, polygamum, revolutum.*

Berberidaceae: [*Berberis thunbergii*], [*vulgaris**]. *Caulophyllum thalictroides. Podophyllum peltatum.*

Lardizabalaceae: [*Akebia quinata**].

Menispermaceae: *Menispermum canadense.*

Magnoliaceae: *Liriodendron tulipifera. Magnolia acuminata,* [*tripetala*], *virginiana.*

Annonaceae: *Asimina triloba.*

Lauraceae: *Lindera benzoin. Sassafras albidum* typ. & v. *molle.*

Papaveraceae: *Adlumia fungosa.* [*Chelidonium majus*]. *Corydalis flavula, sempervirens,* [*solida**]. *Dicentra cucullaria.* [*Eschscholtzia californica**]. [*Fumaria officinalis*]. [*Papaver dubium*]. *Sanguinaria canadensis.*

Capparidaceae: [*Cleome spinosa**]. [*Polanisia graveolens*].

Cruciferae: [*Alliaria officinalis*]. [*Alyssum alyssoides*]. [*Arabidopsis thalianum*]. *Arabis canadensis,* [*glabra*], *hirsuta* v. *pycnocarpa, laevigata, lyrata, patens.* [*Armoracia lapathifolia*]. [*Barbarea verna*], [*vulgaris* typ., & v. *arcuata*], & [v. *sylvestris*]. [*Berteroa incana*]. [*Brassica hirta**], [*juncea*], [*kaber* v. *pinnatifida*], [*nigra*], [*rapa*]. [*Camelina microcarpa*]. [*Capsella bursa-pastoris*]. *Cardamine bulbosa,* [*hirsuta*], *parviflora* v. *arenicola, pensylvanica, pratensis* v. *palustris, rotundifolia.* [*Cardaria draba*]. [*Conringia orientalis**]. *Dentaria laciniata.* [*Descurainia sophia*]. [*Diplotaxis muralis*], [*tenuifolia*]. [*Draba verna*]. [*Erucastrum gallicum*]. [*Erysium cheiranthoides*], [*repandum*]. [*Hesperis matronalis*]. [*Iberis umbellata**]. *Lepidium* [*campestre*], [*densiflorum*], *virginicum.* [*Lobularia maritima**]. [*Lunaria annua*]. *Nasturtium officinale. Rorippa islandica* v. *fernaldiana,* [*sylvestris*]. [*Sisymbrium altissimum*], [*officinale* typ. & v. *leiocarpum*]. [*Thlaspi arvense*], [*perfoliatum*].

Resedaceae: [*Reseda lutea*].

Droseraceae: *Drosera rotundifolia.*

Crassulaceae: *Sedum* [*acre*], [*alboroseum*], [*album**], [*sarmentosum*], [*telephium*], *ternatum.*

Saxifragaceae: *Chrysosplenium americanum.* [*Deutzia scabra*]. *Heuchera americana. Hydrangea arborescens. Mitella diphylla. Penthorum sedoides.* [*Philadelphus coronarius*]. *Ribes americanum,* [*grossularia*], *hirtellum,* [*odoratum**], *rotundifolium,* [*sativum*]. *Saxifraga pensylvanica, virginiensis.*

Hamamelidaceae: *Hamamelis virginiana.* [*Liquidambar styraciflua**].

Platanaceae: *Platanus occidentalis.*

Rosaceae: *Agrimonia gryposepala, microcarpa, parviflora, pubescens, rostellata, striata. Amelanchier arborea, canadensis, laevis, stolonifera. Crataegus biltmoreana, calpodendron, crus-galli, dodgei, holmesiana, intricata, macrosperma,* [*monogyna**], [*phaenopyrum*], *punctata.* [*Duchesnea indica*]. *Fragaria* [*vesca* typ.], [f. *alba*] & v. *americana, virginianum. Geum aleppicum, canadense, laciniatum, vernum, virginianum. Gillenia trifoliata. Physocarpus opulifolius. Potentilla* [*argentea*], *arguta, canadensis,* [*intermedia*], *norvegica,* [*paradoxa**], [*recta*], [*reptans*], *simplex* typ. & v. *calvescens. Prunus americana,* [*avium*], [*cerasus*], [*mahaleb**], *pensylvanica,* [*persica*], *serotina, susquehanae, virginiana. Pyrus americana, arbutifolia,* [*communis*], *coronaria, floribunda,* [*malus*], *melanocarpa.* [*Rhodotypus scandens*]. *Rosa* [*canina*], *carolina* typ. & v. *villosa,* [*eglanteria*], [*multiflora*], *palustris,* [*setigera*], *virginiana. Rubus allegheniensis, enslenii, hispidus* typ. & v. *obovalis,* [*illecebrosus*], [*laciniatus*], *occidentalis, odoratus,* [*phoenicolasius*]. *Sanguisorba canadensis,* [*minor*]. *Spiraea alba,* [*japonica*], *latifolia, tomentosa. Waldsteinia fragaroides.*

Leguminosae: [*Amorpha fruticosa*]. *Amphicarpa bracteata* typ. & v. *comosa.*

Apios americana. Baptisia tinctoria typ. & v. *projecta. Cassia fasciculata, hebecarpa, nictitans. Cercis canadensis. Clitoria mariana.* [*Coronilla varia*]. *Crotalaria sagittalis.* [*Cytisus scoparius**]. *Desmodium canadense, canescens, ciliare, cuspidatum, dillenii, glutinosum, laevigatum, marilandicum, nudiflorum, nuttallii, paniculata, rigidum, rotundifolium. Galactia regularis*, volubilis.* [*Gleditsia triacanthus*]. *Lathyrus* [*latifolius*], *palustris. Lespedeza capitata* v. *vulgaris,* [*cuneata*], *hirta, intermedia,* × *nuttallii, procumbens, repens,* [*stipulacea, striata*], *violacea, virginica.* [*Lotus corniculatus**]. *Lupinus perennis.* [*Medicago lupulina*], [*sativa*]. [*Melilotus alba*], [*officinalis*]. *Phaseolus polystachios* v. *aquilonius,* [*Robinia pseudoacacia*]. [*Strophostyles helvola*], [*leiosperma**]. *Stylosanthes biflora, riparia. Tephrosia virginiana.* [*Trifolium agrarium*], [*arvense*], [*dubium*], [*fragiferum**], [*hybridum*], [*incarnatum**], [*pratense*], [*procumbens*], [*repens*], [*resupinatum**]. *Vicia americana,* [*angustifolia*], [*cracca*], [*dasycarpa*], [*villosa*].

LINACEAE: *Linum medium* v. *texanum,* [*perenne**], *striatum,* [*usitatissimum**], *virginianum.*

OXALIDACEAE: *Oxalis* [*corniculata*], *europaea, filipes, stricta, violacea.*

GERANIACEAE: [*Erodium cicutarium*]. *Geranium carolinianum,* [*columbinum*], *maculatum,* [*molle*], [*pusillum*], *robertianum.*

ZYGOPHYLLACEAE: [*Tribulus terrestris*].

RUTACEAE: *Xanthoxylum americanum.*

SIMAROUBACEAE: [*Ailanthus altissima.*]

POLYGALACEAE: *Polygala paucifolia, polygama* v. *obtusata, sanguinea* typ. & f. *albiflora, verticillata* typ., v. *ambigua,* & v. *isocycla.*

EUPHORBIACEAE: *Acalypha gracilens, rhomboidea, virginica. Euphorbia* [*cyparissias*], [*dentata*], [*esula*], [*falcata*], [*lathyris*], *maculata,* [*marginata*], [*peplus*], *supina, vermiculata.*

CALLITRICHACEAE: *Callitriche deflexa* v. *austini, palustris,* [*stagnalis*].

BUXACEAE: [*Pachysandra terminalis**].

LIMNANTHACEAE: *Floerkea proserpinacoides.*

ANACARDIACEAE: *Rhus copallina, glabra, radicans, typhina, vernix.*

AQUIFOLIACEAE: *Ilex laevigata, montana, opaca*, verticillata. Nemopanthus mucronata.*

CELASTRACEAE: *Celastrus* [*orbiculatus*], *scandens. Euonymus americanus, atropurpureus.*

STAPHYLEACEAE: *Staphylea trifolia.*

ACERACEAE: *Acer* [*ginnala*], *negundo, pensylvanicum,* [*platanoides*], *rubrum* typ. & v. *trilobum, saccharinum, saccharum, spicatum.*

HIPPOCASTANACEAE: [*Aesculus glabra*].

BALSAMINACEAE: *Impatiens capensis, pallida.*

RHAMNACEAE: [*Rhamnus cathartica*], [*frangula*]. *Ceanothus americanus.*

VITACEAE: [*Ampelopsis brevipedunculata*]. *Parthenocissus quinquefolia,* [*tricuspidata**]. *Vitis aestivalis* typ. & v. *argentifolia, labrusca, riparia,* [*vinifera**], *vulpina.*

TILIACEAE: *Tilia americana.*

MALVACEAE: [*Abutilon theophrasti*]. [*Althea officinalis**], [*rosea**]. [*Hibiscus moscheutus*], [*syriacus**], [*trionum*]. [*Malva moschata*], [*neglecta*], [*sylvestris**]. [*Sida spinosa*].

GUTTIFERAE: *Ascyrum hypericoides* v. *multicaule. Hypericum canadense,* [*densiflorum**], *ellipticum, gentianoides, mutilum,* [*perforatum*], *punctatum, virginicum.*

CISTACEAE: *Helianthemum bicknellii, canadense, propinquum. Lechea intermedia, leggettii, minor, racemulosa.*

VIOLACEAE: *Hybanthus concolor. Viola affinis,* [*arvensis*], *blanda, conspersa, cucullata, emarginata, fimbriatula* typ. & f. *glabrata, hirsutula, kitaibeliana* v. *rafinesquii, lanceolata,* [*odorata* typ. & f. *albiflora*], *pallens, palmata, papilionacea* typ. & [f. *albiflora*], *pedata* typ. & v. *lineariloba, pensylvanica* v. *leiocarpa, primulifolia* typ. & v. *villosa, pubescens, rostrata, rotundifolia, sagittata, sororia, stoneana, striata,* [*tricolor**], *triloba.*

CACTACEAE: [*Opuntia humifusa*].

THYMELAEACEAE: *Dirca palustris.*

ELAEAGNACEAE: [*Elaeagnus umbellata*].

LYTHRACEAE: *Cuphea petiolata. Decodon verticillatus. Lythrum alatum,* [*salicaria*]. *Rotala ramosior.*

NYSSACEAE: *Nyssa sylvatica.*

MELASTOMATACEAE: *Rhexia virginica.*

ONAGRACEAE: *Circaea alpina, quadrisulcata* v. *canadensis. Epilobium angustifolium, coloratum, glandulosum* v. *adenocaulon,* [*hirsutum*], *strictum. Gaura biennis.* [*Jussiaea michauxiana*]. *Ludwigia alternifolia, palustris* v. *americana. Oenothera biennis,* [*laciniata**], *perennis,* [*speciosa**], *tetragona.*

HALORAGACEAE: *Myriophyllum exalbescens, humile* typ. & f. *capillaceum. Proserpinaca palustris.*

ARALIACEAE: [*Acanthopanax sieboldianus**]. *Aralia hispida, nudicaulis, racemosa,* [*spinosa*]. [*Hedera helix*]. [*Kalopanax septemloba*]. *Panax quinquefolius, trifolius.*

UMBELLIFERAE: [*Aegopodium podagraria*]. [*Aethusa cynapium*]. [*Anethum graveolens**]. *Angelica atropurpurea, venenosa.* [*Anthriscus sylvestris*]. [*Carum carvi**]. *Chaerophyllum procumbens. Cicuta bulbifera, maculata.* [*Conium maculatum*]. [*Coriandrum sativum*]. *Cryptotaenia canadensis.* [*Daucus carota*]. [*Eryngium planum**]. *Heracleum maximum. Hydrocotyle americana. Osmorhiza claytoni, longistylis* typ. & v. *villicaulis.* [*Pastinaca sativa*]. [*Pimpinella saxifraga*]. *Sanicula canadensis, gregaria, marilandica, trifoliata. Taenidia integerrima. Thaspium barbinode.* [*Torilis japonica*]. *Zizia aptera, aurea.*

CORNACEAE: *Cornus alternifolia, amomum, canadensis, florida, racemosa, rugosa,* [*sanguinea*], [*stolonifera*].

CLETHRACEAE: [*Clethra alnifolia**].

PYROLACEAE: *Chimaphila maculata, umbellata* v. *cisatlantica. Monotropa hy-*

popithys, uniflora. Pyrola elliptica, rotundifolia v. *americana, secunda, virens* v. *convoluta* & v. *paucifolia.*

Ericaceae: *Epigaea repens. Gaultheria procumbens. Gaylussacia baccata, frondosa. Kalmia angustifolia, latifolia. Leucothoe racemosa. Lyonia ligustrina. Rhododendron maximum, nudiflorum* typ. & f. *glandiferum, roseum, viscosum. Vaccinium angustifolium* typ. & v. *hypolasium, atrococcum, corymbosum, macrocarpon, stamineum, vacillans.*

Primulaceae: [*Anagallis arvensis* typ. & f. *caerulea*]. *Lysimachia ciliata,* [*nummularia*], *producta,* [*punctata**], *quadrifolia, terrestris. Trientalis borealis.*

Ebenaceae: *Diospyros virginiana.*

Oleaceae: *Fraxinus americana* typ. & v. *biltmoreana, nigra, pensylvanica* typ. & v. *subintegerrima.* [*Ligustrum obtusifolium*], [*ovalifolium*], [*vulgare*].

Loganiaceae: [*Buddleja davidii*].

Gentianaceae: *Bartonia paniculata, virginica.* [*Centaurium pulchellum*]. *Gentiana andrewsii, clausa, crinita, villosa. Menyanthes trifoliata.* [*Nymphoides peltata**]. *Obolaria virginica. Sabatia angularis* typ. & f. *albiflora.*

Apocynaceae: *Apocynum androsaemifolium, cannabinum* typ. & v. *pubescens, medium, sibiricum.* [*Vinca minor*].

Asclepiadaceae: *Asclepias amplexicaulis, exaltata, incarnata* typ. & f. *albiflora, purpurascens, quadrifolia, syriaca, tuberosa* typ. & f. *lutea, variegata, verticillata, viridiflora* typ. & v. *lanceolata. Gonolobus obliquus.*

Convolvulaceae: *Convolvulus* [*arvensis*], [*pellitus* f. *anestius*], *sepium, spithamaeus. Cuscuta compacta,* [*epithymum*], *gronovii, pentagona. Ipomoea* [*coccinea*], [*hederacea*], [*lacunosa**], *pandurata,* [*purpurea*].

Polemoniaceae: *Phlox divaricata, maculata, ovata,* [*paniculata*], *pilosa, subulata. Polemonium reptans, vanbruntiae*.*

Hydrophyllaceae: *Hydrophyllum virginianum.* [*Phacelia bipinnatifida**].

Boraginaceae: *Cynoglossum* [*officinale*], *virginianum.* [*Echium vulgare* typ. & f. *roseum*]. *Hackelia virginiana.* [*Heliotropium europaeum*]. [*Lithospermum arvense*]. *Mertensia virginica. Myosotis* [*arvensis*], *laxa,* [*scorpioides*], [*stricta*], [*sylvatica*], *verna.*

Verbenaceae: *Verbena* [*bracteata**], × *engelmannii, hastata, simplex, urticifolia* typ. & v. *leiocarpa.*

Labiatae: *Agastache nepetoides, scrophularioides.* [*Ajuga reptans*]. *Collinsonia canadensis. Cunila origanoides.* [*Glechoma hederacea*]. *Hedeoma* [*hispida**], *pulegioides. Isanthus brachiatus.* [*Lamium amplexicaule* typ. & f. *clandestinum*], [*maculatum* typ. & f. *lacteum*], [*purpureum*]. [*Leonurus cardiaca*], [*marrubiastrum*]. *Lycopus americanus,* [*europaeus*], *rubellus, uniflorus, virginicus.* [*Marrubium vulgare*]. *Mentha* [*alopecuroides*], [*arvensis* typ.] & v. *villosa,* [*crispa*], [*gentilis* f. *variegata*], [*longifolia*], [*piperata*], [*spicata*]. *Monarda clinopodia,* [*didyma**], *fistulosa* typ. & [v. *mollis*], [*media**]. [*Nepeta cataria*]. [*Origanum vulgare*]. [*Perilla frutescens* typ. & v. *crispa*]. *Prunella* [*vulgaris* typ.] & v. *lanceolata. Pycnanthemum clinopodioides, incanum, muticum, tenuifolium, virginianum. Salvia* *lyrata,* [*verticillata**]. *Satureja* [*acinos*], *vulgaris* v. *neogaea. Scutellaria elliptica, epilobiifolia, integrifolia, lateriflora, nervosa, parvula* v. *leonardi. Stachys palustris, tenuifolia. Teucrium canadense* v. *virginicum. Trichostema dichotomum, setaceum.*

Solanaceae: [*Datura stramonium*]. [*Lycium chinense*], [*halimifolium*]. [*Petunia violacea*]. *Physalis heterophylla, subglabrata. Solanum americanum,* [*carolinense*], [*dulcamara* typ. & f. *albiflorum*], [*nigrum*].

Scrophulariaceae: *Castilleja coccinea.* [*Chaenorrhinum minus*]. *Chelone glabra.* [*Cymbalaria muralis*]. *Gerardia* [*auriculata*], *flava, pedicularia, tenuifolia, virginica. Gratiola neglecta.* [*Kickxia elatine*]. *Linaria canadensis* typ. & f. *cleistogama,* [*vulgaris*]. *Lindernia anagallidea, dubia* typ. & v. *riparia.* [*Mazus japonicus*]. *Melampyrum lineare. Mimulus alatus, ringens.* [*Paulownia tomentosa*]. *Pedicularis canadensis, lanceolata. Penstemon* [*calycosus*], [*digitalis*], *hirsutus, laevigatus**, [*pallidus*]. *Scrophularia lanceolata, marilandica.* [*Verbascum blattaria* typ. & f. *albiflora*], [*lychnitis*], [*thapsus*]. *Veronica americana,* [*anagallis-aquatica* typ. & v. *anagalliformis*], [*arvensis*], *comosa,* [*filiformis*], [*hederaefolia*], [*officinalis*], *peregrina,* [*persica*], [*polita*], *scutellata,* [*serpyllifolia*]. *Veronicastrum virginicum.*

Bignoniaceae: [*Campsis radicans*]. [*Catalpa bignonioides*].

Orobanchaceae: *Epifagus virginiana. Conopholis americana. Orobanche uniflora.*

Lentibulariaceae: *Utricularia geminiscapa.*

Phrymaceae: *Phryma leptostachya.*

Plantaginaceae: *Plantago* [*aristata*], [*indica*], [*lanceolata*], [*major*], *rugelii, virginica.*

Rubiaceae: [*Asperula odorata**]. *Cephalanthus occidentalis.* [*Diodia teres*]. *Galium* [*aparine*], *asprellum, boreale, circaezans,* typ. & v. *hypomalacum, concinnum,* [*erectum*], *lanceolatum,* [*mollugo*], *obtusum, pilosum, tinctorium, triflorum* typ. & v. *asprelliforme,* [*verum**]. *Houstonia caerulea, longifolia. Mitchella repens.* [*Sherardia arvensis*].

Caprifoliaceae: *Diervilla lonicera. Lonicera dioica, hirsuta,* [*japonica*], [*maackii*], [*morrowi*], [*sempervirens*], [*standishii*]. *Sambucus canadensis, pubens* typ. & f. *calva.* [*Symphoricarpos albus* v. *laevigatus*], [*orbiculatus*]. *Triosteum angustifolium, aurantiacum, perfoliatum. Viburnum acerifolium, cassinoides, dentatum, lentago,* [*opulus*], *prunifolium, rafinesquianum,* [*tomentosum*].

Valerianaceae: *Valerianella intermedia,* [*olitoria*], *patellaria.*

Dipsacaceae: [*Dipsacus fullonum**], [*laciniatus*], [*sylvestris*]. [*Knautia arvensis**].

Cucurbitaceae: *Echinocystis lobata. Sicyos angulatus.*

Campanulaceae: *Campanula americana, aparinoides,* [*rapunculoides*], *rotundifolia. Lobelia cardinalis, inflata, siphilitica, spicata* typ. & v. *campanulata. Specularia perfoliata.*

Compositae: Aster Subfamily: [*Achillea millefolium*]. *Ambrosia artemisiifolia, trifida. Anaphalis margaritacea. Antennaria fallax, neglecta, neodioica, par-*

linii, plantaginifolia. [*Anthemis arvensis*], [*cotula*]. [*Arctium lappa*], [*minus*]. [*Artemisia vulgaris*]. *Aster acuminatus, cordifolius, divaricatus, dumosus, infirmus, laevis, lateriflorus, linariifolius, lowrieanus, macrophyllus,* [*novae-angliae*], *novi-belgii, patens* typ. & v. *phlogifolius, pilosus* typ. & v. *demotus, prenanthoides, puniceus, radula, sagittifolius, schreberi, simplex, umbellatus, undulatus, vimineus. Bidens bipinnata, cernua, comosa, connata, discoidea, frondosa, laevis,* [*polylepis*], *vulgata. Cacalia atriplicifolia.* [*Carduus nutans*]. [*Centaurea jacea*], [*maculosa*], [*vochinensis*]. [*Chrysanthemum leucanthemum* v. *pinnatifidum*]. *Cirsium altissimum,* [*arvense* typ., v. *integrifolium* & v. *vestitum*], *discolor, muticum, pumilum,* [*vulgare*]. [*Coreopsis lanceolata*]. *Eclipta alba. Erechtites hieracifolia. Erigeron annuus, canadensis, philadelphicus, pulchellus, strigosus. Eupatorium* [*altissimum*], *aromaticum, dubium, fistulosum, perfoliatum, pilosum, pubescens, purpureum, rugosum,* [*serotinum*], *sessilifolium.* [*Galinsoga ciliata*], [*parviflora*]. *Gnaphalium obtusifolium, purpureum, uliginosum. Helenium autumnale, nudiflorum. Helianthus decapetalus, divaricatus, giganteus,* [*grosseserratus*], [*laetiflorus*], *strumosus,* [*tuberosus*]. *Heliopsis helianthoides. Kuhnia eupatorioides. Liatris* [*scariosa*], *spicata.* [*Matricaria matricarioides*]. *Mikania scandens. Polymnia uvedalia. Rudbeckia fulgida, hirta, laciniata, serotina, speciosa,* [*triloba*]. *Senecio aureus* v. *gracilis* & v. *intercursus, obovatus, pauperculus,* [*vulgaris*]. *Sericocarpus asteroides. Solidago altissima, arguta, bicolor, caesia, canadensis, flexicaulis, gigantea* typ. & v. *leiophylla, graminifolia* v. *nuttallii, odora, patula, puberula rigida, rugosa, squarrosa, ulmifolia.* [*Tussilago farfara*]. *Vernonia altissima, noveboracensis. Xanthium chinense, italicum, pennsylvanicum.*

COMPOSITAE: CHICORY SUBFAMILY: [*Chondrilla juncea*]. [*Cichorium intybus* typ., f. *album* & f. *roseum*]. *Hieracium* [*aurantiacum*], [*flagellare*], [*florentinum*], *gronovii, paniculatum,* [*pratense*], *scabrum, venosum,* [*vulgatum*]. [*Hypochoeris radicata*]. *Krigia biflora, virginica. Lactuca biennis, canadensis* v. *latifolia* & v. *obovata, floridana* typ. & v. *villosa, hirsuta* typ. & v. *sanguinea* f. *calvifolia,* [*saligna* typ. & v. *ruppiana*], [*scariola* typ. & v. *integrata*]. [*Lapsana communis*]. [*Picris hieracioides*]. *Prenanthes alba, altissima, serpentaria, trifoliata.* [*Sonchus arvensis*], [*asper* typ. & f. *inermis*], [*oleraceus* typ. & f. *lacerus*], [*uliginosus*]. [*Taraxacum erythrospermum*], [*officinale*]. [*Tragopogon majus*], [*porrifolius*], [*pratensis*].

A CHEMOSYSTEMATIC STUDY OF THE SERIES LAURIFOLIAE OF THE RED OAKS: PHENOLICS OF LEAVES

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The series Laurifoliae of the red oaks (Subgenus *Erythrobalanus*) was first proposed by Trelease (1924). He grouped five species from the southeastern United States into this series. They include the Laurel Oak (*Quercus laurifolia* Michx.), Upland Willow Oak (*Q. incana* Bartr.), Shingle Oak (*Q. imbricaria* Michx.), Scrub Oak (*Q. myrtifolia* Willd.), and Willow Oak (*Q. phellos* L.). Muller, in his treatment of the oaks of Texas (Muller, 1951), combined the series Nigrae of Trelease and parts of the series Phellodrys of Rafinesque with this series. The series Nigrae of Trelease consists of only a single species, the Water Oak (*Q. nigra* L.). None of the members of the series Phellodrys is represented in the United States.

The leaves of the members of this series are relatively small and mostly entire, rarely few-lobed or toothed. The fruits mature in the second year. The fruit cups are rather shallow, enclosing one-fourth of the acorns at their bases. The species are generally distributed in the Atlantic and Gulf states of the United States. *Quercus laurifolia, Q. nigra,* and *Q. phellos* inhabit stream banks, borders of swamps and rich river bottom-lands. *Quercus incana* and *Q. myrtifolia* are usually found in sandy uplands and on sandy ridges. *Quercus imbricaria* inhabits rich upland soils. Although hybridization within the series is probably common, as indicated by the presence of many intermediate forms, and especially among species with similar ecological preferences, distinctions between the species are clear and usually unquestionable.

This study is a part of the chemosystematic study of the American oaks (Li & Hsiao, 1974). The purpose of the present study is to evaluate the implications of chromatographic patterns of leaf phenolics on the systematics of the series Laurifoliae.

MATERIALS AND METHODS

Depending on availability of material, one leaf sample of *Q. myrtifolia* and *Q. incana* and three samples of each of the other species were studied chromatographically. Leaves were air dried and ground into fine powders. The ground leaf powders were extracted in 80% aqueous methanol. Each extract was spotted on a Whatman 3MM chromatographic paper (46 × 57 cm). The chromatograms were developed descendingly in the long direction in a chromatographic cabinet using TBA (ter-butanol: acetic acid: water = 3:1:1, v/v/v) as solvent for the first dimension. After drying, HOAc (15% acetic acid) was used as solvent for the second dimension. The chromatograms were observed under UV light alone and in the presence of ammonia vapor. The colors of each spot were recorded. The chromatographic pattern of each species was compared with those of the other

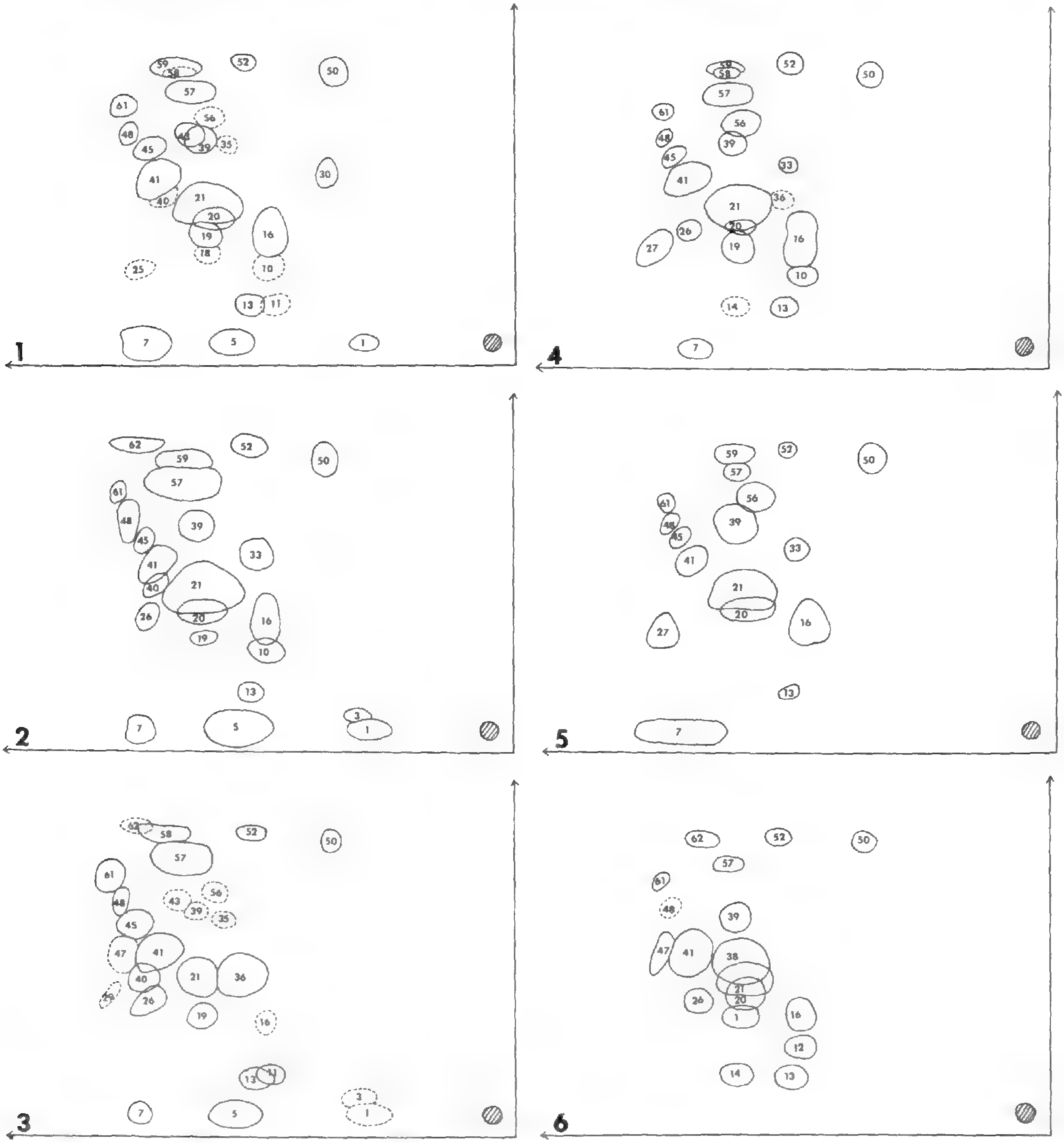

FIG. 1-6. — Two dimensional paper chromatographic pattern of phenolic compounds present in the leaves of: 1. *Quercus laurifolia;* 2. *Q. incana;* 3. *Q. imbricaria;* 4. *Q. nigra;* 5. *Q. myrtifolia;* 6. *Q. phellos.*

species. UV spectrophotometry (Mabry *et al.*, 1970) was employed in interpreting the chemical structures of several major spots.

RESULTS AND DISCUSSIONS

The leaf chromatographic patterns of the six species belonging to the series Laurifoliae are shown in Figures 1–6. The colors and Rf values of each of the spots can be found elsewhere (Li & Hsiao, 1974). Spots in broken outline are those spots which are present in some leaf samples while undetectable in other samples of the same species, indicating that these are the more variable spots. Spots in solid outline are those spots which were consistently found in all leaf samples of a given species.

The relationships between species of the series Laurifoliae as exhibited by the leaf chromatographic patterns of the phenolic compounds have been found to correlate very well with those based on gross leaf morphology. The species with similar leaf morphologies tend to possess similar leaf chromatographic patterns.

Quercus laurifolia (Fig. 1) possesses several variable spots (indicated by broken outlines). Since these spots are all minor ones, it is uncertain whether the absence of these spots in some leaf samples is due to the complete absence of the compounds or the quantity of the compound being too low to be detected. Among the species in the series, the leaf chromatographic pattern of *Q. laurifolia* is closest to that of *Q. incana* (Fig. 2). It is interesting to note that these two species are also most closely related in their leaf morphology. The leaves of these two species are all oblong to oblanceolate in shape, 4 to 10 cm in length, and usually entire or rarely few-toothed along the margins. The leaves of *Q. incana* are dull beneath with a felt-like stellate tomentum, while those of *Q. laurifolia* are glabrate. It has been found that in *Platanus,* the Plane trees, several flavonoids are present exclusively in the hairs (Hsiao, 1972). It is yet unknown whether the major differences in the chromatographic patterns of these two oak species can be mostly attributed to the presence or absence of leaf hairs.

The leaf chromatographic pattern of *Q. imbricaria* (Fig. 3) does not indicate close relations to that of any other species in the series. It merely suggests some similarities with those of *Q. laurifolia* and *Q. incana.* In *Q. imbricaria,* the quantity of spot 16 is unusually low while spot 36 is unusually high for this series. Aside from these characteristics, the pattern of *Q. imbricaria* is generally similar to those of Figs. 1 and 2. Spots, 1, 5 and 7 are present in all of the three species. These findings seem also well correlated with morphological characteristics. The leaves of *Q. imbricaria,* being oblong-lanceolate in shape and usually entire on the margins, are more similar to those of *Q. laurifolia* and *Q. incana* than to other species of the series.

The chromatographic pattern of *Q. nigra* (Fig. 4) shows significant differences from those of the three species (Figs. 1–3) above-mentioned. Especially noteworthy are the absence of spots 1 and 5 and the presence of spot 27 in *Q. nigra.* Within the series, the pattern of *Q. nigra* is most similar to that of *Q. myrtifolia* (Fig. 5). The absence of spots 1 and 5 and the presence of spot 27 are also observed in the chromatogram of *Q. myrtifolia.* The major differences between these two species are the presence of spots 10, 19, 26 and 58 in *Q. nigra* while undetectable in *Q. myrtifolia.* Since these are all minor spots, and considering the fact that only one leaf sample of *Q. myrtifolia* was available for chromatographic study, it is not really certain whether these spots are completely absent from *Q. myrtifolia.* Therefore, the leaf chromatographic patterns of *Q. nigra* and *Q. myrtifolia* appear rather similar to each other. The leaves of *Q. nigra* are usually oblong-obovate and entire or slightly 3-lobed at the rounded apex. *Quercus myrtifolia* also possesses oblong-obovate leaves, mostly entire on the margins. The size and thickness of the leaves of these two species are also similar to each other. Thus, morphologically, the leaves of these two species are more similar to each other than to other species in this study. Trelease (1924) treated *Q. nigra* as the sole member of his series Nigrae, while Muller (1951) transferred this species to the series Laurifoliae. Of the two, Muller's treatment seems to have more support from the chromatographic study of the leaves.

Quercus phellos has a very distinct chromatographic pattern (Fig. 6) from all other species of the series. The absence of spots 1, 5 and 7 and the presence of spots 12, 14, and especially 38, in the chromatogram of *Q. phellos* are uncommon in other species. Spot 38 is the largest spot in the chromatogram of *Q. nigra.* It is interesting to note that this spot is completely undetectable in all other species of the series. The absence of spot 7 and the presence of spot 12 in *Q. phellos* are also unique in the series. On the basis of these chromatographic data, *Q. phellos* should probably be excluded from the series Laurifoliae and would seem to deserve a new series of its own. It is however, desirable to study the chromatographic patterns of other plant parts besides leaves before this proposition can be further confirmed. Similar to the chromatographic findings, the leaf morphology of *Q. phellos* is also rather different from those of other species in the series. The leaves of *Q. phellos* are linear, smaller in size, comparatively thinner, and tightly inrolled when young.

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SCIRPUS CYLINDRICUS: AN ECOLOGICALLY RESTRICTED EASTERN NORTH AMERICAN TUBEROUS BULRUSH

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Species of the sedge genus *Scirpus* (*sensu lato*) with tuberous rhizomes, leafy culms, large spikelets, awned pubescent scales, and large achenes are readily distinguished from other North American species of *Scirpus* but are easily confused with each other. Both Beetle (1947) and Fernald (1950) recognized the following four species with these characteristics in eastern North America: *Scirpus fluviatilis* (Torr.) Gray, *Scirpus maritimus* L., *Scirpus robustus* Pursh, and *Scirpus paludosus* Nels. However their interpretations of the specific boundaries among the latter three taxa were different from each other and from the interpretation given here. Because Fernald's treatment of eastern North American tuberous bulrushes has been more widely followed than Beetle's treatment, it is used as a point of reference for further discussion.

Fernald (1950) considered North American plants of typical *S. maritimus* to be adventive from Europe but recognized two native North American infraspecific taxa as *Scirpus maritimus* var. *fernaldii* (Bickn.) Beet. and *Scirpus maritimus* var. *fernaldii* f. *agonus* Fern. *Scirpus novae-angliae* Britt. was considered to be a synonym of *S. maritimus* var. *fernaldii.* Now it is apparent that Fernald erroneously applied all three of the above names for North American plants to the same species when actually they apply to three different species. The type of *S. maritimus* var. *fernaldii* (Me, Mt. Desert, Somes Sound, 20 Aug 1898, *Bicknell,* NY; GH, isotype) is conspecific with plants of *S. paludosus;* the type of *S. maritimus* var. *fernaldii* f. *agonus* (Nova Scotia: Shelburne Co.: Jordan Falls, border of salt marsh, 9 Sep 1921, *Fernald + Long 23398,* GH; NY, isotype) is conspecific with plants of *S. robustus;* and the type of *S. novae-angliae* (cited below) is conspecific with plants of *Scirpus cylindricus* (Torr.) Britt. All three of these species are distinct from *S. maritimus,* which is not known from eastern North America except as an occasional introduction.

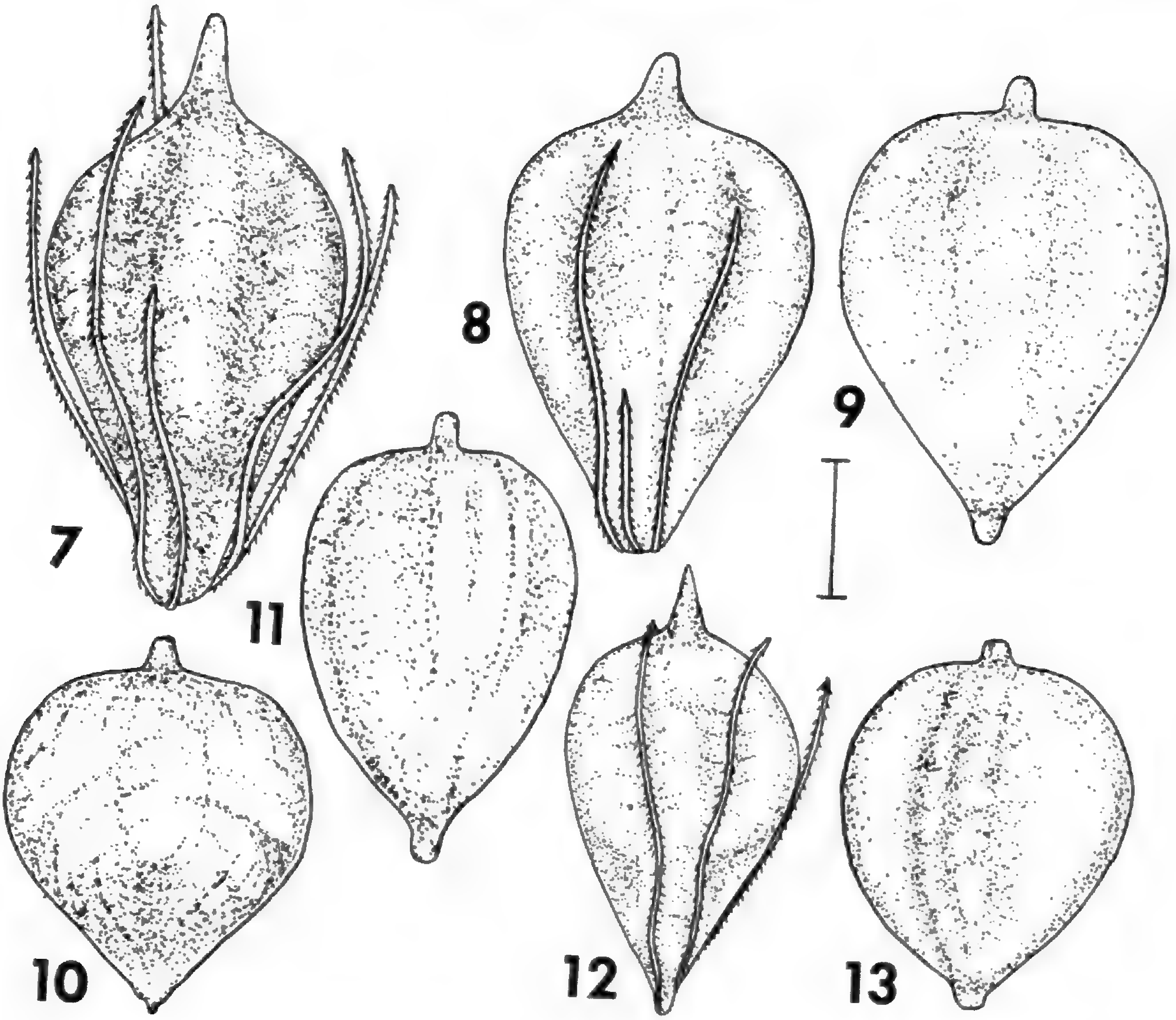
The failure of Fernald and other botanists to properly delineate *S. cylindricus, S. robustus,* and *S. paludosus* is caused by the close morphological resemblances among these species, the lack of knowledge about the specialized habitat of *S. cylindricus,* and the failure to understand infraspecific variation in *S. robustus* and *S. paludosus.* Further confusion has been caused by the erroneous application (Britton, 1892; Beetle, 1947) of the name *Scirpus cylindricus* to plants of still another species, *Scirpus etuberculatus* (Steud.) Ktze., which is not a tuberous bulrush.

MORPHOLOGICAL DISTINCTIONS OF S. CYLINDRICUS FROM RELATED SPECIES

Morphological characteristics of *S. cylindricus* most useful for distinguishing it from other North American tuberous bulrushes are the persistent bristles which extend from about one-half as long to about as long as the achenes, the obovate achenes (Fig. 8) which are plano-convex or have a low dorsal angle, and the rounded achene summit which gradually tapers into the beak. In contrast, the persistent bristles of *S. fluviatilis* frequently exceed the obpyriform to obovate achenes (Fig. 7) which have a prominent dorsal angle and nearly form an equilateral triangle in cross section. Spikelets of *S. fluviatilis* (Fig. 1) are mostly ovate or elliptic and scales are uniformly (or nearly so) pale brown. In contrast, spikelets of *S. cylindricus* (Fig. 2) are more frequently narrowly ovate or narrowly elliptic and the scales are brown with variable degrees of reddish streaking. Both *S. robustus* and *S. paludosus* consistently differ from *S. cylindricus* by having mostly caducous bristles (occasionally a few persist and extend from about one-third to three-fourths as long as the achenes), and a truncate (or nearly so) achene summit with an abruptly differentiated beak (Figs. 9, 10, + 13). Generally the inflorescences of *S. robustus* (Fig. 3) and *S. paludosus* (Fig. 4) are more congested (mostly having 3-20 spikelets) than the more open inflorescences (mostly having 15-40 spikelets) of *S. cylindricus* (Fig. 2).

Scirpus maritimus L., native to Europe, Asia, and Africa, differs from *S. cylindricus* by having compact inflorescences usually with less than 15 spikelets, chest-

FIGS. 1-6. — Inflorescences of 1. *Scirpus fluviatilis;* 2. *S. cylindricus;* 3. *S. robustus;* 4. *S. paludosus;* 5. *S. paludosus;* 6. *S. robustus.*



Figs. 7-13. — Achenes of 7. *Scirpus fluviatilis;* 8. *S. cylindricus;* 9. *S. paludosus;* 10. *S. paludosus;* 11. *S. maritimus;* 12. *S. maritimus;* 13. *S. robustus.* The unit is 1 mm.

nut brown scales, mostly caducous bristles, achenes mostly less than 3.5 mm long (achenes of *S. cylindricus* are mostly longer than 3.5 mm), and a nearly truncate achene summit with an abruptly differentiated beak (Fig. 11). Occasionally, however, bristles of *S. maritimus* persist and the achene summit may gradually taper into the beak (Fig. 12). Ecologically, *S. maritimus* differs from *S. cylindricus* by growing in both tidal and non-tidal conditions instead of being restricted to tidal shores and marshes.

Distribution and Habitat of S. cylindricus

Scirpus cylindricus is restricted to brackish tidal marshes and shores along the Atlantic coast of North America from Maine to Georgia (specimens cited below). Throughout its range, it is sympatric with *S. robustus,* a species of saline tidal marshes and shores but also known from the vicinity of Onondaga Lake in upstate

New York. Over much of the range of *S. cylindricus, S. fluviatilis* usually grows in fresh tidal conditions and *S. paludosus* usually grows in saline tidal conditions. However, both of the latter species occur inland across the North American continent whereas *S. cylindricus* only occurs near the Atlantic coast.

Scirpus cylindricus is mostly found in the narrow brackish transition zones of tidal river systems between the more extensive fresh zones where *S. fluviatilis* usually grows and the saline zones where *S. robustus* and *S. paludosus* usually grow. I have observed this upstream-downstream zonation pattern of *S. fluviatilis, S. cylindricus,* and *S. robustus* in the Delaware River system in Pennsylvania, New Jersey, and Delaware; and in the Kennebec River system in Maine where *S. paludosus* also is commonly found in saline marshes with *S. robustus.* In both river systems, as well as the Penobscot system in Maine, stands of *S. cylindricus* (*Schuyler 4488, 4412, + 4477* cited below) have been found growing adjacent to stands of *S. robustus* where conditions appear to be transitional from brackish to saline. In all cases, plants of *S. cylindricus* were morphologically distinguishable and ecologically differentiated from plants of *S. robustus.* Stands of *S. cylindricus* were more common in the upstream direction or higher in the marshes where conditions were probably less saline while stands of *S. robustus* were more common in the downstream direction or lower in the marshes where conditions were probably more saline. In the Penobscot system, stands of *S. paludosus* were also found adjacent to stands of *S. cylindricus* and were more common in the downstream direction while those of *S. cylindricus* were more common in the upstream direction. *S. fluviatilis* and *S. cylindricus* have not been found growing together but have been found in close proximity in the Delaware system below Wilmington, Delaware. Along this portion of the Delaware River there apparently is a transition from fresh to brackish conditions which marks the downstream distributional boundary of *S. fluviatilis* and the upstream distributional boundary of *S. cylindricus.*

INFRASPECIFIC VARIATION IN S. ROBUSTUS AND S. PALUDOSUS

In Massachusetts and southward, plants of *S. robustus* usually have ovate spikelets (Fig. 3) and reddish brown scales, while northward they frequently have narrowly ovate spikelets (Fig. 6) and brownish scales. Generally, the spikelets of northern plants also have more acute tips than those of southern plants. Various degrees of intergradation can be found between such northern and southern variants, particularly in southern Maine, and make giving them any taxonomic status extremely arbitrary. For example, on Arrowsic Island near Bath, Maine, four morphologically distinguishable stands of *S. robustus* have been found at three localities within a distance of 4 miles. At the most inland and closest locality to Bath (ca .8 mi S of Woolwich, brackish marsh, *Schuyler 4479,* PH), an extensive stand with plants mostly lacking inflorescence bearing culms was found. However, many plants did have inflorescences which were comparatively open and contained mostly narrowly ovate acutely tipped spikelets with reddish-brown scales. A stand of *S. cylindricus* (*Schuyler 4412,* cited below) also occurred at this locality but was higher up along the edge of the marsh. Farther seaward at the next locality (ca 4 mi S of Woolwich, salt marsh, *Schuyler 4414,* PH), a stand was found where culms were shorter, inflorescences were more congested, and scales were browner than those at the previous locality. The spikelets were mostly narrowly ovate and acute at the tip. Plants from this stand closely resemble the plant in Fig. 6 and the type of *S. maritimus* var. *fernaldii* f. *agonus* (cited above). At the most seaward locality visited on Arrowsic Island (ca 3.5 mi NNW of Georgetown, salt marsh, *Schuyler 4482 + 4483,* PH), two morphologically distinguishable stands were observed growing adjacent to each other. Plants of the taller stand (*4482*), which resembled plants in Fig. 3 usually found farther south, had blunter spikelets and more reddish scales than plants of the shorter stand (*4483*). The culm height, spikelet shape, and scale color of plants in the shorter stand were intermediate between those of plants at the previous locality (*4414*) and in the adjacent stand (*4482*).

A survey of herbarium material throughout the eastern North American range of *S. robustus* indicates that there is more variation than that found in the four stands studied on Arrowsic Island. Some herbarium specimens, particularly those having comparatively open inflorescences, narrowly ovate spikelets, and brown scales, bear a superficial resemblance to specimens of *S. cylindricus.* However, the morphological and ecological distinctions between *S. cylindricus* and *S. robustus* given earlier readily separate these taxa despite the variation in inflorescence structure, spikelet shape, and scale color found in *S. robustus.*

Infraspecific variation in *Scirpus paludosus* is similar to that found in *S. robustus* although not so closely correlated with latitudinal distribution. Instead the variation appears more correlated with upstream-downstream distribution along rivers or altitudinal distribution in marshes. Upstream plants or plants in the upper portions of marshes (Fig. 5) generally have taller culms, more open inflorescences, and browner scales than downstream plants or plants in the lower portions of marshes (Fig. 4). In addition, the plants with more open inflorescences sometimes have achenes with prominent dorsal bulges (Fig. 10) instead of the more standard lenticular or plano-convex achenes (Fig. 9). As is the case with *S. robustus,* various degrees of intergradation make taxonomic recognition of these variants extremely arbitrary even though morphologically different stands may grow in close proximity. For example, at Kouchibouguac National Park in northeastern New Brunswick, two morphologically distinguishable stands of *S. paludosus* were found adjacent to each other toward the upper part of an extensive tidal marsh at Kellys Beach. In the shorter stand (*Schuyler 4456,* PH), the plants had congested inflorescences, brown scales, and mostly lenticular or plano-convex achenes. Actually the plants from this stand had taller culms, more spikelets, and browner scales than plants generally found in lower marshes or on lower shores. In the taller stand at Kellys Beach (*Schuyler 4455,* PH), the plants had comparatively open inflorescences (Fig. 5), brown scales with conspicuous reddish streaking, and achenes with prominent dorsal bulges. The inflorescences and achenes of plants in this stand closely resemble those of the type of *S. maritimus* var. *fernaldii* (cited above), a name here regarded as a taxonomic synonym of *S. paludosus.* The plants in this stand bear a superficial resemblance to plants of *S. cylindricus* because of their open inflorescences and brown scales with reddish streaking. However, the morphological and ecological distinctions between *S. cylindricus* and *S. paludosus* given earlier readily separate them despite these similarities of inflorescence and scale characteristics.

APPLICATION OF SCIRPUS CYLINDRICUS (TORR.) BRITT.

Scirpus cylindricus (Torr.) Britt. and its basionym, *Scirpus maritimus* γ. *cylindricus* Torr., generally have been regarded (Britton, 1892; Small, 1933; Beetle, 1947; Koyama, 1962) as synonyms of *Scirpus etuberculatus* (Steud.) Ktze. and its basionym, *Rhynchospora etuberculata* Steud. The latter names apply to a distinctive non-tuberous aquatic bulrush of the southern United States. However, the type of γ. *cylindricus,* which apparently botanists have overlooked, is obviously a tuberous bulrush and not conspecific with plants of *S. etuberculatus.* Even from Torrey's original description and remarks (1836), it is apparent that he was not applying γ. *cylindricus* to plants of *S. etuberculatus.* For example, he stated that the scales of γ. *cylindricus* are "somewhat pubescent" and "aristately mucronate." These are characteristics of tuberous bulrushes, not of *S. etuberculatus* which has glabrous scales with short awns. Furthermore, Torrey stated that *S. maritimus* β ? *fluviatilus* "differs so much from the common *S. maritimus* of our salt marshes . . ., that I should have proposed it as a distinct species, did not the succeeding variety [γ. *cylindricus*] connect the two." Plants treated here as *S. cylindricus* conform with this statement and are morphologically and ecologically intermediate between *S. fluviatilis* (originally described by Torrey as *S. maritimus* β ? *fluviatilis*) and *S. robustus* (which Torrey considered to a synonym of *S. maritimus* L.). Thus it is apparent that Torrey had a good understanding of the relationships among North American tuberous bulrushes but later botanists confused the situation.

The following list of names and associated types are given to clarify the nomenclature of *S. cylindricus:*

Scirpus cylindricus (Torr.) Britt., Trans. N.Y. Acad. Sci. 11:79. 1892.
Scirpus maritimus γ. *cylindricus* Torr., Ann. Lyceum Nat. Hist. New York 3:325. 1836 (Georgia, Baldw, herb Schw, PH; spikelet of type, NY).
Scirpus novae-angliae Britt., Illus. Fl. 3:509. 1898 (Conn., Fairfield, in a fresh-water marsh bordering creek, tide-water getting back to this point, 19 Jul 1896, *Eames,* NY, type and 2 isotypes; almost brackish marsh, local, [remaining data same as NY] US, isotype).
Scirpus campestris var. *novae-angliae* (Britt.) Fern., Rhodora 8:163. 1906.
Scirpus robustus var. *novae-angliae* (Britt.) Beet., Amer. J. Bot. 29:82. 1942.
Scirpus subterminalis var. *cylindricus* (Torr.) Koy., Canad. J. Bot. 40:930. 1962.

SPECIMENS OF S. CYLINDRICUS[1]

CONNECTICUT: Types of *Scirpus novae-angliae* cited above; Guilford, wet border of salt marsh, 3 Sep 1917, *Harger 6976,* UC; below Essex, Lords Bay, 21 Jul 1936, *Uhler,* US; Fairfield, Salt Cr., 2 Jul 1886, *Johnson 3108,* F; Fairfield, marshes bordering creek within tidal influence but brackish or fresh water, 2 Aug 1898 & 8 Aug 1899, *Eames 47,* GH, NEBC; Stratford, bank of Housatonic R., bathed by 2 ft of brackish water at each high tide, 17 Jul 1897, *Eames,* NY; Stratford, brackish tidewaters, 31 Jul 1898, *Eames,* GH, NY; Middletown, 1836, Herb. Buckley, MO. DELAWARE: Kent Co.: Milford nr New Wharf, 21 Jul 1908, *Long & Van Pelt,* PH; Kent Co.: ca 2.2 mi NE of Milford, brackish tidal marsh along Swan Cr., 28 Jun 1973, *Schuyler 4388,* PH; New Castle Co.: Collins Beach, 1866, *Commons,* NY; New Castle Co.: NW fork of Duck Cr., tidal mud, 5 Jul 1897, *Canby,* DELS; New Castle Co.: ca .65 mi NE of Smyrna, brackish tidal marsh along Duck Cr., 28 Jun 1973, *Schuyler 4389,* PH; New Castle Co.: SE of Odessa, brackish marsh along Appoquinimink R., 3 Oct 1973, *Schuyler 4488,* PH; New Castle Co.: N of Odessa, edge of brackish marsh along Drawyer Cr., 3 Oct 1973, *Ferren 1296,* PH; New Castle Co.: Augustine Beach, swale of brackish marsh, 3 Aug 1916, *Pennell 7809,* PH; New Castle Co.: Delaware City, river shore, 1894, *Tatnall,* DELS; New Castle Co.: ca 2.7 mi SW of New Castle, Gambles Gut, tidal marsh, 28 Sep 1972, *Schuyler 4370,* PH; Wilmington, tidal muddy banks of Delaware R. 24 Jul 1886, *Commons,* PH. GEORGIA: Type of *Scirpus maritimus γ. cylindricus* cited above. MAINE: Cumberland Co.: Scarboro, salt marsh along Nonesuch R., 21 Sep 1923, *Fassett 1050,* NEBC; Sagadahoc Co.: Woolwich, Back River Cr., border of salt marsh, 15 Sep 1916, *Fernald & Long 12847,* GH, PH; Sagadahoc Co.: ca 1 mi NE of Woolwich, along rocky shore of Pleasant Cove, 16 Aug 1973, *Schuyler 4417,* PH; Sagadahoc Co.: Arrowsic Is., ca .8 mi S of Woolwich, edge of brackish marsh, 15 Aug 1973, *Schuyler 4412,* PH; Waldo Co.: NE of Prospect along South Branch Marsh R., tidal shore, 16 Aug 1973, *Schuyler 4420,* PH; Waldo Co.: ca 2 mi N of Prospect, in brackish to saline marsh, 31 Aug 1973, *Schuyler 4477,* PH. MARYLAND: Baltimore Co.: Bay shore, brackish marsh, 28 Jun 1920, *Knowlton,* GH; Caroline Co.: Choptank R., brackish marsh at E end of Dover Bridge, 7 Jun 1936, *Tatnall 2966,* PH; Caroline Co.: marshy border of Choptank R. nr rt. 331, 15 Aug 1964, *Baltars 3587,* US; Harford Co.: marshy border of Grays Run, nr Pulaski hwy., 23 Jun 1957, *Baltars 1190,* US; Talbot Co.: 5½ mi E × N of Easton, Kings Cr., marshy area nr bridge, 23 July 1968, *Earle 5417,* PH. MASSACHUSETTS: Barnstable Co.: East Dennis, Quivett Cr., rich swale bordering salt marsh, 18 Aug 1919, *Fernald & Long 18061,* GH, PH; Barnstable Co.: East Brewster, Namskaket Cr., springy border of salt marsh, 22 Jul 1919, *Fernald & Long 18060,* GH, PH, US; West Barnstable, springy swales bordering the Great Marshes, 26 Aug 1919, *Fernald & Long 18062,* PH; Barnstable Co.: West Barnstable, salt marsh along RR nr rt. 6A, 30 Aug 1968, *Svenson 1642,* PH; Dukes Co.: Naushon, E end of island, margin of Typha swamp, 1 Oct 1927, *Fogg 3154,* PENN; Nantucket Co.: Squam, swamp, 22 Aug 1921, *Pennell 11091,* PH; Nantucket Is., Squam, 20 Jun 1910, *Bicknell,* NY; Squam Pond, 4 Jul 1912, *Bicknell 1177,* PH; Medford, banks of Mystic R., 23 Aug 1859, *Boott,* GH; along Alewife Brook between Cambridge & Arlington, 14 Sep 1917, *St. John & Bryant,* NCU. NEW JERSEY: Atlantic Co.: 2.7 mi E of Weekstown, tidal marsh of Mullica R., 1 Sep 1971, *Schuyler 4286,* PH; Atlantic Co.: ca 2 mi SW of Lower Bank, Gloucester Landing on Landing Cr., firm peaty tidal marsh, 27 Sep 1974, *Ferren 1384,* PH; Atlantic Co.: Clarks Landing, sandy muddy tidal shore of Mullica R., 27 Sep 1974, *Ferren 1386,* PH; Atlantic Co.: Catawba, tidal marsh along Miry Run ca .1 mi E of Egg Harbor R., 20 Oct 1972, *Ferren 1203,* PH; Bergen Co.: Secaucus, along creek N of old cedar bog, 7 Aug 1948, *Heuser,* CHRB; Burlington Co.; W side of Wading R. NW of bridge for rt. 542, just below high tide level, 1 Sep 1971, *Schuyler 4282,* PH; Burlington Co.: ca 1.4 mi SE of Wading River, along Merrygold Branch, nr upper tidal

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[1] Abbreviations of herbaria are those of Lanjouw & Stafleu (1964).

limit, 3 Aug 1972, *Schuyler 4320,* CHRB, PH; Cape May Co.: ca 1.25 mi WNW of Tuckahoe, tidal marsh along Mill Cr., 4 Oct 1972, *Schuyler 4371,* PH; Cumberland Co.: Millville, upper tidal marsh of Maurice R. ca .35 mi N of Manantico Cr., 8 Aug 1973, *Ferren 1264,* PH; Cumberland Co.: Greenwich Piers, Cohansey Cr., tidal marsh, 10 Nov 1935, *Long 47970a,* PH; Cumberland Co.: E of Greenwich, marshes along Molly Wheaton Run, 27 Jun 1937, *Long 50262,* PH; Cumberland Co.: Dutch Neck, tidal marsh along Cohansey Cr., 29 Sep 1935, *Long 47787,* PH; Cumberland Co.: NW of Fairton, tidal shore, Cohansey Cr., 22 Sep 1935, *Long 47588,* PH; Cumberland Co.: S of Bridgeton, tidal marsh along Rocaps Run, 16 Sep 1934, *Long 44609,* PH; Cumberland Co.: Bridgeton, along Cohansey Cr., edge of upper tidal marsh, 18 Aug 1972, *Ferren 1042,* PH; Hudson Co.: Meadows Sta. PRR, 10 Jul 1894, *Seal,* PH; Middlesex Co.: Sayreville, edge of South R., 15 Aug 1916, *Wiegmann,* NY; Salem Co.: 2 mi SW of Harrisonville, tidal marsh along Delaware R., 5 Nov 1934, *Long 45263,* GH, PH; Salem Co.: NW of Salem, 14 Jun 1973, *Abraitys,* CHRB; Salem Co.: ca 3 mi NE of Salem, upper tidal brackish marsh along Mannington Cr., 15 Aug 1972, *Ferren 1025,* PH; Salem Co.: ca 3.8 mi SW of Salem, tidal marsh along Delaware R., 15 Aug 1972, *Schuyler 4329,* PH; Salem Co.: Quinton, along small tidal tributary of Alloway Cr., 16 Oct 1972, *Schuyler 4377,* PH. NEW YORK: Bronx Co.: Spuyten Duyvil Cr., 1 Jul 1891, *Bicknell,* NY; Rockland Co.: Piermont, Hudson R., tidal marsh, 26 Aug 1936, *Muenscher & Curtis 5678,* GH; Rockland Co.: Iona Is., 31 Aug 1954, *Lehr 575,* NY; Westchester Co.: Hudson between Glenwood & Hastings, 5 Sep 1898, *Bicknell,* NY; Long Is., Smithtown Cr., 13 Jul 1910, *Bicknell,* NY; Long Is., Wading R., 23 Jul 1877, *Miller,* F, PH; Wading R., salt marsh, 15 Jul 1873, *Young,* NY. NORTH CAROLINA: Craven Co.: marsh of Jack Smith Cr. along Oaks Rd. at W edge of New Bern, 11 Jun 1952, *Whitford 297A,* NSC. RHODE ISLAND: Newport Co.: Block Is., dryish borders of salt marshes about Harbor Pond & Trim's Pond, 19 Aug 1913, *Fernald & Long 8934,* GH, PH; Newport Co.: Block Is., shore of Harbor Pond, edge of salt marsh, 10 Aug 1939, *Brown & Seymour 5415,* DUKE. VIRGINIA: Charles City Co.: S of Watts Point, Chickahominy R., in sunken marsh, 25 Jun 1948, *Hotchkiss & Uhler 7222,* US; James City Co.: tidal shore of Back R., opp. Jamestown Is., 22 Aug 1939, *Fernald & Long 10972,* GH; New Kent Co.: W of Walker, fresh tidal marsh by Lacy Cr., 9 Sep 1941, *Fernald & Long 13559,* GH, MO, NY, PH, US; Stafford Co.: ca 2 mi S of Widewater, slightly brackish marsh, 29 Jul 1947, *Hotchkiss & Uhler 7143,* US; Surry Co.: E of Scotland, tidal marsh at mouth of Crouch Cr., 12 Jul 1938, *Fernald & Long 8593,* GH, NY, PH, US.

ACKNOWLEDGMENTS

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VEGETATION AND PRODUCTION OF THE WOODBURY CREEK-HESSIAN RUN FRESHWATER TIDAL MARSHES

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The study area consists of 54.7 ha (135 acres) of freshwater tidal marshland in Gloucester County, New Jersey, along Woodbury Creek and Hessian Run (Figs. 1 and 2). The marshes are bounded by Route 130-I-295, Grove Avenue, as well as landfill and residential areas. These marshes include examples of types which were much more extensive in the recent past. The Woodbury Creek-Hessian Run marshes lie in an area of the upper Delaware estuary characterized by perturbations such as landfill and highly polluted waters (Walton and Patrick, 1973).

Marsh vegetation occurs on organic silt or sometimes fine sands. Sample borings indicated as much as 8.25 m of soft organic silt with maximum depths

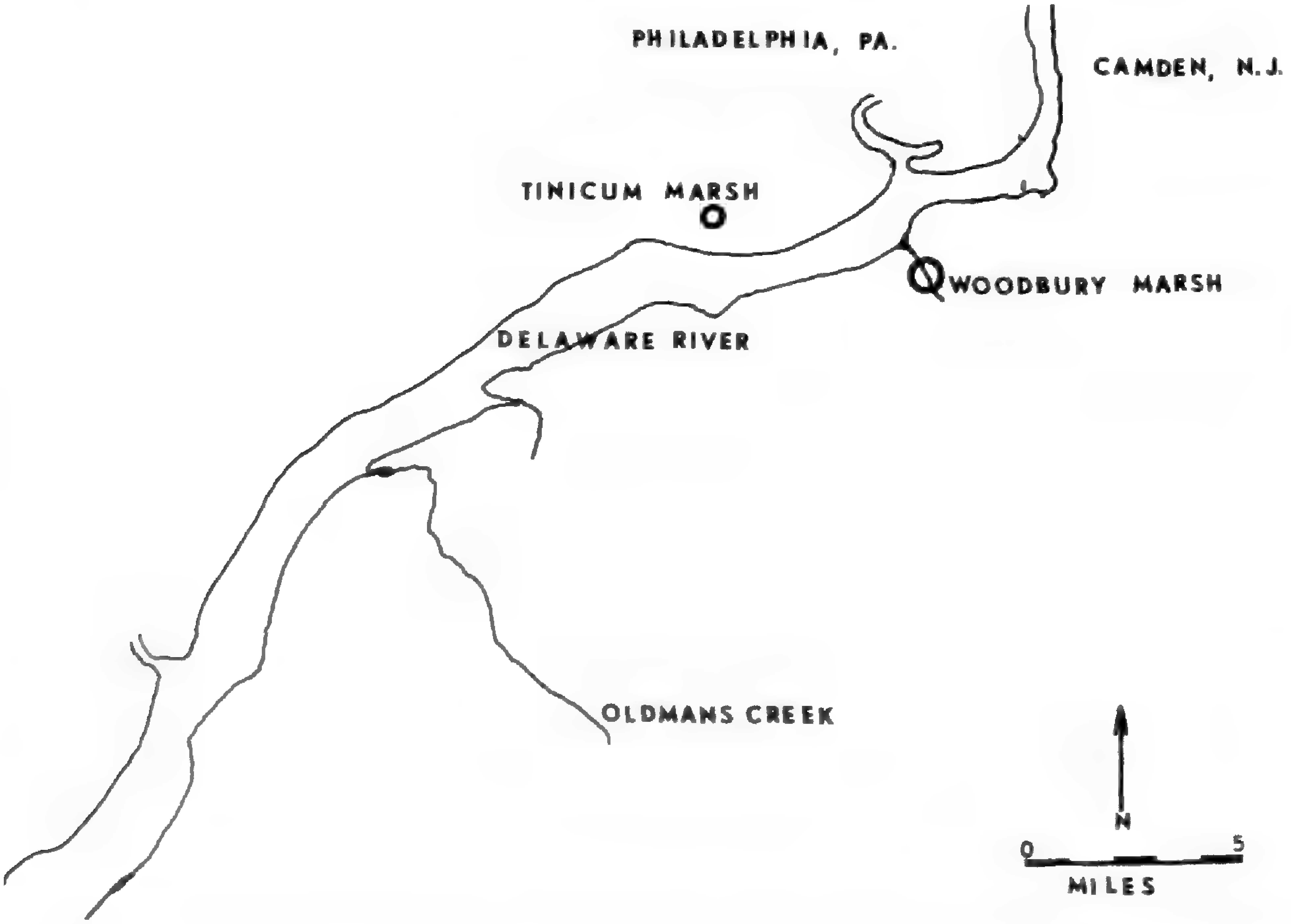

FIG. 1. — Map showing the location of the study area (Woodbury Marsh) as well as Tinicum and Oldmans Creek marshes.

FIGURE 2

TIDAL MARSH VEGETATION TYPES, WOODBURY CREEK AND HESSIAN RUN, GLOUCESTER COUNTY, NEW JERSEY, 1974.

occurring near Woodbury Creek. The tide range in Woodbury Creek averages 1.8 m at spring tides and 1.6 m at neap tides. Tidal currents are quite strong, flooding the marsh twice daily from the adjacent Delaware River.

Data on marsh production were gathered from May-November, 1974 and the vegetation mapped as part of a more comprehensive evaluation of the marsh ecosystem supported through the Marine Sciences Center, Rutgers University.

METHODS

Using the New Jersey Department of Environmental Protection Wetland Map 371-1854 (Woodbury Creek and Hessian Run) as a baseline, the vegetation of Woodbury Creek and Hessian Run between I-295-Route 130 on the east and Grove Avenue on the west was mapped. Color photos were taken throughout the period April-November 1974 to record community extent and development. Color aerial photos were taken in July, 1974 to help determine community boundaries. These tools, in addition to field mapping, were used to prepare a description and vegetation map of the marshes. A planimeter was used to determine the area occupied by each community type.

In order to estimate the productivity of the various plant communities making up the marshes, harvest methods were used. Beginning in June and extending into September, collection of both aerial (aboveground) and subterranean (belowground) portions of the major plant species were made. Aboveground sampling was done by placing a 1 × 1 sq. meter frame on the surface and clipping, at the surface, all the plant material within the plot and placing it in labeled burlap bags. In this marsh all aboveground plant material represents the growth of the current year and thus there is no need for separation of last year's material.

After the aboveground vegetation was removed, 2 randomly selected squares within the same plot, each representing 1/16 of the plot (1/16 m^2) were excavated to a depth of 25 cm and returned to the laboratory for separation of root material by washing. Both the above and belowground materials were dried in a forced draft oven at 80°C for 48 hours and weighed. Because of the limited scope of the study and the difficulty in obtaining samples due to the soft substratum, only 1 or 2 aboveground plots were harvested on each sampling date and belowground samples were not collected each time. Most major communities were sampled 4 times throughout the study in order to show seasonal changes in standing crop (amount of plant material) as well as the peak amount. To determine an average for each community type the sample plots were selected at random over the whole study area.

After drying, all sample material was ground in a Wiley Mill and then replicate samples were ashed in a muffle furnace in preparation for caloric determination of selected samples by a Parr Bomb Calorimeter. Ash values were determined to indicate the amount of the material in organic form. Both belowground samples for each square meter were ashed, then averaged. Caloric determination places the production data on an energy basis so it can be compared with the same species from other areas. Determination of average peak standing crop values for the communities was accomplished by averaging samples for dates appropriate for each species.

RESULTS, AND DISCUSSION OF THE VEGETATION TYPES

Zizania aquatica (wild rice). This is the most common plant at the Woodbury Creek marshes. Essentially pure stands of wild rice occupy 37.8 ha (93.5 acres) or 69% of the plant cover of the marsh (Table 1 and Fig. 2). Wild rice is a very large [up to 3m or more] annual grass. Germination at Woodbury began in mid April with 5.5-8 cm plants formed by April 21. Growth is quite rapid, the plants attaining a height of about 15.3 cm by May 4 and averaging over 1 m tall by June 9. Flowering takes place in late August. The plants were brown and falling down by mid September. Decomposition and/or transport is rapid so that by late fall wild rice communities appear as bare areas of mud largely devoid of any trace of the luxuriant summer growth. The seed is readily eaten by thousands of red-winged blackbirds during maturation and is possibly gleaned from the mud by ducks later in the season (McCormick, 1970). Data on production, caloric value and percent ash appear in Tables 1, 2 and 3. Peak standing crop occurred in August when averages of aboveground material ranged between 1438-1600 g/m^2 (6.41-7.14 tons/acre). This is the highest aboveground value attained for any of the Woodbury marsh communities. The average peak standing crop here is almost as high as values reported for wild rice in northern New Jersey (Jervis, 1969) and is higher than the 6.2 tons/acre found for a similar community in Oldmans Creek and comparable to the marshes of Tinicum (Table 4). Belowground estimates are somewhat harder to make because of the difficulties in obtaining samples from the mud. The root mass seems to be generally comparable

TABLE 1. — Areal Coverage, Average Aboveground Peak Standing Crop and Production for the Plant Communities.

Marsh Communities	Hectares	Acres	% of Total	Peak Production Tons/Acre	Peak Production g/m^2	Total Production Tons
Zizania	37.84	93.46	69	6.41	1437	599
Nuphar	3.69	9.12	7	2.70	605	25
Zizania-Nuphar [a]	4.15	10.26	8	4.56	1022	47
Mixed Aquatics	7.75	19.14	14	1.96	440	38
Typha	0.57	1.40	1	3.70	830	5
Peltandra	0.57	1.42	1	5.63	1262	8
Phragmites	0.09	0.22	0.1	—	—	—
Totals	54.66	135.02		5.39 [b]	1198 [b]	722

[a] Production values for this community are considered to be intermediate between the 2 pure communities based on field observations.

[b] These figures represent average standing crop values for the marshes as a whole.

TABLE 2. — Above and Belowground Production, Total Production in Grams per Square Meter (g/m^2) and Tons/acre for the Major Plant Communities of the Woodbury Creek Marshes.

Community	Date Harvested	Aboveground g/m^2	Tons/acre	Belowground g/m^2	Tons/acre	Total g/m^2	Standing Crop Tons/acres
Zizania	6/18	561	2.50	560	2.50	1121	5.0
	6/26	708	3.16	890	3.97	1598	7.12
	7/16	757	3.38	256	1.14	1013	4.52
	8/6	1600	7.14	721	3.21	2321	10.35
	8/27	1438	6.41				
	9/17	416	1.85				
Mixed Aquatic dominated by *Amaranthus*	6/24	477	1.99	518	2.31	995	4.44
	7/10	276	1.23	440	1.96	716	3.19
	8/22	768	3.43	560	2.50	1328	5.92
	8/29	762	3.40	508	2.26	1270	5.66
	9/21	667	3.03	649	2.89	1361	6.07
dominated by *Sagittaria-Bidens*	9/21	214	.95				
Nuphar	6/24	480	2.14	1134	5.06	1614	7.15
	7/10	605	2.70	1145	5.11	1818	8.11
	8/16	377	1.68	1804	8.05	2181	9.72
	9/17	474	2.09				
Peltandra	6/14	1286	5.74	3152	14.06	4438	19.79
	6/18	819	3.65	1169	5.21	1989	8.87
	7/10	1262	5.63	1459	6.51	2721	12.14
	8/16	532	2.37	1216	5.42	1749	7.80
	8/27	267	1.19	5320*	23.73	5587	24.92
	9/21	367	1.77				
Typha	6/18	825	3.68	576	2.57	1401	6.25
	7/16	884	3.94	1738	7.75	2622	11.70
	8/22	894	3.99	1800	8.03	2694	12.02
	9/17	831	3.70				

* Full rhizome present.

to the shoots early in the season. Peak standing crop for the whole plant may range up to 2321 g/m^2 (10.35 tons/acre). Caloric content of the aboveground parts was essentially constant, ranging between 4114-4448 calories/g ash-free dry weight. Belowground caloric content was similar, varying between 3400-4732 calories/g ash-free dry weight. Ash content of the shoots averaged about 13% and that of the roots 25%.

Nuphar advena (spatterdock, yellow pondlily). This species forms essentially pure stands covering 3.7 ha (9.1 acres) or 7% of the marsh vegetative cover (Table 1). *Nuphar* occurs only as small clumps in the areas adjacent to Woodbury Creek but becomes more important as one goes up Hessian Run (Fig. 2). The upper end of Hessian Run is strongly dominated by an extensive spatterdock community. Spatterdock is a perennial with erect leaves usually extending above the water. This plant commonly reproduces vegetatively from the large rhizome system. The resultant clones often take the shape of ovals or circles which are

TABLE 3. — Caloric and Percent Ash Values for the Major Plant Communities of the Woodbury Creek Marshes.

Community	Date Harvested	Above-ground % Ash	Above-ground calories*	Below-ground % Ash	Below-ground calories*
Zizania	6/18	26.00	4448.08	21.87	3399.66
	6/26	16.68	4363.71	33.43	4731.66
	7/16	7.80		22.91	3390.81
	8/6	9.87		26.73	
	8/27	9.46	4331.92	23.53	3938.36
	9/17	13.31	4114.24		
Mixed Aquatic dominated by *Amaranthus*	6/24	21.23	4344.46		
	7/10	13.76		43.06	
	8/22	14.75		64.19	
	8/29	15.94	4315.23	31.09	4158.05
	9/21	10.25	4300.39	25.11	4371.73
dominated by *Sagittaria-Bidens*	9/21	17.24	4748.26		
Nuphar	6/24	26.02	4162.09	44.23	3987.58
	6/26	20.11		44.14	
	7/10	15.62	3897.54	38.65	
	8/16	25.13	4172.67	29.73	4424.55
	9/17	21.83			
Peltandra	6/14	12.94	4301.45	19.95	4183.58
	6/18	12.82		18.78	
	7/10	32.25	4359.35	19.64	4390.78
	8/16	27.75		42.17	
	8/27	32.80		56.37	
	9/21	37.71	4269.74		
Typha	6/18	7.01	4390.14	21.16	4329.15
	7/16	5.78		27.82	
	8/22	7.90	4448.92	33.09	4296.24
	9/17	5.75	4424.06		

* Calories/gm ash-free dry weight, average of 2 determinations.

conspicuous on the air photos and the vegetation map. Larger areas of spatterdock result from the merging of clones and are more irregular in outline. *Nuphar* at Woodbury initiates new growth in early April and is quite well-developed by the end of April and fully developed by early June. Unlike wild rice, standing crop of spatterdock was essentially uniform during the sampling period (Table 2) with the variation recorded a result of different plant density rather than developmental change. Even the early samples are for completely developed plants. Aboveground estimates vary between 377-605 g/m^2 (1.68-2.70 tons/acre) which is considerably lower than the peak recorded for wild rice. These values slightly exceed the values reported for Oldmans creek but are less than values reported for Tinicum (Table 4). The rhizome mass of *Nuphar* is extensive, ranging from 1134-1804 g/m^2 (5.06-8.05 tons/acre). These estimates may be low as more rhizomes may have occurred below the sampling depth. The underground system is much more extensive than wild rice but it must be remembered that the rhizomes

TABLE 4. — Values for Aboveground Standing Crop in Tons/acre for Several Delaware River Marsh Areas.

Community	Aboveground Standing Crop Tons/acre Tinicum [a]	 Oldmans [b]	 Woodbury (this study)
Zizania	6.9 2.7	6.2	6.4
Nuphar	5.2 5.3	2.3	2.7
Typha	9.2 3.9 3.9	4.4	3.7
Mixed Aquatic	4.0 2.3	3.4	1.96
Peltandra	—	1.2	5.63

[a] Data from McCormick, 1970.

[b] Data from McCormick and Ashbaugh, 1972.

are perennial and the samples include not only material from the current year but also portions of at least several other years. The higher estimates of rhizome mass toward the end of the growing season may reflect translocation of materials for storage but more samples would be needed to determine this positively. Caloric content (Table 3) for the shoots was relatively stable (3897-4173 calories/g ash-free dry weight). The two caloric values determined for the rhizomes (3987, 4425) may be sufficiently different to reflect some storage later in the season but more samples would be needed to verify this. A caloric value of 4480 is reported in the literature (Cummins and Wuycheck, 1971) for *Nuphar*.

Nuphar-Zizania. A sufficiently large area, 4.15 ha (10.26 acres) or 8% of the marsh vegetation (Table 1) of a mixed wild rice-spatterdock community occurs to warrant consideration as a separate entity. This community occupies two large areas along Hessian Run (Fig. 2). No production data were recorded from these areas. Standing crop would probably be between that of *Nuphar* and *Zizania* since the total plant density in this community is not the sum of the densities of the pure community types.

Mixed aquatics. This term, as used here, does not refer to a single, well-defined community type but rather to a variable group of types having some or all of the following species; wild rice, spatterdock, *Bidens laevis* (bur marigold), *Amaranthus cannabinus,* (*Acnida cannabina,* water hemp), *Polygonum* spp. (smartweed) and *Sagittaria latifolia* (arrowhead). Taken as a whole, these types occupy 7.8 ha (19.1 acres) or 14% of the marsh (Table 1). These areas occur adjacent to the upland on a stream leading into Hessian Run and along a small stream off Woodbury Creek opposite of the mouth of Hessian Run. The vegetation map (Fig. 2) identifies the dominants of each area of mixed aquatics by placing the species numbers on top of the mixed aquatics pattern. Mixed aquatic communities included at least two and as many as five of the six species listed. Almost no two areas of mixed aquatics were exactly alike and none of the six component species was universally present. It was not possible to sample all these variants but production and caloric data are presented (Tables 2, 3) for two areas, one with a high proportion of water hemp and another including a high percentage of bur marigold and arrowhead. Aboveground production of the water hemp type was as high as 768 g/m^2 (3.43 tons/acre) in late summer and early fall. These values are fairly similar to those reported for Tinicum (Table 4). Estimates of underground production were generally in the range of 508 g/m^2 (2.26 tons/acre). Caloric content of both above and belowground material was similar (4158-4371 calories/g ash-free dry weight). Only three samples, taken in September, are available for the bur marigold-arrowhead mixture. Standing crop at this time was quite low (214 g/m^2 or 0.95 tons/acre) but a higher standing crop might have been present earlier in the season. Caloric content was 4748 calories/g ash-free dry weight. No determinations for belowground material were made.

Peltandra virginica (arrow-arum). *Peltandra* is relatively uncommon in the Woodbury marshes. It occurs in a few relatively pure stands along Woodbury Creek (Fig. 2). These stands total only 0.57 ha (1.40 acres) or about 1% of the marsh (Table 1). Like *Nuphar,* arrow-arum develops early from a perennial root system with development complete in early June. Aboveground production data (Table 2) indicate a high early season standing crop, 819-1286 g/m^2 (3.65-5.74 tons/acre) with a decline in August and September. Leaves were starting to turn brown and curl at the end of August, indicating early senesence. Values for *Peltandra* greatly exceed those obtained for the Oldmans Creek (Table 4) marshes. Root data were tremendously variable (1169-5320 g/m^2) depending on the proportion of mud and rhizome encountered in the sample. The high figure represents a very large rhizome taken with the sample plot. Caloric value was essentially the same for above and belowground parts (4183-4390 calories/g ash-free dry weight).

Typha angustifolia (narrow-leaved cattail). Cattail was not common on the study site although a very large area of it occurs just outside the study area to the west. The *Typha* community includes only 0.57 ha (1.40 acre) or about 1% of the marsh. It occurs in several relatively pure but scattered areas (Fig. 2). Aboveground standing crop was relatively uniform throughout most of the sampling period with all samples around 850 g/m^2 while belowground estimates are more variable (576-1800 g/m^2 or 2.57-8.03 tons/acre). Aboveground estimates are similar to those obtained in Virginia (Keefe, 1972) and slightly below values obtained for Oldmans Creek and some stands at Tinicum (Table 4). Belowground values are quite similar to those obtained in a study in northern New Jersey (Jervis, 1969). Caloric content (Table 3) was rather uniform, 4329-4449 cal/g ash-free dry weight. Cummins and Wuycheck (1971) reported a caloric value of 4340 for *Typha.*

Additional species. Two small areas of *Phragmites communis* (common reed) occur at the marsh periphery (Fig. 2). These areas total 0.09 ha (0.22 acre) or only 0.1% of the marsh. More extensive areas of reed occur on adjacent uplands. No production data were taken for *Phragmites.* A stand of *Acorus calamus* (sweetflag) is present near Route 130-I-295 but was too small to map. Other minor species present at Woodbury include *Pontedaria cordata* (pickerelweed), *Polygonum sagittatum* (arrowleaved tearthumb), *Impatiens capensis* (jewelweed), *Lythrum salicaria* (purple loosestrife), *Echinochloa walteri* (water millet) and and *Hibiscus* sp. (marsh mallow).

SUMMARY

The Woodbury Creek-Hessian Run marshes are strongly dominated by extensive stands of wild rice. Wild rice also occurs in mixtures with spatterdock, bur marigold, water hemp, smartweed and arrowhead. Wild rice is probably the most productive plant of the marshes with peak aboveground standing crop exceeding 1400 g/m^2 and peak belowground standing crop approximating 900 g/m^2. Peak aboveground standing crops for other community types are considerably lower than wild rice, but belowground standing crop of perennial species with rhizomes (*Nuphar, Peltandra, Typha*) exceed those of wild rice. Aboveground standing crop figures obtained for these marshes are in general agreement with those obtained for similar communities at Tinicum and Oldmans Creek. There are no available belowground data for comparison. Caloric values varied little, regardless of species or plant part, with most figures in the range of 4300 ± 300 calories/g ash-free dry weight.

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A NEW INTERTIDAL FORM OF *ELEOCHARIS OLIVACEA* (CYPERACEAE)

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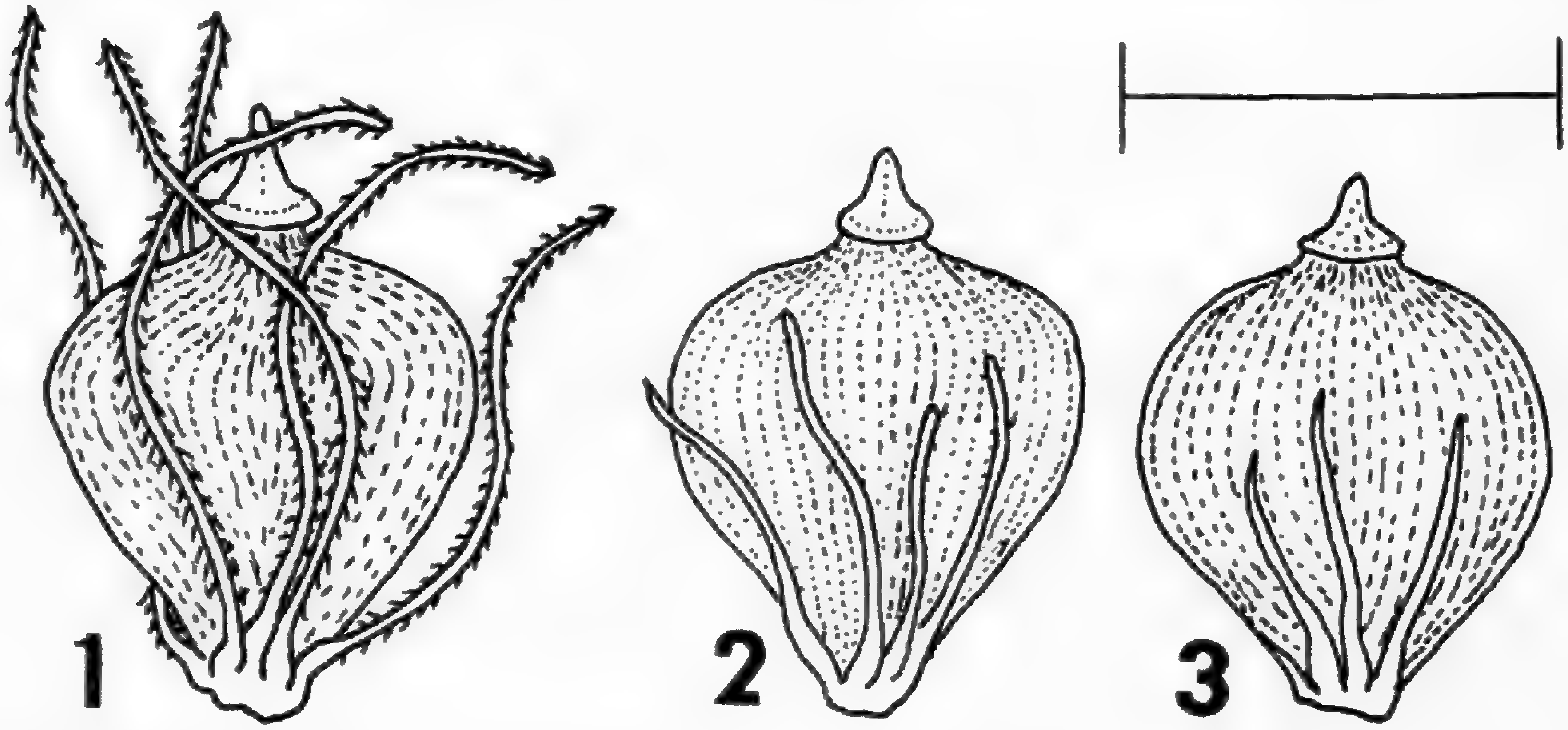
Achenes of *Eleocharis olivacea* Torr., which resemble the type (Quaker Bridge, N.J., Sep 1829, ex herb. Torr., NY), have retrorsely barbed bristles which mostly exceed the achenes (Fig. 1; as described and illustrated by Svenson, 1929, 1939, & 1957). However in some intertidal localities in New Jersey and Virginia, plants have smooth or nearly smooth bristles which are mostly shorter than the achenes (Figs. 2 and 3). These intertidal plants with atypical bristle characteristics are described as:



Figs. 1-3. — Achenes of *Eleocharis olivacea.* Fig. 1. f. *olivacea;* Fig. 2. f. *reductiseta;* Fig. 3. f. *reductiseta.* Unit is 1 mm.

Eleocharis olivacea f. **reductiseta** Schuyler & Ferren, f. nov.

Setae acheniis plerumque breviores, dentibus nullis vel obscuris.

Type: new jersey: Atlantic Co.: tidal mud along Great Egg Harbor River, 1½ mi SW of Gravelly Run, 30 Aug 1933, *W. M. Benner 5390,* PH.

Additional Specimens: new jersey: Atlantic Co.: Mullica R., below "The Forks," 21 Aug 1910, *B. Long 4720,* PH; Atlantic Co.: Lucas' Branch opp. Crowleytown, 21 Aug 1910, *W. Stone 13080,* PH; Atlantic Co.: mouth of stream along mud-covered gravelly tidal shore of the Mullica R. opp. Green Bank, 5 Sep

1972, *W. R. Ferren 1063,* PH; Atlantic Co.: ca .5 mi N of Catawba, slightly brackish zone of the Great Egg Harbor R., clayey peaty tidal slope disturbed by dredging, 20 Oct 1972, *W. R. Ferren 1202,* PH; Atlantic Co.: within 1 mi S of Catawba, sandy & muddy tidal shore along Great Egg Harbor R., 6 Aug 1937, *B. Long 51218,* PH; Burlington Co.: NW of Sweetwater, along Mullica R. just above Crowley's Landing, sandy peaty edge of tidal marsh, 5 Sep 1972, *W. R. Ferren 1070,* PH; Burlington Co.: Crowleytown, moist sandy tidal-shore, Mullica R., 2 Nov 1917, *B. Long 18328,* PH; Burlington Co.: Herman, muddy tidal flats of Mullica R., 3 Sep 1944, *H. Koster C5-9-7,* PH; Burlington Co.: ca 1.2 mi N of village of Wading River at Chips Folly Camp Ground, mud covered gravelly tidal shore of Wading R., 29 Aug 1971, *W. R. Ferren 751,* PH; Burlington Co.: ca 1 mi N of the village of Wading River at Chips Folly, sandy tidal beach of Wading R., 27 Oct 1971, *W. R. Ferren 880,* PH; Burlington Co.: above the village of Wading River, sandy muddy tidal-shore of Wading R., 10 Sep 1914, *B. Long 10838,* PH; Burlington Co.: ca .3 mi E of the village of Wading River, muddy tidal shore of Wading R. at front of fresh marsh, 29 Aug 1971, *W. R. Ferren 755,* PH; Cape May Co.: ca 2.6 mi WNW of Tuckahoe, intertidal zone of Tuckahoe R., 4 Oct 1972, *A. E. Schuyler 4374,* PH; Cumberland Co.: Manantico, sandy muddy tidal shore, Maurice R., by old brickyard, 1 Nov 1936, *B. Long 49275,* PH; Cumberland Co.: S of Manantico, sandy muddy tidal shore of Maurice R., 20 Oct 1935, *B. Long 47869,* PH. VIRGINIA: Fairfax Co.: New Alexandria, 13 Aug 1910, *F. W. Pennell 2589,* PH.

Infraspecific variation in bristle characteristics is common in sedges. Some species (*Rhynchospora cephalantha* Gray) have forms distinguished by antrorse or retrorse bristle teeth. In others (*Scirpus purshianus* Fern.) the forms have either retrorsely barbed bristles or the bristles are virtually absent. In at least one species (*Scirpus smithii* Gray), the forms may have bristles that are well developed with retrorse teeth, reduced with obscure teeth, or virtually absent.

Some correlations between bristle structure and the intertidal environment are apparent in the Compositae and the Cyperaceae. For example, *Bidens bidentoides* (Nutt.) Britt., a species restricted to fresh or somewhat brackish intertidal zones, has bristles with antrorse teeth. Most other species of *Bidens* are not restricted to intertidal zones and have retrorse bristle teeth. *Bidens frondosa* L. usually has achenes with retrorse bristle teeth, but f. *anomala* (Port. ex Fern.) Fern., found mostly in tidal habitats, has antrorse bristle teeth. The small sedge, *Eleocharis diandra* Wright, locally restricted to intertidal zones, usually lacks bristles while the closely related *Eleocharis obtusa* (Willd.) Schultes, found in diverse aquatic or subaquatic conditions, has retrorsely barbed bristles. Similarly, *Scirpus smithii* f. *smithii,* which has no bristles, is commonly found in fresh intertidal zones while *S. smithii* f. *setosus,* which has retrorsely barbed bristles, is not.

The adaptive significance of these modifications of bristle structure may be related to anchorage of achenes to the substrate. Achenes with well developed retrorsely barbed bristles may have a greater chance of becoming attached to litter washed along shorelines than those lacking retrorsely barbed bristles or having antrorsely barbed bristles. In situations where water level fluctuation is moderate, this anchorage of achenes along shorelines probably has positive adaptive significance for plants which generally grow in a wet or moderately inundated substrate. However in situations where tidal fluctuation of water level occurs, achenes with retrorsely barbed bristles could become stranded in litter at the high tide limit where conditions may not be continually wet enough for the survival of such plants. However if bristles are reduced or lacking, or if bristle teeth are antrorse instead of retrorse, there might be a better chance for achenes to be washed back and forth as the water level fluctuates and eventually be deposited in a more continually wet or inundated substrate lower in the intertidal zone.

The variation pattern in *Eleocharis olivacea* appears to be similar to that in *Bidens frondosa.* Typical forms of both species grow in diverse wet situations including intertidal zones, but the forms with atypical bristles are restricted or nearly restricted to intertidal zones. In both *Bidens frondosa* and *Eleocharis olivacea,* the forms are known to grow adjacent to each other; in such places it would be interesting to determine whether or not the distribution of the forms is correlated with differences in ecological conditions.

Acknowledgments

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David Berkheimer (1896-1972). — David Berkheimer, who contributed a large number of specimens to the herbaria of the Academy of Natural Sciences of Philadelphia and the University of Pennsylvania, was born in Osterburg, Bedford County, Pennsylvania, on January 10, 1896, and died in Sun City, Arizona, on February 4, 1972. He practiced as a dentist in Reading, Pennsylvania, for many years, retiring in 1954.

Dr. Berkheimer became interested in ferns about 1935, and started collecting specimens of ferns and flowering plants soon after, especially in Berks and Bedford Counties, Pennsylvania. He joined the Philadelphia Botanical Club in 1943. His collections amounted to nearly 23,000 numbers, collected mostly in Pennsylvania, but also in New Jersey, New England, and on trips to Rocky Mountain, Glacier, and Yellowstone National Parks.

Before moving to Arizona in 1969, Dr. Berkheimer gave his personal herbarium to the Carnegie Museum in Pittsburgh. Besides botanical collecting, he also had a continuing interest in bird watching. — *Hans Wilkens.*

Harold W. Pretz (1877-1973). — Harold W. Pretz was born on November 18, 1877 in Allentown, Pennsylvania where he resided throughout his long life. He grew up at a time when little money was available, and as a consequence, his family was forced to live a very frugal life. Their habits of thrift and conservation became a part of his daily life. Because occupational opportunities were rare and financial aid for further education was unavailable, Harold left school as soon as a position was open at the Allentown National Bank. As a consequence he never received a high school diploma, even though he ranked second in his class at the time he left school.

At the bank he advanced from one position to another until he was appointed Trust Officer, a position he held until his retirement after more than sixty years of service to the bank and his community. Throughout his life his efforts were devoted to his work and to his avocation, floristic botany.

Harold was born with natural curiosity and an inherent interest in plant life.

Early in his botanical career he became acquainted with Phillip Dowell, who taught biology at Muhlenberg College from 1897 until 1902. Dowell lived next door to the Pretz family and the two naturalists went on many field trips. It was Dowell who taught his companion how to prepare specimens and labels, and Harold's labels were prepared with great care. Dowell's intense interest in genetics and evolution had a profound influence on Pretz's scientific views. When Dowell moved to New York City, Walter and Edward Mattern became Harold's field companions.

Because of inadequate transportation systems, their activities were often limited. Hikes of fifteen or more miles were common events. Often most of the day was spent walking to and from a good collecting spot which was situated far from a railroad or trolley line. In time the Matterns purchased an automobile which opened new vistas for these field men. Throughout this association Pretz did all the work of collecting and pressing the specimens. In time Ned Mattern moved away from Allentown, and Walter, who developed a heart condition, turned to oil painting, an area where he demonstrated unusual talent.

When the Mattern boys passed from the botanical scene, Frank W. Cressman, who was Harold's associate and close friend, became his field companion. Their acquaintance began in 1902 and continued until Harold died. As they walked to and from work, their neighbors claimed that it was possible to set their clocks as the two passed on their way to the bank. In 1936 the author introduced himself to Harold. Our mutual interests cemented a lasting friendship which was one of cooperation. Along with our friend Frank Cressman, we continued botanical excursions. Saturdays and holidays were reserved for trips which continued until Harold was in his nineties. Only illness or very bad weather prevented the group from taking the trips. When Harold no longer felt capable of taking the long walks, he went along for the ride. He enjoyed the motor trips until two weeks before he died.

Pretz developed into an excellent field botanist. He knew his plants and he could detect the unusual. No families of vascular plants were neglected. He enjoyed mastering difficult groups such as *Cyperaceae, Crataegus,* and *Potamogeton.* His herbarium was started in 1899 and continued to expand for fifty years. His own collecting numbers approached 16,000. Through the years a large library was accumulated. His books and periodicals were carefully read, for his knowledge of floristic botany and related areas was profound. He rapidly grew in stature, and all recognized him as the authority on local plants. President John Haas of Muhlenberg College requested that Pretz put the Muhlenberg herbarium in order, and revise the nomenclature of the specimens. This work was done in his free time, and there was no remuneration. In 1919, when the task was completed, Muhlenberg College granted him an honorary Master of Science degree.

Early in his botanical career an association was developed with the Philadelphia Botanical Club which he joined in 1916. Bayard Long, who always had genuine interest in the work of local botanists, began to correspond with Harold. Bayard encouraged him to pursue field work in the northern section of the range covered by the Philadelphia Botanical Club. Most of the collecting was done within a radius of one hundred miles around Allentown. Whenever possible a duplicate specimen was sent to Philadelphia. About thirty years ago his private collection was sent to Philadelphia, for Bayard was anxious to select specimens which were not already represented in the herbarium. Unfortunately Long's illness delayed the task of checking all the specimens. The present personnel of the Academy of Natural Sciences of Philadelphia have finally completed the job. Many of the duplicates were sent to Muhlenberg College.

For many years descriptions of the trips were carefully prepared. More than eighty volumes of notes and records were compiled and typed by Harold. The accounts are well written and make fascinating reading material. Next to his specimens, he considered his notes to be his important contribution to the field of botany.

He corresponded with most of the outstanding botanists of his day, for he was interested in the opinions and concepts of others. The many amateur botanists around the Allentown area knew him well and sometimes accompanied him on field trips. Walter Benner, Bayard Long, and Edgar Wherry visited him frequently. All who knew him enjoyed their association with this dedicated, amiable, and interesting man.

Before starting his botanical career, he was active in his church choir. His gifted mother, who taught music, trained him to become an accomplished pianist and organist. One of his few possessions was a fine piano which was purchased in New York City. The music rolls which accompanied the piano contained superb recordings of classical music. As the rolls moved in the piano case, it was possible for someone to manipulate expression gears. Harold learned to do the job well. The music produced was far superior to the piano music available from a phonograph. The piano proved to be a good investment, for later in his life he sold it for a nice sum of money. His dedication to floristic botany forced him to drop his church work, but his love of good music persisted to the end.

He never tired of his botanical studies and pursued his interests as long as possible. The continuous addition of species new to Lehigh County as well as range extensions ruled out the publication of a county flora. There was always more to do and additional places to visit. His drive never waned.

Pretz never married. He lived with his parents until they died. His older brother moved to New York, and Harold maintained the home until the end of his life. He inherited genes for longevity from both sides of the family, for his mother, brother, and many of his cousins were in their nineties when they passed away.

Harold was almost 96 years old when he died on November 8, 1973. He outlived all of his close relatives and most of his associates. His few living friends saw this remarkable man buried on a hill overlooking the Great Valley which he loved and where he spent most of his life.

Publications of Harold W. Pretz

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1954. *Arenaria patula* in Pennsylvania. Bulletin of the Torrey Botanical Club 81:455-456.

Plant Named for Harold W. Pretz

Polygala Pretzii Pennell. Bartonia 13:7-17.

— *Robert L. Schaeffer, Jr.*

Marian Ropes Robertson (1934-1975). — Mrs. Robertson, a member of the Philadelphia Botanical Club and an enthusiastic local amateur botanist, died of cancer at the age of 40 on February 25, 1975, in Mount Holly, New Jersey. She was born in Salem, Massachusetts, and is survived by her mother Ruth Guppy Ropes, her husband Dr. Robert Robertson (a curator in the Malacology Department of the Academy of Natural Sciences), and by her daughter Pamela Lucinda.

Mrs. Robertson received her bachelor's degree from Carleton College, Minnesota, in 1956, and her master's from Radcliffe in 1958. In 1964 she studied at Duke University. Her main botanical interest was mosses, especially their morphology, systematics, life cycles, ecology, and floristics. Mrs. Robertson's private collection, mainly comprised of mosses from the northeastern United States but with some from England, Switzerland and other places, includes 8536 numbered packets, the disposition of which has not yet been decided. Mrs. Robertson also studied the flowering plants of the New Jersey Pine Barrens and of the Bahama Islands.

A woman of many interests, Mrs. Robertson was a member of Phi Beta Kappa, the American Bryological and Lichenological Society, the British Bryological Society, the Botanical Society of America, and the International Association for Plant Taxonomy. She also belonged to organizations concerned with zoology, conservation, geography, ethnology, art, music, religion, and dogs. Towards the end of her life she was active in the League of Women Voters.

The area botanical community will remember Mrs. Robertson for her efforts to foster the appreciation of the local flora and in particular the mosses. — *Ed.*

NEWS AND NOTES

Acquisition of Wagner Institute Moss Collections by the Academy of Natural Sciences. — In June 1973, the Academy of Natural Sciences of Philadelphia acquired the herbarium of the Wagner Free Institute of Science, 17th Street and Montgomery Avenue, Philadelphia. A major portion of this herbarium consisted of late 19th and early 20th century moss collections given to the Wagner Institute by George Bringhurst Kaiser (1874-1944). Dr. Kaiser held the following positions: Professor of Botany at the Ambler School of Horticulture, Professor of Botany at the Wagner Free Institute of Science (1927-1942), Secretary of the Botanical Society of the University of Pennsylvania and leader of its field trips, Treasurer of the Delaware Valley Naturalists Union, and Curator of the Herbarium of the Sullivant Moss Society (1911-1936). He was also a member of the Cryptogam Society of Philadelphia and the Academy of Natural Sciences. After his death on January 1, 1944 his library and herbarium were deposited at the Wagner Free Institute of Science.

Most of the approximately 4,000 moss specimens are from North America, especially the northeastern and northwestern United States and adjacent Canada, Minnesota and Florida. Other areas represented by significant collections are the British Isles, Hungary, France, Italy, Japan, and New Zealand. All except about 300 specimens have locality data and virtually the entire collection is identified.

Of the 279 collectors identified as contributors to the herbarium, 35 made major contributions. Their names, number of specimens collected, and regions of collection are as follows: Bailey, J. W. (80; B.C., Wash., Ore.), Brinkman, A. (142; Alba., B.C.), Cardot, J. (26; Fr.), Corti, E. (68; Ital.), Dixon, H. N. (34; Lapland, Br. Is., Nor., Aus., Fr., Ital.), Dunham, E. M. (29; N. B., Me., Mass., N.C.), Dupret, F. H. (104; Can., Fr., Ital.), Dutton, D. L. (23; Vt.), Fleischer, M. (24; Java, Ceylon), Foster, A. S. (109; Minn., Ore, Wash.), Gadsby, E. B. (27; Can., N.J., Pa., Wyo., Col.), Gray, W. (50; N. Zeal.), Grout, A. J. (111; Vt., N.H., N.Y., N.J., N.C., Fla., Minn.), Györffy, I. (34; Hung.), Hill, A. J. (23; Id., B.C.), Hirotsu, T. (31; Jap.), Holzinger, J.M. (120; N.Y., Md., D.C., Minn., Wis., S.D., Mon., Col.), Hood, S. C. (23; Fla.), Howe, M. A. (58; Cal.), Hunt, L. E. (34; Ore.), Jishiba, E. (27; Jap.), Jones, D. A. (38; Br. Is.), Kaiser, G. B. (349; Vt., N.H., N.Y., N.J., Pa., Del., Md., Mich.), Kingman, C. C. (37; Mass., B.C., Ore., Cal.), Lewis, J. F. (116; Pa.), Lillie, D. (66; Scot.), Macfarlane, J. M. (26; Pa., B.C., Switz.), Nicholson, W. E. (35; Lapland, Nor., Br. Is., Switz., Aus., Ital.), Pendleton, G. M. (40; Cal.), Rapp, S. (54; Fla.), Rhodes, P. G. M. (58; Br. Is., Switz.), Schumo, S. L. (43; Newf., N.C., Fla.), Small, J. K. (24; Pa., Va., N.C., Ga., Fla.) and Sullivant, W. S. and Lesquereux, L. (414; N. Am.).

A few other collectors who made contributions to the moss herbarium are as follows: Burnett, D. A. (17; N.Y., Pa.), Chamberlain, E. B. (15; Me., N.Y., N.J., D.C.), Farr, M. (12; Eur.), Flett, J. B. (15; Wash.), Gray, F. W. (16; W. Va., N.C.), Hansen, J. (18; Minn., N.W.T.), Huntingdon, J. W. (18; Mass.), Jewett, H. S. (19; Oh., Col.), Knight, H. H. (19; Br. Is., Switz.), Langlois, A. B. (13; La.), Macoun, J. (20; Cal.), Nelson, N.L.T. (11; Minn., Mo., Col.), Peterson, H. (13; B.C.), Waghorne (15; Lab., Newf.), Watts, W. W. (15; Austral.) and Weiblejohn, J. (16; N. Zeal.).

Appreciation is expressed to Robert Chambers, Director of Wagner Free Institute of Science, for his aid in locating information concerning George B. Kaiser and his moss herbarium. — *Michael E. Kachur*

Dr. Gordon Honored. — Botany Club member Dr. Robert Gordon was honored by West Chester State College when the Robert B. Gordon Area for Environmental Studies was dedicated to him in October, 1973. The approximately 70 acres, located east of South New Street on the South Campus, includes meadow, stream, and hardwoods and has been in use by biology students for research.

Dr. Gordon, who joined the West Chester faculty in 1938, was chairman of its science department (biology, chemistry, and physics) from 1943 until he retired in 1963 as professor emeritus. — *Charlotte Shaefer*

Herbaria Moved. — In November, 1973, the herbarium of the Academy of Natural Sciences of Philadelphia (PH) moved to a new location at 2501 Fairmount Avenue, Philadelphia, Pennsylvania. The site, designated the Scientific Research Center, provides increased office and collection space on the first floor of the west wing of the building. The location is near the Art Museum, several blocks along the Parkway from the old location. All of the plant collections with the exception of fossil plants and algae are now housed in the Scientific Research Center.

In June, 1974, the herbarium of the University of Pennsylvania was moved to the Scientific Research Center. This collection, containing an estimated 250,000 specimens, has been deposited on "permanent loan" to the Academy. Specimens from the University herbarium bear the stamp "Herbarium of the University of Pennsylvania" while those from the Academy collections are either punched "ANSPHILA" or stamped "Academy of Natural Sciences of Phila., Phila. Botanical Club." When citing specimens from the University of Pennsylvania and Academy of Natural Sciences herbaria, the abbreviations "PENN" and "PH" respectively should still be used. All correspondence concerning the two herbaria should be addressed to: Botany Department, Academy of Natural Sciences of Philadelphia, 19th and the Parkway, Phila., Pa. 19103. — *John W. Braxton*

Recent Publication of Local Interest. — *Rare or Endangered Vascular Plants of New Jersey* by D. E. Fairbrothers and M. Y. Hough (N.J. State Museum, Science Notes No. 14, 1973) is a working list of the rare or endangered plant species of New Jersey as determined through a consensus of a dozen local botanists and naturalists. Ninety of the included species were adjudged to be rare, 74 endangered, and 26 undetermined. For comparison with the current status of the species old publications were checked and plant specimens preserved in the

Chrysler Herbarium at Rutgers University, New Brunswick, were consulted. An Introduction, Working Concept of Terms, and Annotated Plant List with habitat, generalized range and collecting history, and current status for each species are included. — *Wayne R. Ferren, Jr.*

Orchid Colony. — On June 9, 1974 local botanizers Edgar Wherry, Ralph Sargent, Howard Wood, Paul Friar, and John Wolf, Jr. made a field trip to south central Pennsylvania. At Safe Harbor, near the junction of the Conestoga and Susquehanna Rivers, on a wet, grassy shoal, they found and photographed a fine stand of *Spiranthes lucida* in full bloom. The flowers of this species are notable for the brilliant yellow stripe on the lip.

Spiranthes lucida is regarded as essentially a northern orchid, as it flourishes in New England and the Canadian maritime provinces. Correll in his *Native Orchids of North America* notes that outlying, disjunct stands have been reported from as far away as Tennessee, Missouri, and Kansas. This substantial colony in southern Pennsylvania, almost on the Maryland line, is worthy of noting and preserving. — *Ralph M. Sargent*

Tyler Award to Dr. Patrick. — Dr. Ruth Patrick, Chairman of the Board of Trustees of the Academy of Natural Sciences and a member of the Botanical Club, was the recipient of the second annual John and Alice Tyler Ecology Award. The $150,000.00 international prize, endowed by the late John C. Tyler, cofounder of Farmers Insurance Group, and his wife, Alice, honors outstanding achievement in the studies of organisms and their environments. Dr. Patrick was selected from distinguished nominees of fifteen nations for her pioneering accomplishments in limnology. She plans to use the award to work on her planned book on river ecology. — *Ed.*

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ARBORESCENT COMPOSITION OF WOODLANDS ON DIABASE IN BUCKS AND MONTGOMERY COUNTIES, PENNSYLVANIA

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Rhode Island College

In the northern part of Bucks and Montgomery Counties, there occurs an extensive area of woodlands on a substrate mapped as diabase (Gray, 1960). Elevations range from 100 to 250 m above sea level and the area is covered by the Neshaminy–Mt. Lucas–Watchung catena described by Smith (1967). Lull (1968) reports the region as having an average January minimum temperature of $-14°$ to $-16°$C.; the daily July maxima average is 30°–31°C. The frost free period is from 150 to 180 days and there is an annual precipitation of 110–120 cm.

From 1962 to 1966 I surveyed a total of 23 stands occurring on the Neshaminy, Mt. Lucas, and Watchung soils to establish their composition and find if these woodlands are basically still those described by Bean (1884) and Davis (1876) as being the ". . . oak, hickory, ash, walnut, chestnut, butternut, maple, gum, tulip popular . . ." forest found by the settlers from 1684 to 1748.

METHODS

Stands were selected on the basis of having a minimum area of 5–10 ha, well developed arborescent vegetation, and no signs of recent disturbance. Each was sampled at 20 to 40 points using the variable radius method (Grosenbaugh, 1952) for trees and 23.3 m^2 circular plots for counting seedlings and saplings. Seedlings

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[1] I thank the Faculty Research Committee of Temple University for funds which made this study possible.

were considered to be ≦ .5m tall, saplings ≧ .5m tall but less than 2.5 cm dbh, and trees ≧ 2.5 cm dbh. In each stand 10–15 cores were taken with a Swedish increment borer and the height of 5 canopy trees was determined by Suunto climometer.

Stands were grouped according to the soil type they occupied, and importance values determined for trees (relative frequency + relative basal area), seedlings, and saplings (relative frequency + relative density). Based on ages of trees, an analysis of variance was made between the age of stands on each soil type and between the stand ages on different soil types. T-tests were used to determine if significant differences existed between average tree importance values on different soils and average importance values of different species on the same soil. Nomenclature follows Gleason (1952).

RESULTS

Forty-seven tree species were recorded in 23 stands; 15 stands on Neshaminy, 4 on Mt. Lucas, and 4 on Watchung soils (Figure 1). The average canopy height in all instances was about 23 m; the understory averaging 7 m was dominated by dogwood (*Cornus florida*). Age of stands averaged 61, 66, and 69 yrs. on the Neshaminy, Mt. Lucas, and Watchung soils respectively, and analysis

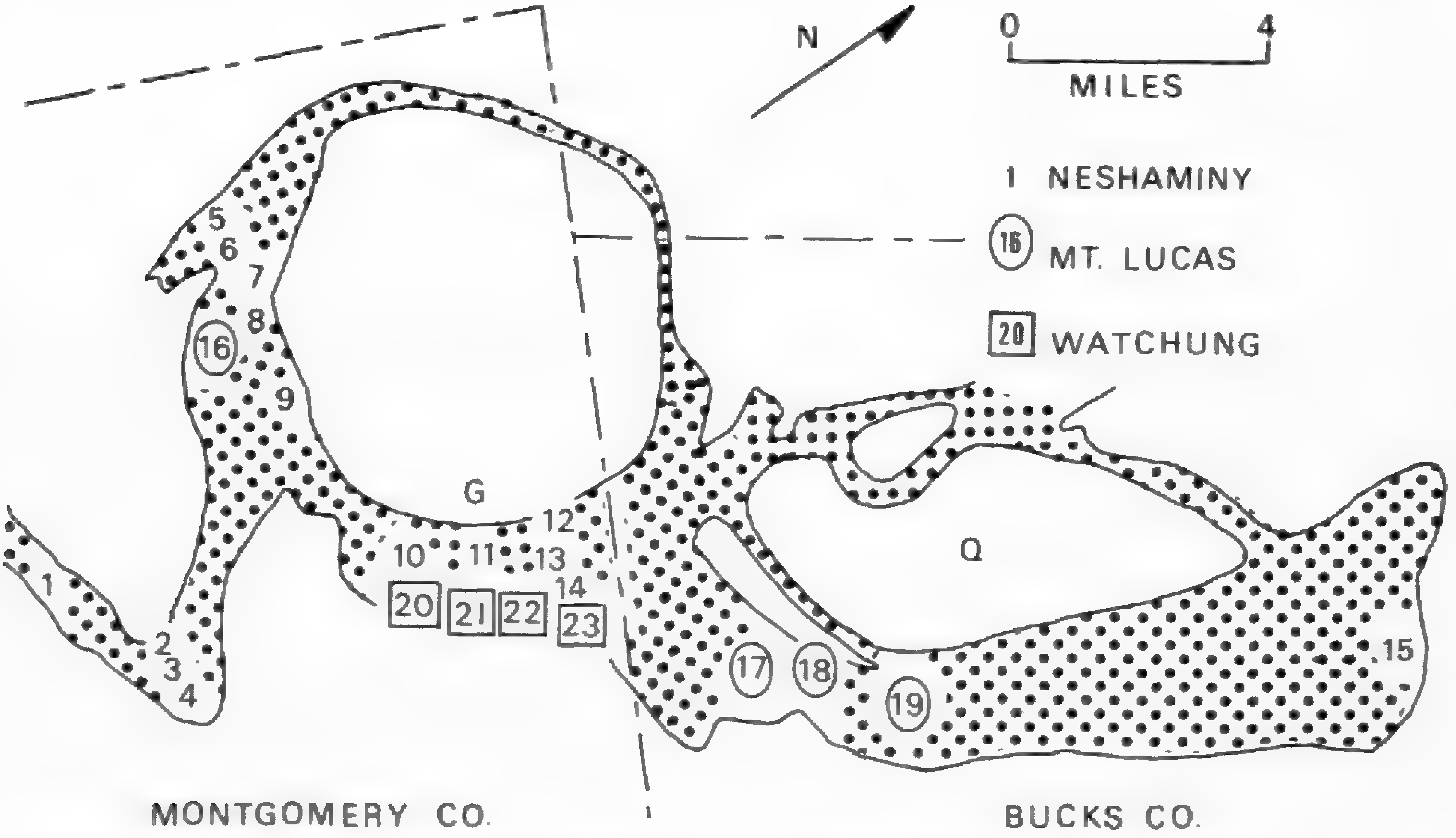


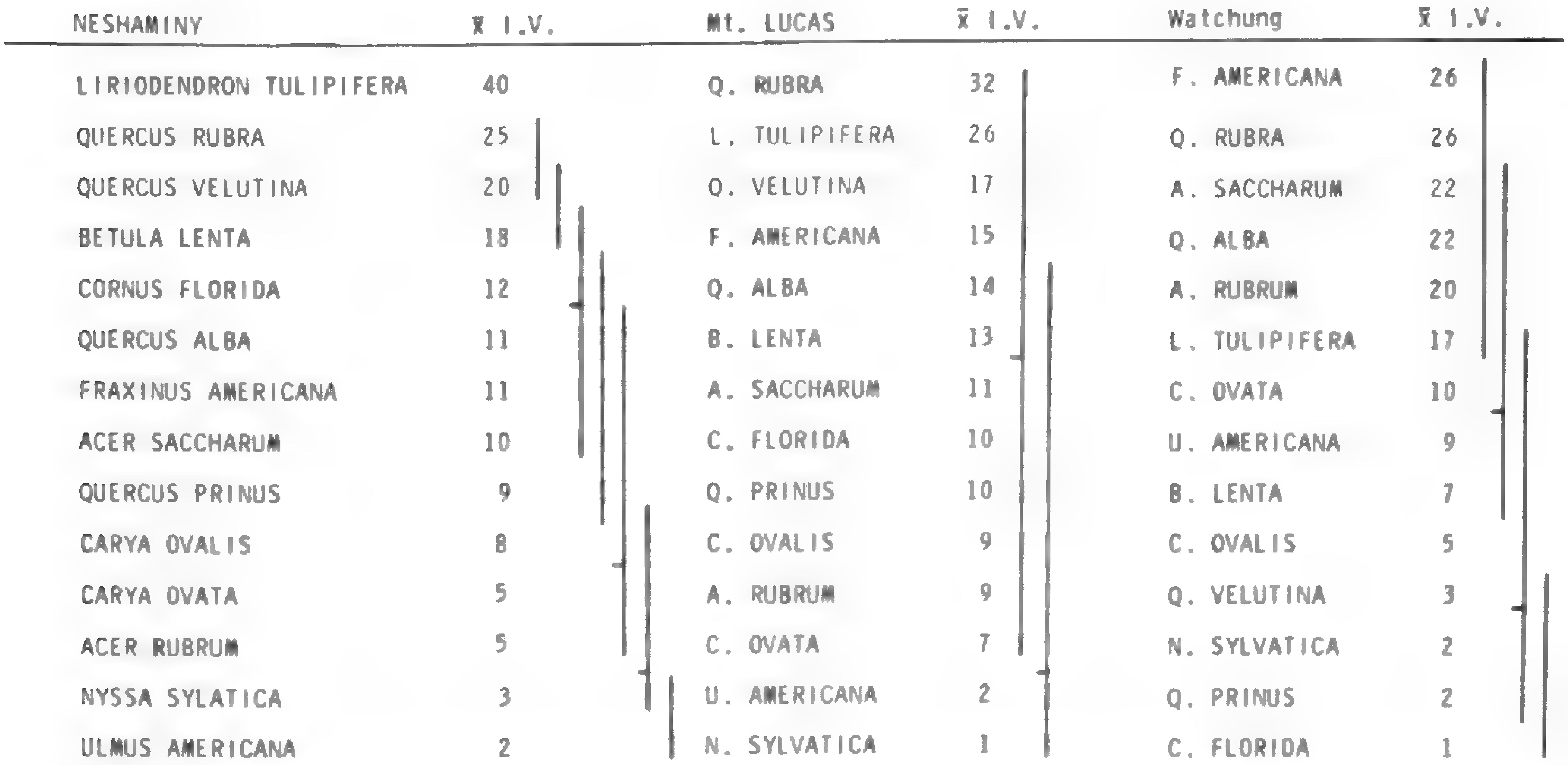
FIG. 1. — Location of stands on diabase: 1. Game Farm; 2. Upper Spring Mtn.; 3. Lower Spring Mtn.; 4. North Spring Mtn.; 5. Little Rd.; 6. Lee Rd.; 7. Deep Creek Rd.; 8. Kulp Rd.; 9. Henning-Hill Rds.; 10. Unami Creek; 11. Hill Rd.; 12. White's Mill; 13. Scout Camp; 14. North Schultz Rd.; 15. Haycock Mtn.; 16. Finn Rd.; 17. Rockhill Tower; 18. West Rockhill; 19. Rockridge; 20. Ridgedale Rd.; 21. Camp Rd.; 22. Dietz Mill Rd.; 23. Schultz Road; G. Green Lane Village; Q. Quakertown.

of variance shows no significant difference between stand ages on a given soil or the groups of stands on different soils. Dense undergrowth is composed primarily of *Hamamelis virginiana, Parthenocissus quinquefolia, Lindera benzoin, Viburnum acerifolium, Vitis* spp., *Rhus radicans,* and *Viburnum dentatum;* the leading species of 28 shrub and vine species were recorded.

Figure 2 shows the average importance values of prominent species; other species occurring on the 3 soils are *Carpinus caroliniana, Carya cordiformis, Carya tomentosa, Fagus grandifolia, Juglans nigra, Ostrya virginiana,* and *Sassafras albidum.* Trees appearing only on Neshaminy and Watchung soils are *Juglans cinerea, Platanus occidentalis,* and *Ulmus rubra;* on Neshaminy and Mt. Lucas soils *Populus grandidentata, Prunus avium,* and *Quercus palustris.*

Low importance value trees sampled only on Neshaminy soil were *Amelanchier* sp., *Cercis canadensis, Pinus strobus, Prunus virginiana,* and *Tsuga canadensis. Juniperus virginiana* was tallied only on Mt. Lucas soil and *Quercus bicolor* sampled only on Watchung soil. Trees appearing as occasional juveniles were *Acer spicatum, Castanea dentata, Celtis occidentalis, Crataegus* spp., *Morus alba, M. rubra, Robinia pseudo-acacia, Staphylea trifolia,* and *Zanthoxylum americanum.*

Species and groups of species whose values are not significantly different on a given soil are seen in Figure 2. No significant differences exist between importance values of prominent species on Neshaminy and Mt. Lucas soils and only black oak (*Quercus velutina*) is significantly lower on the Watchung compared to the Mt. Lucas soil. Red maple (*Acer rubrum*), ash (*Fraxinus americana*),



NESHAMINY	$\bar{x}$ I.V.	Mt. LUCAS	$\bar{x}$ I.V.	Watchung	$\bar{x}$ I.V.
LIRIODENDRON TULIPIFERA	40	Q. RUBRA	32	F. AMERICANA	26
QUERCUS RUBRA	25	L. TULIPIFERA	26	Q. RUBRA	26
QUERCUS VELUTINA	20	Q. VELUTINA	17	A. SACCHARUM	22
BETULA LENTA	18	F. AMERICANA	15	Q. ALBA	22
CORNUS FLORIDA	12	Q. ALBA	14	A. RUBRUM	20
QUERCUS ALBA	11	B. LENTA	13	L. TULIPIFERA	17
FRAXINUS AMERICANA	11	A. SACCHARUM	11	C. OVATA	10
ACER SACCHARUM	10	C. FLORIDA	10	U. AMERICANA	9
QUERCUS PRINUS	9	Q. PRINUS	10	B. LENTA	7
CARYA OVALIS	8	C. OVALIS	9	C. OVALIS	5
CARYA OVATA	5	A. RUBRUM	9	Q. VELUTINA	3
ACER RUBRUM	5	C. OVATA	7	N. SYLVATICA	2
NYSSA SYLATICA	3	U. AMERICANA	2	Q. PRINUS	2
ULMUS AMERICANA	2	N. SYLVATICA	1	C. FLORIDA	1

FIG. 2. — Average importance values ($\bar{x}$ I.V.) of species on Neshaminy, Mt. Lucas, and Watchung soils. No significant difference exists between values joined by a bar. Values above or below a given bar are significantly higher or lower than the joined values. Below a horizontal bar marker, values lie between the .10 and .05 levels of confidence.

and elm (*Ulmus americana*) values are significantly higher on the Watchung than on the Neshaminy soil; black oak is significantly lower on the Watchung soil. Prominent species had juveniles recorded in most instances; producers of airborne fruits and the prolific sprouting-layering dogwood usually had high values (Table 1).

Discussion

With the exception of tulip tree on the Neshaminy, each of the soils is characterized by a group of species with no significant differences in importance values (Figure 2). An interesting feature is that the soil with the most number of such groupings is the well-drained Neshaminy occurring on rolling low hills with their many slopes and greater surface variance. The level, less stoney, and poorly drained Watchung soil has fewer and generally larger groups while the intermediate Mt. Lucas soil seems to represent a situation where neither the leading species of the well-drained or poorly-drained soils gain ascendency.

Uniting the stands on the 3 soils is red oak (*Quercus rubra*), always being a first or second ranked species. Tulip tree (*Liriodendron tulipifera*) and black oak, in the top 3 species on the Neshaminy and Mt. Lucas soils, are another common feature. The greatest difference occurs on the Watchung soil where there are six dominant species of which only red oak appears as a dominant on the other soils.

There being no significant difference in stand ages, the pattern of certain species bears examination. The significantly higher values of red maple, ash, and elm and the significantly lower value of black oak on Watchung soil compared to the Neshaminy is interesting. These soils are respectively the poorly-drained and well-drained members of the catena and it seems probable that drainage is a principal cause for the significant differences. Black oak is also significantly higher on the Neshaminy compared to the moderately well-drained Mt. Lucas, suggesting that the species is sensitive to drainage conditions. Sugar maple (*Acer saccharum*), shagbark hickory (*Carya ovata*), and white oak (*Quercus alba*) have definite, but inconclusive, trends toward significantly greater values on poorly-drained compared to the intermediately- and well-drained soils while the trend of sweet birch (*Betula lenta*) is just the opposite.

Species such as red maple, sugar maple, dogwood, and ash which are shade tolerant in their juvenile stages (Fowells, 1965) have the greatest reproduction. Thus, it is probable that the high dominance of tulip tree on the Neshaminy soils will be lessened as the more shade tolerant oak and hickories increase. These species will, in turn, probably be partially replaced by the tolerant maples. The present oak-hardwood community on the Neshaminy and Mt. Lucas soils will, in time, resemble more closely the present mixed hardwood community on the Watchung soil, the understories always being dominated by dogwood.

Similarities between the diabase stands in Bucks and Montgomery Counties and stands studied by others on diabase are striking. The five first-ranked species

TABLE 1. — Average Importance Values[a] of Seedlings (Sd) and Saplings (Sp).

	Soil Type					
	Neshaminy		Mt. Lucas		Watchung	
Species	Sd	Sp	Sd	Sp	Sd	Sp
Acer rubrum	11	11	10	5	17	8
Acer saccharum	21	12	14	24	46	15
Betula lenta	1	1	2	2	3	8
Carya spp.[b]	15	17	10	3	5	2
Cornus florida	27	39	43	36	12	43
Fraxinus americana	60	59	71	50	41	68
Liriodendron tulipifera	2	2	1	1	1	3
Quercus alba	4	2	2	1	6	
Quercus prinus	3	6	5		1	1
Quercus rubra	6	2	4	3	4	
Quercus velutina	2	2		2	1	
Ulmus americana	5	4	12	6	6	4

[a] Relative frequency + relative density.

[b] *Carya ovalis* and *C. ovata*.

on the three soil types (Fig. 2) are species mentioned (except dogwood) as canopy dominants in the nine stands studied by Andresen and McCormick (1962), Baird (1956), Cantlon (1952), and Keever (1973). Canopy species ranking among the first five in Figure 2 include all of the prominent species listed in the studies cited above with the exception of chestnut oak (*Quercus prinus*) and hemlock (*Tsuga canadensis*). Either red, white, black, or chestnut oak ranked first in six, second in seven, and third in four of their stands. Tulip tree appeared as a first-ranked species in two of their stands, while sweet birch and ash were each ranked third in one instance. Red maple, when present, ranked second in only one stand and fourth in two other instances. Sugar maple appeared in four of their stands with its highest ranking (second) in the cove forests (Baird, 1956). Hickories (*Carya* spp.) ranked lower in both their studies and this study, and elm, present only in the stand of Andresen and McCormick (1962), was more prominent in most of the stands reported here. Hemlock, a rare species in this study, was recorded as being a dominant only in the cove habitats on northwestern slopes (Baird, 1956).

The tendency for hickories to be more abundant on the gentle slopes and for chestnut oak, not abundant in these stands, to be more prominent on the steeper slopes is similar to that which Keever (1973) observed concerning these species. Keever noted that sugar maple is confined to steep, moist-habitat slopes at low altitudes. This is not the case on diabase stands here, the species being an important tree on drier soils even though its importance value increases on moist soils. Diabase soils, being richer in nutrients than the surrounding red shale (Smith, 1967) may be able to support sugar maple in greater numbers near the limits of its range, in contrast to the species's uneven distribution and reproduction on other soils to the southwest (Keever, 1973). Additional evidence is that sugar maple does not occur on nearby quartzite soils having stands of comparable age (Pearson, 1963, 1974), but is found on the local flood plain soils (Pearson, 1972) and only becomes established in the oak-hickory stands on red shale in the absence of fire (Monk, 1961). The greater species diversity of stands on diabase compared to a climax stand on red shale in nearby New Jersey (Monk, 1961) is another indication that diabase substrate influences community composition.

In general, the stands on diabase are richer in species than those surrounding geological formations in the southeastern Pennsylvania region and have characteristic species listed by other investigators for diabase stands. Keever (1973) considered stands having at least three of the species — hemlock, beech (*Fagus grandifolia*), red oak, sweet birch, basswood (*Tilia americana*) and bitternut (*Carya cordifomis*) — as being mixed mesophytic while Bromley (1935) considered the mixed mesophytic forest of southeastern New England as indicated by the presence of oak, chestnut (*Castanea dentata*), shagbark hickory, pignut, sugar maple, beech, tulip tree, and sweet birch. Since, compared to nearby stands on other strata all of these species are present in varying amounts, it appears the woodlands of the diabase-derived soils in Bucks and Montgomery Counties not only have retained the basic composition described by historians (Bean, 1884; Davis, 1876) but should be considered to be outliers of the mixed mesophytic forest.

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A PRELIMINARY STUDY OF THE CHEMOSYSTEMATICS OF AMERICAN OAKS: PHENOLIC CHARACTERS OF STAMINATE CATKINS [1]

HUI-LIN LI AND JU-YING HSIAO

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University of Pennsylvania

In a previous article (Li and Hsiao, 1973), we reported the results of a chromatographic study on the phenolic characters of the leaves of American oaks. We concluded that the phenolic constituents of leaves do not seem to constitute a basis for subgeneric division, though they may be helpful in the grouping of species into series. As a continuation of this chemosystematic investigation in American oaks, we report here the results of a chromatographic study of the staminate catkins. The findings of the present study will be compared with those of the leaf study in the following discussions.

MATERIALS AND METHODS

Freshly dried staminate catkins were obtained either from the Michaux Quercetum collection of the Morris Arboretum or through correspondents from other institutions. Depending on availability, one to three specimens were obtained for each of the 21 species belonging to 13 series of Trelease (Trelease, 1924). The dried catkins were ground into fine powders. For each specimen, 0.2 gram of ground material were used for extraction. The method of extraction and the procedures of chromatographic separation followed exactly those employed in the leaf study. The materials were extracted with 6 ml. of 90% aqueous methanol for one day and then spotted on Whatman 3 MM chromatographic papers (46 × 57 cm). Two-dimensional chromatograms were developed by using TBA (tertiary butanol: acetic acid: water = 3:1:1) and HOAc (15% acetic acid) as solvents. The dried chromatograms were observed under UV light and also in the presence of ammonia vapor. The colors of spots were recorded and the relative concentrations of spots were estimated subjectively. Voucher specimens were deposited in the herbarium of the Morris Arboretum of the University of Pennsylvania.

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[1] This study was supported by a grant from the Michaux Fund of the American Philosophical Society. Grateful acknowledgment is due to Dr. J. T. Baldwin, Jr., College of William and Mary, Williamsburg, Virginia; Pacific Northwest Forest and Range Experiment Station, Roseberg, Oregon; Pacific Southwest Forest and Range Experiment Station, Arcata, California; Institute of Forest Genetics, Pacific Southwest Forest and Range Experiment Station, Placerville, California; and Pacific Southwest Forest and Range Experiment Station, Redding, California, who supplied us with freshly collected materials.

RESULTS AND DISCUSSIONS

A composite chromatographic pattern of staminate catkins of the 21 species studied is shown in Figure 1. The colors of spots and the occurrences of spots in species are listed in Table 1. The spots with similar colors and similar position on chromatograms are assumed to be the same chemically.

As in the leaves, the phenolic contents of staminate catkins do not seem to constitute a basis for subgeneric division. There are no spots present exclusively in all species of any one of the subgenera while absent in the others, though some spots do have the tendency of being found in one subgenus more frequently or being present in larger quantities. Spots 10 and 11, both appearing pinkish in daylight and probably belonging to anthocyanins, are found exclusively in a few species of red oaks. The spot 12 of red oaks is generally present in larger quantities as compared to those of the two other subgenera. In intermediate oaks, spot 14 is present in much higher concentrations as compared with those of the other subgenera. Spots 28 and 34 are present exclusively in two and four species of white oaks respectively. In general, though no detailed statistical analysis has been made, the distinctions between the phenolic contents of male catkins among

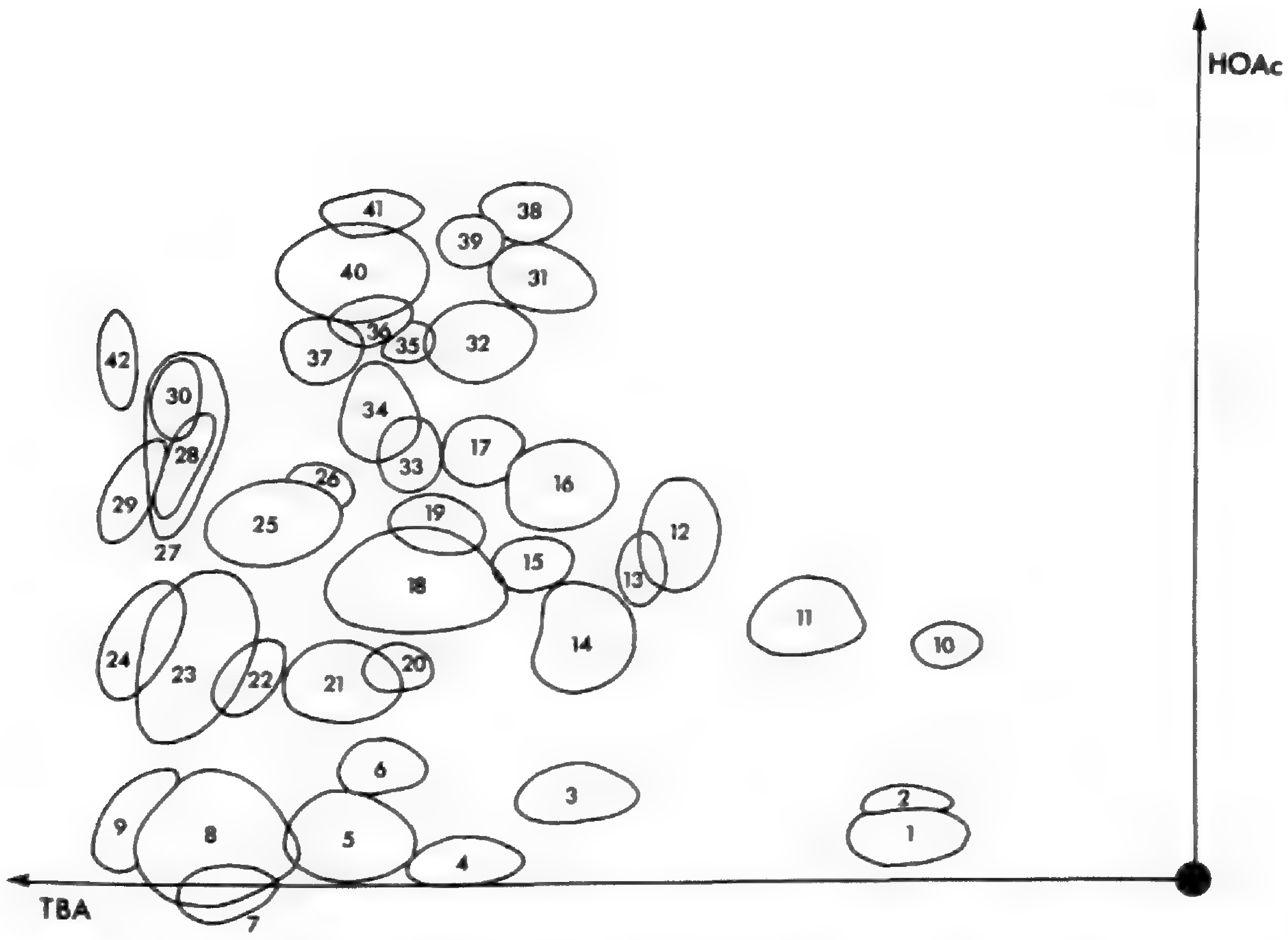

FIG. 1. — A composite chromatographic diagram of the staminate catkins of American oak species.

SERIES	SPECIES	N	COLOR	SPOT NUMBER																																									
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
			UV	dO	lO	lO	lY	YB	YB	dGY	YB	l	P	P	PkO	d	d	d	d	d	d	d	d	YB	d	BY	l	d	l	YB	dG	l	B	YB	d	d	d	d	B	d	d	l	d	B	Y
			UV/NH_3	dGY	PkO	YO	Y	fBY	fGY	GY	fBY	B	P	P	GY	GY	OGY	GY	GY	GY	GY	OBr	GY	fGY	GY	fGY	B	GY	YB	fGY	GY	B	B	B	GY	d	GY	GY	BY	GY	GY	B	BrY	B	Y
WHITE OAKS																																													
Stellatae	*Q. stellata*	1		2	—	—	1	1	2	1	3	1	—	—	1	—	—	—	2	1	5	—	1	1	—	5	2	3	1	2	—	1	1	4	1	—	2	—	—	—	—	—	4	—	—
Albae	*Q. alba*	2		1	—	1	1	3	1	1	4	1	—	—	—	—	1	—	3	2	4	—	1	2	—	5	1	4	—	3	—	1	1	3	3	2	3	—	—	1	1	1	4	1	1
				1	—	1	1	1	2	1	2	1	—	—	1	—	1	—	2	2	5	—	2	1	1	4	1	3	—	2	—	1	—	1	2	—	—	—	—	2	1	—	4	—	—
Macrocarpae	*Q. macrocarpa*	2		1	—	1	1	1	1	1	3	2	—	—	1	1	—	1	2	1	5	—	—	2	—	5	2	3	1	3	—	1	1	2	1	1	1	—	—	—	1	—	4	1	1
				1	—	—	1	1	2	1	3	1	—	—	1	1	—	1	2	—	5	—	—	2	—	5	2	3	1	4	—	1	—	2	1	1	—	1	—	—	1	—	4	1	—
	Q. bicolor	1		1	—	—	1	1	1	1	4	2	—	—	—	—	—	—	4	—	2	3	1	1	1	5	2	5	—	2	—	1	1	1	2	1	—	—	—	2	1	—	4	1	1
Prinoideae	*Q. prinus*	3		2	—	—	2	2	2	1	3	1	—	—	1	1	1	1	1	2	5	—	2	1	1	5	2	2	—	3	—	1	—	1	1	—	2	—	1	—	1	—	4	—	1
				2	—	1	2	2	1	1	4	1	—	—	1	—	2	—	1	3	5	—	2	2	1	5	1	2	1	2	—	1	1	3	1	—	2	—	1	—	1	—	4	1	—
				2	—	1	1	1	2	1	3	2	—	—	1	1	2	1	2	2	5	—	1	—	1	5	2	2	—	2	—	2	2	3	2	—	1	—	1	—	1	1	4	2	—
	Q. muehlenbergii	1		1	—	—	1	2	1	1	4	2	—	—	—	3	—	2	3	1	4	—	—	2	—	5	2	1	1	2	—	1	—	1	3	1	—	—	2	—	1	—	4	—	—
Douglasiae	*Q. douglasii*	2		1	—	—	1	1	1	1	3	1	—	—	1	—	—	1	1	—	5	—	2	1	—	5	1	3	—	1	1	—	1	1	1	—	—	—	—	—	—	1	3	—	—
				1	—	1	1	1	2	1	2	1	—	—	1	—	—	1	1	—	5	—	1	1	—	5	1	3	—	1	1	—	2	1	1	—	—	—	—	—	1	1	2	—	—
Lobatae	*Q. lobata*	3		1	—	—	2	1	2	1	2	1	—	—	1	—	2	1	1	—	5	—	2	1	1	4	1	3	1	—	2	—	—	2	1	—	—	—	—	—	2	1	2	—	—
				1	—	1	2	1	2	1	1	1	—	—	1	—	1	1	2	—	5	—	2	1	1	5	1	4	1	4	—	—	—	1	2	—	—	1	—	—	1	1	3	—	1
				1	—	1	2	1	3	1	2	2	—	—	1	—	2	2	1	—	5	—	2	1	2	4	1	5	1	1	3	—	—	2	1	—	—	1	—	—	1	1	2	—	—
	Q. garryana	3		1	—	—	2	1	1	1	3	1	—	—	2	—	—	1	2	—	5	—	1	1	—	5	1	3	—	1	—	—	—	1	3	—	—	—	—	—	1	—	4	—	—
				1	—	—	2	1	1	2	3	1	—	—	3	—	—	1	1	—	5	—	2	1	—	5	1	3	—	1	—	—	—	1	2	—	—	1	—	—	2	—	4	—	—
				1	—	—	1	1	1	1	2	1	—	—	2	—	—	1	1	—	5	—	2	—	—	5	1	4	—	1	—	—	—	—	2	—	—	—	—	—	—	—	3	—	—
INTERMEDIATE OAKS																																													
Chrysolepides	*Q. chrysolepis*	3		1	1	—	1	2	2	—	5	2	—	—	1	—	5	1	2	—	5	—	2	1	2	3	1	2	—	—	—	—	2	—	1	1	—	—	—	—	—	1	3	2	—
				1	—	1	—	1	1	—	4	2	—	—	1	—	4	1	1	—	4	—	1	—	1	4	1	2	—	—	—	—	2	—	1	1	—	—	—	—	—	1	3	2	—
				1	1	—	1	1	2	—	3	2	—	—	1	—	4	1	1	—	5	—	1	—	—	4	1	3	—	—	—	—	1	—	1	1	—	—	—	—	—	1	3	2	—
	Q. vaccinifolia	3		1	1	1	2	1	2	1	2	1	—	—	—	—	4	1	1	—	5	—	2	1	2	3	1	3	1	2	—	—	3	1	1	1	—	—	—	—	1	—	4	2	—
				1	1	—	1	1	2	1	2	1	—	—	—	—	4	1	1	—	5	—	4	1	2	3	1	2	—	1	—	—	3	1	1	1	—	—	—	—	1	1	3	1	1
				1	1	—	1	1	2	1	3	1	—	—	1	—	4	1	2	—	5	—	3	1	1	5	1	2	1	1	—	—	1	1	1	1	—	—	—	—	1	—	4	1	—
RED OAKS																																													
Agrifoliae	*Q. kelloggii*	2		1	—	—	2	1	1	1	2	1	—	—	1	—	—	2	2	—	5	—	3	1	—	5	1	3	—	3	—	—	2	2	4	1	—	—	—	—	1	—	5	—	—
				1	—	1	1	2	—	1	3	2	—	—	1	—	1	1	2	—	5	—	2	1	—	5	1	3	—	1	—	—	1	2	4	—	—	—	1	—	1	1	4	1	—
	Q. morehus	1		2	—	1	1	—	—	—	—	—	—	—	3	1	3	1	—	—	5	—	2	—	—	—	—	3	—	—	—	—	3	—	—	1	—	—	2	—	—	1	—	2	—
Laurifoliae	*Q. imbricaria*	2		1	1	—	1	1	—	1	4	2	—	1	3	3	—	2	3	—	5	—	1	1	—	4	1	1	—	1	—	1	3	1	2	1	—	1	1	1	1	—	4	2	1
				1	1	—	1	2	—	1	4	1	—	—	3	2	—	3	3	—	5	—	1	2	—	5	1	1	—	3	—	1	1	2	2	1	—	1	1	1	1	—	4	2	—
	Q. phellos	1		1	—	—	1	1	1	2	2	2	—	—	1	—	1	—	3	—	5	2	1	—	1	4	2	4	—	1	—	2	3	2	1	—	—	—	1	—	1	—	4	1	—
Nigrae	*Q. nigra*	2		2	—	—	2	1	1	1	2	1	—	—	5	—	—	1	3	—	5	—	2	1	—	5	2	1	1	3	—	2	2	2	1	—	—	1	1	—	1	—	4	2	1
				3	—	—	2	1	—	1	1	1	—	—	4	—	—	1	2	—	5	—	2	1	—	5	1	1	1	2	—	1	—	1	2	—	—	1	1	—	1	—	4	1	—
Pagodaefoliae	*Q. falcata*	1		3	—	—	1	1	1	—	1	1	—	—	5	1	—	—	2	—	5	—	1	—	—	3	1	2	—	1	—	2	1	3	1	—	—	1	—	—	—	—	4	3	—
Coccineae	*Q. borealis*	3		2	—	—	1	1	1	1	3	1	—	2	1	—	—	—	2	—	4	—	4	1	—	4	1	5	—	1	—	1	2	1	1	2	—	1	1	—	1	—	4	2	—
				2	—	—	—	1	1	1	5	3	—	1	3	—	1	—	3	1	5	—	1	—	1	3	2	3	—	1	—	1	1	1	4	1	—	—	1	—	1	—	4	3	—
				2	—	—	1	2	1	—	2	1	—	—	1	1	—	—	2	—	5	—	1	1	1	4	1	1	—	2	—	1	—	3	1	—	—	1	1	—	1	—	4	1	—
	Q. coccinea	1		2	1	—	1	1	—	1	2	1	—	1	4	—	—	1	2	—	5	—	1	—	—	4	2	1	—	3	—	1	—	1	2	1	—	1	1	—	1	—	3	2	1
Ilicifoliae	*Q. ilicifolia*	2		2	—	—	1	1	1	1	3	1	1	1	3	1	—	—	1	—	5	—	1	1	—	5	1	1	—	1	—	1	2	1	2	—	—	1	1	—	1	—	3	1	—
				1	1	1	1	2	—	1	4	1	1	3	3	1	1	—	3	—	5	—	1	1	—	4	1	1	—	1	—	1	1	1	3	1	—	1	—	—	1	1	4	1	—
Velutinae	*Q. velutina*	1		2	—	1	—	1	1	1	1	1	—	1	3	—	—	—	1	1	5	—	—	—	1	2	1	2	—	2	—	1	2	1	1	—	—	1	1	—	1	—	3	4	—

the subgenera are less clear-cut than the leaf phenolics. As to the variations between species, phenolic characters of staminate catkins seem also to be less variable than leaf phenolic characters. Corresponding to the general situation among morphological characters of plants, the phenolic characters of reproductive organs in oaks seem to be less variable and are in a certain sense more conservative than the phenolic characters of vegetative organs. The same conclusion has been reached in a chemosystematic study of *Platanus* (Hsiao, 1973; Hsiao, 1975). In addition to these general findings, there are several noteworthy points to be discussed below.

In the leaf phenolic study, we proposed that *Q. macrocarpa* and *Q. bicolor* should probably be separated into two different series because their leaf chromatographic patterns are quite different from each other. The present study reinforces that belief because the chromatographic patterns of their staminate catkins are also quite different–having 12 spots present in one of the species but absent in the other.

Series Albae, Macrocarpae, Lyratae, and Prinoideae were treated as members of the section Prinus Loud. by Schwarz (1936). In the previous leaf study we noted that significant differences exist between the chromatographic patterns of the series Prinoideae and those of the three other series. We also noted that the series Prinoideae is not only different from the other series of the section Prinus, it is a rather distinct one among the white oaks because of its possession of several features that are characteristic of the red oaks. No material of the series Lyratae is available to the present study. The present study of staminate catkins does not indicate any major differences between the series Prinoideae and the two other series. However, it is interesting to note the presence of spot 36 in this series. With the exception of Prinoideae, spot 36 has so far been found only in species of the red oaks.

In the series Lobatae, some differences were noted between the leaf phenolics of *Q. lobata* and *Q. garryana*. In the present study, Table 1 indicates that some differences in the phenolic constituents of staminate catkins exist also between these two species.

Quercus chrysolepis and *Q. vaccinifolia* of the intermediate oaks are generally similar in their chromatographic patterns of staminate catkins. No major differences have been found between the intermediate oaks and the other two subgenera except, as noted before, that spot 14 is present in much higher concentrations in the intermediate oaks. Based on its Rfs and colors, spot 14 is probably a flavonoid glycoside.

The results of the earlier leaf study support Muller's treatment (Muller, 1938) in which *Q. kelloggii* was excluded from the series Agrifoliae and, together with

TABLE 1. — List of Species Studied and the Occurrence of Spots.
(Concentration of spots: from 0–5. Abbreviations for colors: B–blue; Br–brown; d–dark; f–fluorescent; G–green; I–invisible; l–light; O–orange; P–purple; Pk–pink; Y–yellow.)

Q. morehus, constitutes his new series called Californicae. No other members of the series Agrifoliae, such as *Q. agrifolia* and *Q. wislizenii,* are available to the present study. The chromatogram of staminate catkins of *Q. morehus* is not only quite different from those of *Q. kelloggii* but also very distinct among all the oak species studied. Since only one specimen of *Q. morehus* is available for this study, we are uncertain as to whether this distinctiveness represents the prevalent condition in *Q. morehus* or whether it may be due to other factors such as poor condition of the specimen collected or improper handling after collecting. This species seems to deserve further investigation.

Quercus phellos was considered to be remotely related to four other species of the series Laurifoliae in the leaf phenolic study (Li and Hsiao, 1973; Li and Hsiao, 1975). Besides other differences, spot 38 is present in the highest concentration in the leaf chromatograms of *Q. phellos* while it is completely undetectable from other members of the series. *Quercus imbricaria* and *Q. phellos* are the only species of the series available in the present study. Spot 19, which is probably equivalent to spot 38 of the leaf chromatograms, is present in the chromatogram of *Q. phellos* but undetectable from that of *Q. imbricaria.* It is not known whether this spot, which is believed to be a flavonoid glycoside, is also present in the staminate catkins of other species of the series.

Quercus ilicifolia is the only member of the series Ilicifoliae (Trelease, 1924). The leaf phenolic study did not indicate any distinctiveness of this species although morphologically it is relatively different from the other species. In the chromatograms of staminate catkins, spot 10 is found exclusively in *Q. ilicifolia;* Spot 11 is present in *Q. ilicifolia* and four other species of red oaks. These two spots, as mentioned before, are believed to be anthocyanins. The presence of these two spots is probably responsible for the reddish color of the staminate catkins of *Q. ilicifolia.*

Quercus velutina was treated as the sole member of the series Velutinae by Trelease (Trelease, 1924). Muller (Muller, 1951) transferred this species to the series Marilandicae. Although both the leaf phenolic study and the present study of staminate catkins do not indicate any noteworthy distinctiveness of this species, in a chromatographic study of young twigs of American oaks (Li and Hsiao, 1976) it is shown that the young twigs of *Q. velutina* possess many flavonoid glycosides in unusually large quantities and are quite different from all other species of American oaks.

General Conclusions

Like leaf phenolics, the phenolics of staminate catkins of American oaks do not seem to constitute a basis for subgeneric divisions. Within the genus, the phenolic characters of the staminate catkins seem to be much less variable than those of the leaves, a phenomenon similar to the situation in the morphological characters.

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A PRELIMINARY STUDY OF THE CHEMOSYSTEMATICS OF AMERICAN OAKS: PHENOLIC CHARACTERS OF YOUNG TWIGS [1]

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The phenolic chromatographic patterns of the leaves and staminate catkins of a number of species of American oaks have been studied by us before (Li and Hsiao, 1973; 1975; 1976). Attempts were made to correlate the distributions of these phenolic characters among oak species with previous systematic treatments based chiefly on external morphology. The results of these studies indicate that though the distributions of phenolic constituents do not constitute a basis for subgeneric divisions in oaks the study of these characters are sometimes of some value in interpreting relationships at lower taxonomic hierarchies such as series and sections. Many phenolic characters, especially those of male catkins, are present in all or most of the species studied. This seems to reinforce the belief that oak species as a whole constitute a coherent group. Schwarz's treatment (Schwarz, 1936) in which *Macrobalanus* (a group of large-fruited white oaks) and *Erythrobalanus* (red oaks) were raised to the generic level does not receive any support from this study of their phenolic characters. The variabilities of phenolic characters, both within and between species of oaks, are found to be greater for leaves than for staminate catkins. This finding coincides with the situation as found among morphological characters. More studies on variations among these characteristics need to be made before phenolic characters can be fully employed in systematic interpretations. As a part of our preliminary chemosystematic investigation of American oaks, we report in the present article the results of a chromatographic study of the young twigs of a number of oak species native to the United States.

MATERIALS AND METHODS

Young twigs of two seasons' growth were used. The twigs were either freshly collected from the Michaux Quercetum of the Morris Arboretum or received from other institutions. The freshly collected twigs were air dried and then ground

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into fine powders. One gram of each ground material was extracted with 6 ml. of 90% aqueous methanol for one day and then spotted on a Whatman 3MM chromatographic paper (46 × 57 cm). TBA (tertiary butanol: acetic acid: water = 3:1:1) and HOAc (15% acetic acid) were used for the developments of two-dimensional chromatograms. The chromatograms were observed under UV light alone and in the influence of ammonia vapor. The concentrations of spots were estimated subjectively. The twigs of several species were separated into bark and wood portions. These portions were chromatographed separately in order to determine the differences between the phenolics of bark and wood. One year to four year old twigs of a plant of *Quercus alba* (Morris Arboretum #MQ 213) were chromatographed separately in order to investigate the developmental changes of these chemical characters.

RESULTS AND DISCUSSIONS

A composite chromatographic pattern and a list of the occurrences of spots in the species studied are shown in Figure 1 and Table 1 respectively.

The results of the study on developmental changes indicate that, among the plants studied, spots 3, 14, 35, and 46 decrease slightly in concentration along with the increase of age. Otherwise, the phenolic compositions of oak twigs remain rather stable from the first year growth to the four year old twigs. Since

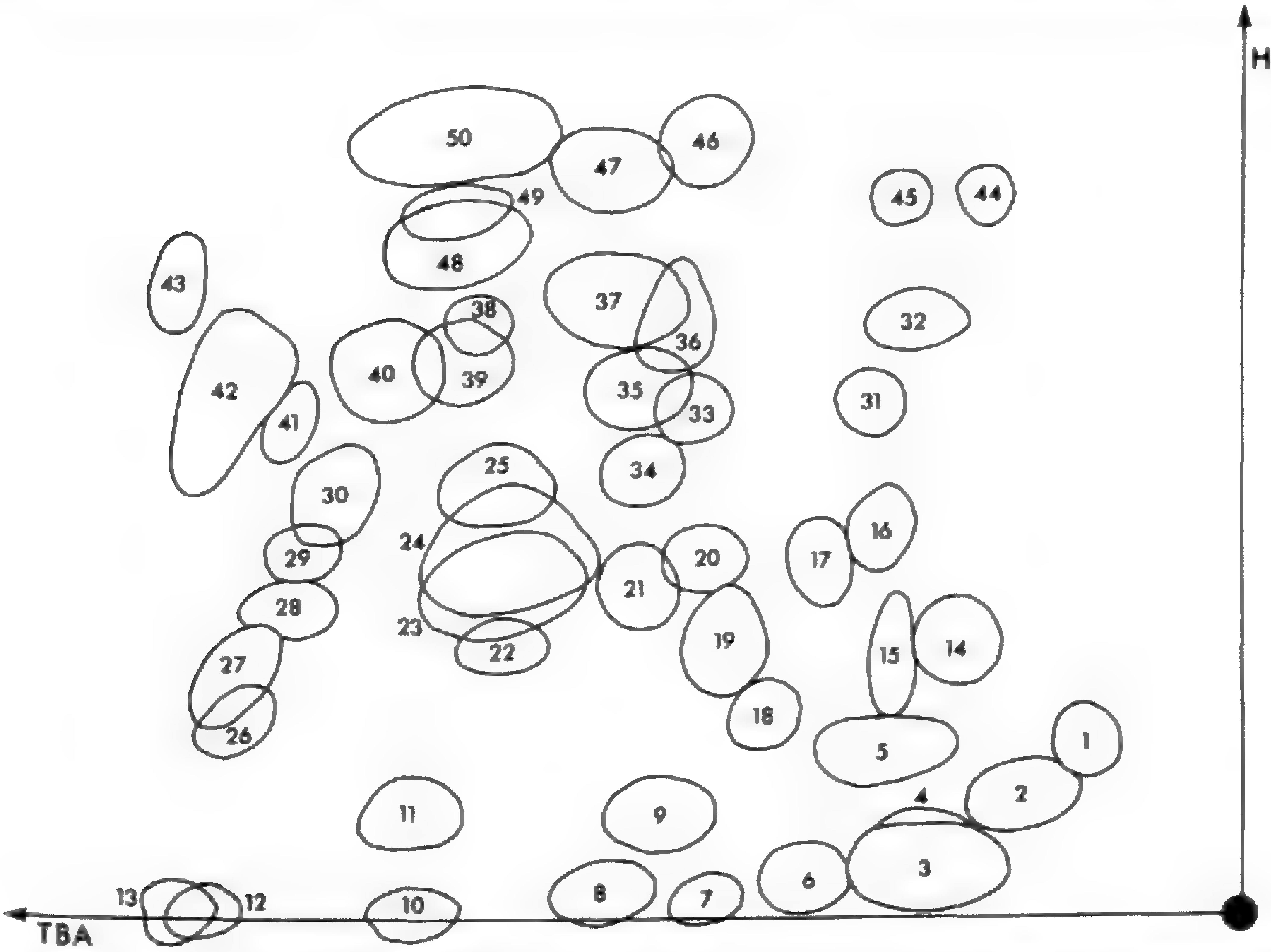

FIG. 1. — A composite chromatographic diagram of the young twigs of American oak species.

TABLE 1. — List of Species Studied and the Occurrence of Spots. (Concentration of spots: from 0–5. Abbreviations for colors: B–blue; Br–brown; d–dark; f–fluorescent; G–green; I–invisible; l–light; O–orange; P–purple; Pk–pink; Y–yellow.)

SERIES	SPECIES	N=	COLOR	SPOT NUMBER																								
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
			UV	d	d	dO	lO	d	DO	d	YB	fGY	B	fGY	d	l	d	YB	B	YO	O	d	d	l	d	l	d	d
			UV/NH$_3$	dGY	dGY	dGY	PkO	dGY	dGY	dBr	fBY	fOY	fY	YO	O	B	dGY	YB	B	OGY	BGY	GY	GY	fGY	GY	YB	GY	OGY
WHITE OAKS																												
Virentes	*Q. virginiana*	3		---	122	334	---	233	---	--1	---	111	-1-	---	---	---	-2-	1--	112	313	---	21-	---	-11	---	12-	31-	---
	Q. minima	1		-	2	4	-	2	-	-	-	1	-	-	-	-	-	1	1	1	-	2	-	-	-	1	1	-
Stellatae	*Q. stellata*	6		--- ---	--1 111	422 424	--- ---	111 -2-	--- ---	--- 1-1	--- ---	11- 1--	--- 1--	4-1 4-3	--- ---	--- ---	--- ---	2-- 1--	121 222	3-- 2-3	--- 1-1	--- ---	--- ---	112 313	--- ---	111 111	11- 1-1	--- ---
Albae	*Q. alba*	4		--- 0-	211 0-	114 02	-1- 0-	21- 0-	--- 0-	--- 0-	--- 0-	131 0-	--- 0-	--- 03	--- 0-	111 0-	-2- 0	1-- 0	-11 0	--3 01	--1 02	5-2 02	--- 0-	121 01	--- 0-	332 01	463 01	--- 0-
Lyratae	*Q. lyrata*	3		---	-11	112	---	213	---	---	---	---	---	---	---	---	---	---	--1	---	---	-22	---	--1	---	332	-11	---
Macrocarpae	*Q. macrocarpa*	3		---	-11	311	---	111	---	1--	-11	11-	---	3-1	---	---	---	1--	111	2--	---	-11	--1	211	---	212	-11	---
	Q. bicolor	3		---	111	111	---	111	---	---	1--	---	---	---	---	---	---	---	1--	---	---	112	--1	11-	-12	222	122	---
Prinoideae	*Q. prinus*	3		---	---	132	11-	11-	---	---	-4-	--1	11-	11-	---	---	21-	---	---	---	1--	232	---	---	---	222	332	---
	Q. muehlenbergii	2		--	11	21	--	11	-1	-3	34	1-	--	--	--	13	--	11	11	23	--	--	21	--	--	22	11	--
	Q. prinoides	2		--	-1	33	--	11	--	--	23	--	--	--	--	--	--	22	1	21	--	--	1	1-	--	-1	11	--
Dumosae	*Q. dumosa*	2		11	21	43	--	21	--	2-	--	11	--	--	--	--	--	-1	11	22	--	24	--	--	1-	--	13	--
Douglasiae	*Q. douglasii*	2		11	11	34	1-	11	--	--	--	1-	--	2-	--	--	--	1-	11	23	--	41	--	-1	--	--	31	--
Sadlerianae	*Q. sadleriana*	1		1	1	3	-	1	-	3	-	1	-	-	-	-	-	-	2	1	-	-	-	-	-	-	3	-
Lobatae	*Q. lobata*	6		-11 11-	111 111	342 222	--- ---	333 233	--- ---	--- ---	--1 11-	112 121	--1 11-	112 -2-	--- ---	--- ---	--1 11-	--- ---	221 121	331 111	--- ---	121 211	--- ---	1-- -11	--- ---	1-1 111	-11 1--	--- ---
	Q. garryana	3		-11	-1-	444	---	132	3-2	-11	---	-1-	---	--1	---	1--	-11	1--	221	422	---	332	--1	111	1--	---	212	---
Oblongifoliae	*Q. engelmannii*	1		-	1	4	-	3	-	1	1	-	1	2	-	1	-	2	1	1	-	4	-	1	-	-	3	-
INTERMEDIATE OAKS																												
Chrysolepides	*Q. chrysolepis*	6		--- ---	221 221	342 141	--- ---	231 232	--- ---	--- ---	--- ---	-11 1-1	--- ---	111 ---	--- ---	--- ---	122 111	-- ---	121 111	221 231	--1 1--	234 322	212 21-	--- ---	--- ---	-1- 1-1	335 322	-- --
	Q. vaccinifolia	4		--- -	111 1	322 2	--- -	1-- 1	--- -	--- -	--- -	1-- -	--- -	--1 -	--- -	--- -	-1- 1	--- -	1-1 1	2-- -	222 2	544 4	--- -	1-- 1	222 -	-11 2	544 3	--- -
RED OAKS																												
Agrifoliae	*Q. kelloggii*	5		-11 1-	222 22	543 33	--- --	121 22	--- --	-11 1-	--- 1-	-1- 11	--1 1-	--- --	--- --	--- --	--1 11	--- --	321 21	321 21	111 11	433 44	--- --	11- --	1-- 11	--- --	211 34	--- --
	Q. morehus	1		1	3	2	-	1	-	1	-	1	-	1	-	-	1	-	2	1	2	2	-	1	-	-	3	-
	Q. wislizenii	1		1	2	4	-	-	-	-	-	1	-	2	-	-	-	1	1	2	1	2	-	2	-	-	1	-
	Q. agrifolia	1		-	1	3	-	1	-	-	-	-	-	-	-	-	-	3	1	2	1	-	-	2	-	-	-	-
Laurifoliae	*Q. imbricaria*	3		---	111	2-1	---	--1	---	---	111	1-	111	---	--1	---	---	---	111	1--	1--	---	---	1-1	---	123	11-	---
	Q. laurifolia	3		---	111	132	---	11-	---	---	211	-11	-11	211	---	---	---	---	111	123	1-1	23-	---	111	-1-	212	111	--
	Q. phellos	3		---	---	-21	---	1-1	---	-1-	212	11-	11-	111	3-3	---	---	-1-	111	121	111	312	---	-2-	---	111	-	444
	Q. incana	1		-	2	3	1	-	-	2	2	2	3	1	-	-	-	-	1	1	-	1	-	-	-	2	3	-
Nigrae	*Q. nigra*	6		--- ---	1-1 1--	412 311	--- ---	--- ---	--- ---	--- ---	223 111	-1- -1-	112 111	222 211	-22 21-	--- ---	--- ---	1-1 1--	1-1 121	31- 1--	113 111	321 112	--- ---	22- 121	--- ---	211 221	111 111	-- ---
Palustres	*Q. palustris*	3		---	1--	311	-11	1--	---	---	1-1	11-	-1-	1--	---	---	---	1--	111	2--	---	1-2	---	1--	---	221	13-	---
Marilandicae	*Q. marilandica*	2		--	12	44	--	11	--	2-	11	11	--	11	--	--	--	1-	11	23	-1	--	--	-1	--	31	--	-
	Q. laevis	1		-	1	3	-	-	1	-	2	1	-	1	-	-	-	1	1	2	2	2	-	-	-	1	-	-
Pagodaefoliae	*Q. falcata*	2		--	1-	31	--	1-	--	--	22	1-	11	21	--	--	--	--	2-	2-	1-	-1	--	11	--	22	--	--
Coccineae	*Q. shumardii*	2		-1	--	32	--	--	--	--	21	21	1-	4-	--	--	1-	2-	11	21	11	-3	--	21	--	--	12	--
	Q. borealis	4		--- -	--- 1	-21 3	--- -	--- -	--- -	--- -	121 2	111 1	122 1	111 1	--- -	--- -	--- -	--- -	-1- 1	--- 2	--- -	-51 1	--- -	--- -	-4- -	1 2 -	13- 2	--- -
	Q. coccinea	2		--	11	22	--	22	--	--	--	11	-2	--	--	--	--	--	2-	--	--	1-	--	-1	--	-1	22	--
	Q. ellipsoidalis	1		-	2	1	-	-	-	-	2	1	2	-	2	-	-	-	2	-	-	1	-	-	1	3	-	-
	Q. nuttallii	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	1	-	-
Ilicifoliae	*Q. ilicifolia*	2		--	--	11	--	1-	--	--	32	11	--	11	22	--	--	--	--	--	11	1-	--	11	--	23	--	--
Velutinae	*Q. velutina*	4		--- -	--- 1	123 2	113 1	11- -	--- -	--- -	--3 3	666 4	-1- -	--- 2	--- -	--- -	--- -	--- -	--1 1	--- 1	--- 1	563 4	--- -	--- -	564 4	--- -	555 5	--- -

only two year old twigs are used in the present comparative chemosystematic study, the probability of experimental error due to developmental changes is probably not great.

Young twigs of *Q. chrysolepsis, Q. kelloggii, Q. laevis, Q. minima, Q. vaccinifolia,* and *Q. virginiana* had been separated into wood and bark portions to study the chemical differences between these plant-parts. The results indicate that in young twigs spots 19, 24, and 35 are present in the bark portion but absent or present only in trace amounts in the wood portion. These spots are probably

TABLE 1. (Continued) — List of Species Studied and the Occurrence of Spots. (Concentration of spots: from 0-5. Abbreviations for colors: B–blue; Br–brown; d–dark; f–fluorescent; G–green; I–invisible; l–light; O–orange; P–purple; Pk–pink; Y–yellow.)

																								SPOT NUMBER				
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	COLOR			
I	B	d	I	d	I	fY	YO	B	d	PkO	B	d	d	B	YB	B	Y	d	B	B	BY	d	B	B	UV			
OY	B	G	B	YG	B	OY	dGY	B	GY	fGY	B	dGY	d	B	YB	B	Y	d	B	B	BY	d	B	B	UV/NH₃	N=	SPECIES	SERIES
																											WHITE OAKS	
- - -	- - -	- - -	1-1	- - -	- - -	11-	- - -	-21	- - -	- - -	11-	- - -	242	- - -	-4-	454	-11	- - -	111	1-2	121	- - -	131	363			*Q. virginiana*	*Virentes*
- - -	-	-	-	1	-	1	-	-	-	-	-	-	2	-	-	3	1	-	1	2	1	-	1	3			*Q. minima*	
11- - - -	- - - 11-	31- 1- -	- - - - - -	14- 32-	- - - - - -	- - - - - -	-11 -1-	- - - -1-	- - -	555 555	231 11-	- - - - - -	133 232	1- - - - -	-11 111	433 434	111 111	- - - -	1- - 1-1	133 222	121 232	-1- 1- -	111 121	244 444			*Q. stellata*	*Stellatae*
-11 -	- - - 1	2-1 -	- - - -	121 3	1- - -	- - - -	- - -	12- -	22- 3	- - - -	144 5	- - - -	432 3	111 -	11- 1	555 4	111 1	- - - -	111 1	31- 2	434 3	431 -	12- 1	555 5			*Q. alba*	*Albae*
- - -	- - -	- - -	- - -	- - -	- - -	111	- - -	- - -	123	112	- - -	- - -	334	- - -	112	221	- - -	- - -	1	434	1-1	- - -	111	333			*Q. lyrata*	*Lyratae*
1- -	- - -	- - -	- - -	-1-	-11	- - -	-1-	-1-	- - -	3-3	- -2	- - -	333	111	-21	412	111	- - -	- -1	122	142	- - -	121	213			*Q. macrocarpa*	*Macrocarpae*
- - -	- - -	- -2	- - -	211	- - -	- -2	2- -	1- -	1-2	- - -	1- -	- - -	324	- - -	1-1	122	111	- - -	11-	223	222	- - -	311	112			*Q. bicolor*	
- - -	- - -	221	- - -	- - -	- - -	- - -	- - -	111	32-	- - -	324	- - -	445	-11	221	555	111	- - -	-11	1- -	445	- -5	11-	556			*Q. prinus*	*Prinoideae*
- -	- -	- -	22	11	- -	- -	- -	- -	22	- -	1-	- -	12	- -	- -	54	11	- -	11	11	22	-1	11	23			*Q. muehlenbergii*	
- -	- -	- -	12	-1	- -	- -	- -	- -	21	- -	- -	- -	11	- -	- -	54	-1	- -	11	11	12	- -	11	31			*Q. prinoides*	
- -	- -	12	- -	31	- -	- -	- -	11	1		- -	- -	21	12	11	25	11	- -	11	32	32	- -	11	22			*Q. dumosa*	*Dumosae*
- -	- -	- -	1-	- -	- -	- -	- -	2-	- -	- -	- -	1-	21	1-	21	52	11	- -	11	21	32	- -	21	21			*Q. douglasii*	*Douglasiae*
-	-	-	-	3	-	-	-	1	-	-	1	-	1	-	-	3	-	-	1	3	1	1	-	3			*Q. sadleriana*	*Sadlerianae*
- - - - - -	- - - - - -	- - - - - -	-1- - -1	- - - - - -	- - - - - -	- - - - - -	- - - - - -	2-1 1-1	- - - - - -	- - - - - -	1-1 -11	11- - - -	113 221	1-1 111	112 212	322 343	1-1 221	- -1 111	- -1 111	223 232	224 333	- - - -	112 212	214 335			*Q. lobata*	*Lobatae*
3-2	1- -	- - -	- - -	2-1	- -	- - -	- - -	22-	- -1	- - -	413	- - -	122	-2-	12-	423	11-	- - -	-11	422	12-	- - -	121	433			*Q. garryana*	
-	-	-	1	-	-	-	-	2	-	-	-	1	3	1	2	5	1	-	-	2	2	-	1	2			*Q. engelmannii*	*Oblongifoliae*
																											INTERMEDIATE OAKS	
- - - - - -	- - - - - -	1-1 1- -	-1- -1-	1-1 1-1	- - - - - -	- - - -	- - - - - -	-1- - -1	- - - - - -	- - - -	- - - - - -	- - - -	222 312	121 1-1	11 1-1	245 435	111 111	121 111	1- - - 1	232 213	132 323	- - - - - -	12- -11	345 545			*Q. chrysolepis*	*Chrysolepides*
- -2 -	- - - -	211 1	- - - 1	111 1	- - - -	- - - -	- - - -	- - - 1	- - - 1	- - - -	- -2 -	-1- -	122 2	331 3	- -1 -	324 4	111 2	-11 -	- - - 1	211 -	233 3	4-3 -	1- -	332 4			*Q. vaccinifolia*	
																											RED OAKS	
- - - - -	- -1 -1	- - - - -	- - - - -	1- - -1	- - - - -	11- 11	- - - - -	212 32	111 22	- - - - -	11- 11	1- - - -	212 11	1- - - -	1-3 21	433 33	212 11	- -1 1-	111 11	321 22	223 33	- - - - -	213 21	433 44			*Q. kelloggii*	*Agrifoliae*
-	4	-	-	-	-	2	-	-	-	-	1	-	1	-	1	2	1	1	2	3	3	-	3	5			*Q. morehus*	
-	2	-	-	1	-	1	-	1	-	-	2	2	-	-	1	2	-	-	1	2	2	-	1	1			*Q. wislizenii*	
-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	3	2	-	2	3	-	-	1	2			*Q. agrifolia*	
131	2- -	- - -	1- -	3-1	- - -	-12	- - -	- - -	1- -	- - -	-43	- - -	343	- - -	111	312	11-	- - -	1-1	213	111	- - -	121	343			*Q. imbricaria*	*Laurifoliae*
- - -	- - -	- - -	12-	-11	- - -	- - -	- - -	11-	- -1	- - -	124	- - -	211	1- -	1- -	232	-11	- - -	111	422	334	- - -	111	333			*Q. laurifolia*	
- - -	2-3	- - -	- - -	442	- - -	- - -	- - -	1-1	- - -	- - -	415	- - -	212	526	- - -	121	111	- - -	11-	111	221	- - -	212	434			*Q. phellos*	
-	-	3	-	5	-	1	-	1	-	-	1	-	2	-	-	3	1	-	1	2	4	-	1	4			*Q. incana*	
- - - - - -	231 233	- - - - - -	- - - - - -	2-1 1- -	1-1 - - -	-1- -21	- - - - - -	- - - 12-	- - - - - -	- - - - - -	353 456	- - - - - -	132 233	1-1 1- -	2- - 21-	323 322	1-1 11-	- -1 - - -	111 111	122 123	314 222	- - - - - -	111 131	332 343			*Q. nigra*	*Nigrae*
1- -	13-	- - -	1- -	4- -	- - -	-21	- - -	-11	- - -	- - -	-11	- - -	343	566	-1-	211	111	- - -	111	3-2	32-	- - -	121	332			*Q. palustris*	*Palustres*
- -	- -	- -	- -	11	- -	-1	- -	1-	- -	- -	31	- -	22	21	- -	53	21	- -	11	12	33	- -	12	43			*Q. marilandica*	*Marilandicae*
-	1	-	-	-	-	1	-	1	-	-	2	-	1	1	1	3	1	-	1	1	4	-	1	5			*Q. laevis*	
- -	- -	- -	1-	11	- -	-2	- -	11	- -	- -	- -	- -	36	- -	1-	22	-1	- -	1-	32	21	- -	22	42			*Q. falcata*	*Pagodaefoliae*
- -	23	- -	1-	11	- -	-1	- -	11	- -	- -	-5	- -	11	- -	11	43	11	- -	11	13	23	- -	33	33			*Q. shumardii*	*Coccineae*
- - - -	3- - -	-2- -	- - - 1	11- 1	- -1 -	1-2 -	- - - -	1-1 1	-1- 1	- - - -	5-1 -	- - - -	324 2	-11 1	- - - 2	113 3	111 1	- - - -	- -1 1	232 2	1-2 2	- - - -	223 2	334 3			*Q. borealis*	
- -	- -	- -	- -	- -	- -	21	1-	2-	- -	- -	- -	- -	23	- -	21	21	1-	- -	- -	23	1-	- -	21	42			*Q. coccinea*	
-	-	-	1	-	-	1	1	1	-	-	3	-	4	1	-	2	1	-	1	4	1	-	-	2			*Q. ellipsoidalis*	
-	2	-	-	1	-	1	-	1	-	-	1	-	3	5	1	1	1	-	-	-	2	-	1	2			*Q. nuttallii*	
- -	12	- -	- -	12	11	- -	-2	- -	- -	- -	43	- -	33	11	21	22	11	- -	11	23	32	- -	12	33			*Q. ilicifolia*	*Ilicifoliae*
- - - -	- - - -	443 4	- - - -	443 3	- - - -	2-2 -	- - - -	- - - 1	232 2	- - - -	- - - 2	322 2	434 2	- - - -	- - - -	-22 1	-11 1	- - - -	- -1 1	24- 1	- -1 3	- - - -	22- 1	443 3			*Q. velutina*	*Velutinae*

flavonoid glycosides as they appear dark in UV light and turning yellowish in the presence of ammonia vapor. Spots 3, 16, 17, 23, 39, 42, 45, 46, 48, 49, and 50 are found in both the bark and wood portions. With the limited number of species studied the distributions of other spots are not very conclusively demonstrated.

In Table 1, the oak species studied are arranged into series and subgenera according to Trelease's system (Trelease, 1924). Based on the availability of fresh materials, one to six twig samples were studied for each species. From

Table 1 we note that there are no major differences existing among the three subgenera recognized. A detailed study of each of the spots indicates that several of these spots are found in some subgenera more often than in others. For example, spot 12 is found exclusively in four species of red oaks. Spots 13 and 36 are only observed in five and three species of white oaks respectively. Both spot 20 and 48 are present exclusively in five species of white oaks and one species of intermediate oaks. Spots 27 and 32 are found to occur in red oaks more frequently. As in the staminate catkins, the divergence in twig phenolics between the three subgenera seems rather little. Phenolic characters of twigs alone do not warrant any subgeneric divisions. Many spots such as spots 3, 39, 42, 46, 47, and 50 are present in all or most of the species studied. This strengthens the belief that all members of *Quercus* belong to a coherent taxonomic group. Among the phenolic characters of leaves, staminate catkins, and young twigs, the differences between the three subgenera seem to be greater in the leaf than in the other two plant-parts.

Within series Virentes, some significant differences have been observed between the leaf phenolics of *Q. virginiana* and *Q. minima*. However, in the present study of young twigs, these two species are found to be generally similar to each other in their chromatographic patterns of twigs.

Quercus stellata constitutes the monotypic series Stellatae. The unusually high concentration of spot 36 is very characteristic to this species. Spot 36 is present in high concentration in all specimens of *Q. stellata* studied. Besides *Q. stellata,* this spot is present in much smaller amount in some twigs of *Q. lyrata* and *Q. macrocarpa.*

Quercus alba, the only member of the series Albae, has been noted to be very variable in its phenolic characters of leaves. The same situation exists in the present study of the phenolics of young twigs. The distributions of many spots, especially spots 11, 17, 19, 46, and 48, are very variable within the species. These findings seem to indicate the greater genetic variability of this species. It is apparently worthy to further investigate in greater detail the variation of phenolic characters within this species and to determine whether this variation of phenolic characters has any correlation with disease resistance of the species. This kind of study may be of some sylvicultural significance.

Quercus macrocarpa and *Q. bicolor* of the series Macrocarpae have shown some difference between them in their phenolic characters of leaves and staminate catkins. Table 1 shows that in the phenolics of twigs these two species also possess rather different compositions. Thirteen spots are found to exist in one of the species but absent from the other. These findings reinforce our previous proposition that these species should probably be separated into two different series.

Within the series Prinoideae, *Q. muehlenbergii* is generally similar to *Q. prinoides* in twig phenolics. *Quercus prinus* is relatively isolated from these two species so far as the phenolics of young twigs are concerned, a situation not found in our earlier leaf and staminate catkin studies. In the previous leaf study, some characteristics of the series Prinoideae were shown to resemble those of the red oaks. In the present study, spot 8 is present in higher concentrations in the series Prinoideae and some species of the red oaks. Spot 8 of twig chromatograms is probably equivalent to spot 5 of leaf chromatograms. The latter is also present in larger quantities in the Prinoideae and species of red oaks.

Quercus sadleriana of California, the only member of the series Sadlerianae, is quite distinct in external morphology, especially in the leaves. The leaf phenolic study has also shown some distinctive features of this species. In the twig chromatograms of *Q. sadleriana,* out of the fifty spots in Table 1, only nineteen spots are found to be present. Some spots such as spot 49, found in most species studied, are undetectable from *Q. sadleriana.*

Quercus lobata differs to some extent from *Q. garryana* in the phenolics of leaves and staminate catkins. In the present study of young twigs we also note some differences between these two species especially with regard to spots 6, 23, 26, 30 and 44. However, it is interesting to note that morphologically these two species are very closely related. It is not certain whether this discrepancy between morphology and chemistry is due to some other factors such as small sample size.

Within intermediate oaks, *Q. chrysolepis* and *Q. vaccinifolia* are found to be generally similar in their twig chromatograms. Some minor differences do exist between these two species, especially in spots 20, 22, and 48.

Four species of the series Agrifoliae are available to the present study. Among these four species, *Q. kelloggii* and *Q. morehus* are relatively different from *Q. wislizenii* and *Q. agrifolia* especially regarding spots 6, 14, 15, 23, and 37. As in the previous leaf study, data on twig phenolics support Muller's treatment (Muller, 1938) in which *Q. kelloggii* and *Q. morehus* were excluded from the series Agrifoliae.

In our previous leaf study (Li and Hsiao, 1973; 1975) we proposed that *Q. phellos* should probably be excluded from the series Laurifoliae. Table 1 shows that *Q. phellos* also differs in several respects from the other members of Laurifoliae in twig phenolics. Spot 25, which is probably equivalent to spot 38 of leaf chromatograms, is found exclusively in the twig chromatograms of *Q. phellos* and is undetectable from all other species studied. Spot 24 is present in other members of the series Laurifoliae but undetectable from *Q. phellos.* Spot 40 is generally found in *Q. phellos* in high concentrations but undetectable or present in only trace amounts in other species of the series. These findings strengthen our belief that *Q. phellos* is diverged from other species of the series Laurifoliae to such an extent that this species should probably be excluded from the series.

Quercus nigra of the series Nigrae resembles generally the species of series Laurifoliae in twig chromatographic patterns, with the exception of *Q. phellos.* The results of the present study, together with those of the previous leaf study, support Muller's treatment (Muller, 1951) in which *Q. nigra* was treated as a member of the series Laurifoliae.

Quercus marilandica was found to differ to some extent from *Q. laevis* in leaf phenolics. However, in the present study of young twigs we noted that the two are generally similar to each other in the chromatographic patterns of twigs. Morphologically, these two species are closely related.

As in the leaves, the phenolic characters of young twigs are relatively variable among species of the series Coccineae. Further study is needed in order to classify species of this series in a more natural arrangement. Although *Q. nuttallii* of this series was treated as a form of *Q. palustris* by Muller (1942), the two are found to be rather different from each other in their chromatographic patterns of young twigs. *Quercus palustris* is usually placed in the series Palustres. However, it should be mentioned that only one specimen of *Q. nuttallii* (Morris Arboretum #MQ287) is available to the present study.

Quercus velutina, the black oak, is the sole member of the series Velutinae. Previous studies on the phenolics of leaves and staminate catkins did not reveal any major distinctiveness of this species. However, in the present study of young twigs, *Q. velutina* is found to be very different from all other species studied. Many spots, such as spots 9, 19, 22, 24, 28, and 30, are present in such unusually high concentrations in *Q. velutina* that it is possible to identify this species based solely on its chromatographic patterns of twigs. We should mention here that due to the "concentration drift" of the Rf-values of spots it is impossible to determine the spot number of each spot on the chromatograms of *Q. velutina* by directly comparing the Rf-values of each spot to those of the other species. Many phenolics have higher Rf-values when higher concentrations are used for the chromatographic study. Instead of Rf-values, the relative position of each spot is more important for the determination of spot numbers, though the definite proof relies on chemical identifications. Most of the large spots of *Q. velutina* are believed to be flavonoid glycosides because they appear dark in UV light and turn yellowish under the influence of ammonia vapor. Since, as noted before, most flavonoid glycosides are present in the bark portions of twigs, the bark of black oaks seems to be a good commercial source of some flavonoids.

General Conclusions

As in the staminate catkins, the distinctions between the three subgenera of oaks for the phenolics of young twigs seem to be very small. Like morphological characters, the phenolic characters of different plant organs of oak species are not necessarily evolving in the same direction. All plant organs, therefore, should be considered together for the estimation of the over-all phenetic relationships between species of oaks.

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RARE PLANTS OF SOUTHEASTERN PENNSYLVANIA

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As there is now much interest in the native plants which are so rare in individual areas that their extinction is threatened in those areas, the following list of the taxa in the nine local flora counties (Northampton to Lancaster) has been compiled from the Pennsylvania Flora records filed at the Morris Arboretum, representing the sheets in the State's five major herbaria–Academy of Natural Sciences and University of Pennsylvania (Philadelphia), State Department of Agriculture (Harrisburg), Pennsylvania State University (University Park) and Carnegie Museum (Pittsburgh). Taxa known in four or less counties are classed as so rare as to be threatened; some which have eluded recent search may indeed now be extinct here.

The primary arrangement is systematic, according (with minor deviations) to that of Gray's Manual, ed. 8, 1950. Under each family, however, it is alphabetical, to facilitate locating individual taxa. The nomenclature is that to be used in the forthcoming Pennsylvania Flora; while based on that of Gray's Manual it is updated in accord with subsequent taxonomic research.

Counties in parentheses are those outside the nine county southeastern Pennsylvania area.

PTERIDOPHYTES

ISOETACEAE: *Isoëtes dodgei* (Pike) Lehigh, Bucks, Phila.

POLYPODIACEAE: *Adiantum pedatum* v. *aleuticum* Chester, Lancaster. *Asplenium bradleyi* (Carbon) Lancaster (York); × *gravesii* Lancaster (York); *platyneuron* f. *hortonae* Lehigh, Bucks, Lancaster (York); *platyneuron* v. *incisum* Lehigh, Montgomery, Delaware; *ruta-muraria* v. *subtenuifolium* Bucks; × *trudellii* Chester, Lancaster (York). *Dryopteris* × *neowherryi* Northampton, Berks (Allegheny). *Thelypteris palustris* v. *haleana* Chester.

MONOCOTYLEDONS

TYPHACEAE: *Typha glauca* Northampton, Lehigh, Lancaster.

SPARGANIACEAE: *Sparganium androcladum* Lehigh, Bucks, Phila., Lancaster.

ZOSTERACEAE: *Potamogeton alpinus* v. *tenuifolius* Northampton, Bucks; *confervoides* (Carbon) Lehigh, Bucks; *filiformis* v. *borealis* Lehigh (York, Huntingdon, Erie); *friesii* Northampton, Lehigh (Centre, Crawford); *porteri* Lancaster (Bedford); *pulcher* (Pike) Bucks (Crawford); *vaseyi* Lehigh, Phila. (Lycoming, Crawford).

ALISMATACEAE: *Lophotocarpus spongiosus* Bucks. *Sagittaria eatoni* Bucks, Delaware; *subulata* v. *subulata* Bucks, Phila., Delaware; *subulata* v. *gracillima* Bucks.

GRAMINEAE: *Agropyron trachycaulum* v. *novae–angliae* (Luzerne, Carbon) Lehigh; *trachycaulum* v. *unilaterale* Lehigh (Huntingdon). *Agrostis altissima* Montgomery — Extinct —. *Alopecurus carolinianus* (Lackawanna) Phila. *Echinochloa walteri* Bucks, Phila.; *walteri* f. *laevigata* Delaware. *Elymus virginicus* v. *glabriflorus* Lancaster. *Erianthus saccharoides* Bucks, Phila., Chester. *Festuca paradoxa* Chester, Lancaster (Venango). *Glyceria obtusa* (Monroe) Delaware. *Gymnopogon ambiguus* Lancaster. *Leptoloma cognatum* (Monroe) Berks, Phila., Chester. *Muhlenbergia capillaris* Lancaster; *curtisetosa* Northampton, Delaware; *uniflora* (Luzerne) Phila. (Sullivan). *Panicum amarulum* Bucks; *annulum* Bucks, Delaware, Chester, Lancaster; *calliphyllum* Berks; *commonsianum* v. *addisonii* Phila.; *longiligulatum* Bucks; *recognitum* Montgomery, Chester, Lancaster; *scoparium* Bucks, Delaware, Chester; *spretum* Bucks. *Paspalum floridanum* v. *glabratum* Lancaster; *psammophilum* Bucks, Montgomery, Phila.; *setaceum* Lehigh, Berks, Bucks, Phila. *Poa autumnalis* Berks, Bucks, Phila. *Sphenopholis pallens* Northampton, Lehigh, Chester. *Sporobolus heterolepis* Chester, Lancaster. *Triplasis purpurea* Bucks, Phila. (Erie). *Uniola latifolia* Chester, Lancaster (Bedford); *laxa* Bucks, Phila., Delaware.

CYPERACEAE: *Carex* × *aestivaliformis* (Monroe) Phila. (Fayette); *barrattii* Delaware; *eburnea* Northampton, Lehigh; *flava* (Wayne, Monroe) Northampton (Erie); *impressa* Phila.; *mitchelliana* (Lackawanna) Phila.; *walteriana* v. *brevis* Delaware. *Cyperus diandrus* (Luzerne) Bucks, Phila. (Dauphin); *odoratus* Bucks, Montgomery, Phila., Delaware; *refractus* Delaware, Lancaster; *retrorsus* Lehigh, Phila. *Eleocharis compressa* Lancaster (Venango); *diandra* Bucks; *engelmannii* f. *detonsa* Delaware; *quadrangulata* Phila. (Erie, Mercer); *tenuis* v. *verrucosa* Bucks; *tricostata* Delaware; *tuberculosa* Montgomery — Extinct —. *Fimbristylis baldwiniana* Phila., Delaware, Chester, Lancaster; *castanea* Phila., Delaware; *drummondii* Lancaster. *Rhynchospora capillacea* Northampton, Lancaster (Bedford). *Scirpus ancistrochaetus* (Lackawanna) Lehigh (Clinton, Blair); *smithii* Bucks, Phila., Delaware (Erie). *Scleria minor* Chester; *verticillata* Northampton, Lehigh, Lancaster (Erie).

LEMNACEAE — COMMELINACEAE: *Lemna valdiviana* (Pike) Northampton, Bucks. *Eriocaulon parkeri* Bucks, Delaware. *Commelina erecta* Lancaster; *virginica* Phila., Lancaster.

JUNCACEAE: *Juncus canadensis* f. *apertus* Montgomery (Erie); *dichotomus* Bucks, Phila., Delaware; *effusus* v. *conglomeratus* Berks; *militaris* (Pike) Delaware. *Luzula bulbosa* Bucks, Delaware, Chester (Franklin).

LILIACEAE: *Lilium canadense* f. *rubrum* Montgomery; *Smilax pseudo-china* Delaware — Extinct —.

IRIDACEAE: *Iris verna* v. *smalliana* Lancaster (Cumberland, Adams). *Sisyrinchium arenicola* Phila. — Extinct —; *atlanticum* Bucks (Columbia, Cambria); × *intermedium* Montgomery, Delaware.

ORCHIDACEAE: *Cypripedium calceolus* v. *parviflorum* (Pike) Chester (Westmoreland, Crawford); *candidum* Lancaster — Extinct —. *Listera australis* Chester (Warren). *Platanthera cristata* Montgomery — Extinct —. *Tipularia discolor* Delaware, Chester, Lancaster.

DICOTYLEDONS

SALICACEAE: *Salix candida* Northampton; *nigra* v. *falcata* (Schuylkill) Berks, Montgomery, Chester; *serissima* Lehigh (Bedford, Fayette, Crawford).

MYRICACEAE: *Myrica heterophylla* Bucks, Montgomery.

FAGACEAE: *Quercus* × *brittonii* Berks; × *bushii* Berks; × *exacta* Bucks; × *jackiana* Chester; *phellos* v. *phellos* Berks, Bucks, Phila., Delaware; *phellos* v. *laurifolia* Northampton; × *rehderi* Berks (Centre); × *rudkinii* Bucks, Delaware.

URTICACEAE — LORANTHACEAE: *Pilea fontana* Berks (Dauphin, Bedford, Warren). *Phoradendron serotinum* Bucks, Delaware, Lancaster (Franklin).

POLYGONACEAE: *Polygonum lapathifolium* v. *salicifolium* Northampton, Berks, Phila.; *opelousanum* Northampton, Lehigh, Bucks; *punctatum* v. *parvum* Bucks; *robustius* Bucks (McKean, Erie, Crawford). *Rumex hastatulus* Delaware.

CHENOPODIACEAE: *Atriplex patula* v. *littoralis* Northampton, Lehigh, Phila. (Allegheny). *Chenopodium desiccatum* v. *leptophylloides* (Luzerne) Northampton, Lehigh, Chester; *strictum* v. *glaucophyllum* Northampton, Lehigh, Bucks (Bradford). *Salsola kali* v. *caroliniana* Lancaster.

AMARANTHACEAE: *Amaranthus cannabinus* Berks, Phila., Delaware.

PORTULACACEAE: *Claytonia virginica* f. *lutea* Bucks, Chester. *Talinum teretifolium* Chester, Lancaster.

CARYOPHYLLACEAE: *Cerastium arvense* v. *villosissimum* Chester, Lancaster. *Paronychia fastigiata* v. *paleacea* Berks.

RANUNCULACEAE: *Anemone riparia* Chester (Fulton). *Ranunculus abortivus* f. *coptidifolius* Montgomery, Lancaster; *hederaceus* Chester; *reptans* Northampton, Lancaster (Dauphin, Clearfield).

BERBERIDACEAE: *Podophyllum peltatum,* pink f. Chester.

CRUCIFERAE: *Arabis missouriensis* (Monroe) Montgomery (Columbia). *Draba reptans* Bucks, Lancaster.

CRASSULACEAE: *Sedum rosea* (Pike) Bucks.

HAMAMELIDACEAE: *Liquidambar styraciflua* Bucks, Montgomery, Phila., Delaware.

ROSACEAE: *Amelanchier obovalis* Montgomery, Lancaster. *Crataegus arnoldiana* Phila.; *canbyi* Bucks, Phila., Delaware (Franklin); *chadsfordiana* Delaware; *disperma* Lancaster (Centre, Huntingdon, Butler); × *evansiana* Phila.; *pausiaca* Delaware (Fayette, Allegheny); *rubella* Lancaster (Huntingdon, Bedford); *stolonifera* Delaware (Greene); *tatnallianna* Berks, Phila., Delaware, Chester. *Po-*

tentilla fructicosa Northampton; *paradoxa* Berks (Erie). *Prunus maritima* Bucks, Montgomery. *Rubus cuneifolius* Bucks, Delaware, Chester, Lancaster; *semisetosus* (Pike) Delaware; *semisetosus* relative *benneri* Bucks.

LEGUMINOSAE: *Aeschynomene virginica* Phila., Delaware. *Clitoria mariana* Berks, Phila., Lancaster. *Desmodium glabellum* Northampton, Berks, Delaware; *humifusum* Berks, Bucks (Centre, Allegheny); *sessilifolium* Lancaster (Lycoming). *Galactia regularis* Phila. (York); *volubilis* Berks, Phila. *Lathyrus palustris* v. *palustris* (Wyoming) Berks, Phila. (Erie). *Lespedeza stuevei* Bucks, Lancaster. *Trifolium reflexum* Montgomery, Phila., Chester (Allegheny).

LINACEAE: *Linum intercursum* Bucks, Montgomery, Chester, Lancaster.

POLYGALACEAE: *Polygala incarnata* Lancaster; *lutea* Bucks — Extinct —.

EUPHORBIACEAE: *Croton capitatus* (Luzerne) Montgomery, Lancaster (Beaver). *Crotonopsis elliptica* Bucks, Delaware. *Euphorbia ipecacuanhae* Bucks — Extinct —; *polygonifolia* Phila. (Erie). *Phyllanthus carolinensis* Phila., Chester, Lancaster (York).

ANACARDIACEAE: *Rhus copallina* v. *copallina* Delaware.

AQUIFOLIACEAE: *Ilex glabra* Bucks — Extinct —.

VITACEAE: *Vitis rupestris* Lancaster (Washington).

MALVACEAE: *Kosteletzkya virginica* Phila.

GUTTIFERAE: *Ascyrum stans* Bucks — Extinct —. *Hypericum adpressum* Bucks (Allegheny); *densiflorum* Lehigh (York, Fayette); *denticulatum* v. *ovalifolium* Bucks — Extinct —; *gymnanthum* Lehigh (Center).

ELATINACEAE: *Elatine americana* Bucks, Phila., Delaware.

VIOLACEAE: *Viola brittoniana* Bucks — Extinct —.

LYTHRACEAE: *Ammania coccinea* Phila. *Lythrum hyssopifolia* Bucks, Montgomery, Phila.

ONAGRACEAE: *Ludwigia sphaerocarpa* Bucks — Extinct —. *Oenothera fruticosa* v. *linearis* Montgomery (Adams).

HALORHAGACEAE: *Myriophyllum heterophylum* Bucks. *Proserpinaca intermedia* Bucks; *pectinata* Bucks — Extinct —.

UMBELLIFERAE: *Eryngium aquaticum* Bucks, Phila., Delaware (Allegheny). *Hydrocotyle umbellata* Bucks, Phila. (Huntingdon). *Ptilimnium capillaceum* Bucks, Phila.

ERICACEAE: *Gaylussacia dumosa* Montgomery, Lancaster (York).

PRIMULACEAE: *Hottonia inflata* Bucks (Sullivan).

GENTIANACEAE: *Gentiana catesbaei* Delaware — Extinct —. *Nymphoides cordata* (Pike, Monroe) Bucks. *Sabatia campanulata* Bucks — Extinct —; *stellata* Bucks — Extinct —.

ASCLEPIADACEAE: *Asclepias rubra* Montgomery, Delaware, Lancaster.

POLEMONIACEAE: *Polemonium* van-bruntiae (Wayne) Berks (Sullivan).

BORAGINACEAE: *Onosmodium virginianum* Delaware, Lancaster.

LABIATAE: *Lycopus americanus* v. *longii* Bucks. *Pycnanthemum pycnanthemoides* Bucks. *Scutellaria serrata* Delaware, Lancaster (York). *Stachys hyssopifolia* v. *ambigua* Bucks, Lancaster; *tenuifolia* v. *hispida* Chester (Bedford, Erie, Mercer). *Teucrium occidentale* (Lackawanna) Phila. (Crawford, Beaver). *Trichostema setaceum* Berks (Montour).

SCROPHULARIACEAE: *Agalinis decemloba* Lancaster; *paupercula* Montgomery (Erie, Mercer). *Limosella subulata* Bucks, Delaware. *Melampyrum lineare* v. *pectinaceum* Delaware. *Micranthemum micranthemoides* Bucks, Phila. *Veronica peregrina* v. *xalapensis* Lehigh, Bucks, Phila.

LENTIBULARIACEAE: *Utricularia fibrosa* Bucks — Extinct —; *inflata* v. *minor* Bucks — Extinct —.

RUBIACEAE: *Hedyotis purpurea* v. *purpurea* Lancaster (Fayette).

CAPRIFOLIACEAE: *Viburnum nudum* Bucks, Montgomery, Chester, Lancaster.

LOBELIACEAE: *Lobelia nuttallii* Bucks, Delaware.

COMPOSITAE: *Antennaria brainerdii* Lehigh; *munda* (Luzerne) Northampton, Lehigh (Huntingdon). *Arnica acaulis* Chester, Lancaster. *Aster* × *amethystinus* Bucks; *depauperatus* Delaware, Chester, Lancaster; *ericoides* v. *prostratus* Bucks, Lancaster (Perry, Huntingdon); *novi-belgii* Berks, Bucks, Montgomery, Delaware; *spectabilis* Bucks — Extinct —; *umbellatus* v. *latifolius* Lehigh. *Bidens bidentoides* Bucks, Phila., Delaware; *connata* v. *anomala* Berks; *frondosa* f. *anomala* Bucks, Phila., Delaware. *Boltonia asteroides* Lancaster (York, Dauphin). *Coreopsis rosea* Bucks — Extinct —. *Erigeron pusillus* Bucks (Bedford); *strigosus* v. *beyrichii* Lehigh, Phila., Delaware. *Eupatorium album* Bucks, Montgomery, Lancaster; *leucolepis* Bucks — Extinct —; *sessilifolium* v. *vaseyi* Lancaster (York, Dauphin). *Helianthus angustifolius* Bucks. *Prenanthes seroentaria* f. *simplicifolia* Phila., Delaware. *Senecio obovatus* f. *elongatus* (Pike) Northampton, Bucks; *pauperculus* v. *crawfordii* Bucks, Montgomery. *Solidago racemosa* Lancaster (York); *sempervirens* Phila., Delaware; *tenuifolia* Bucks, Montgomery, Phila., Delaware. *Vernonia glauca* Montgomery, Phila., Delaware, Chester; *noveboracensis* f. *albiflora* Delaware.

CHROMOSOME NUMBERS OF SOME EASTERN NORTH AMERICAN SPECIES OF *SCIRPUS*

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A wide range of many different chromosome numbers has been reported for plants in the sedge genus *Scirpus* (Darlington & Wylie, 1955; Cave, 1958–1965; Moore, 1973). In general this chromosome number divergence appears to be correlated with morphological divergence and greater chromosome number differences are found between distantly related species than between closely related species. Thus chromosome numbers provide additional evidence of taxonomic relationships among species. Also, in instances where infraspecific variation in chromosome number occurs, further study of morphological and ecological differentiation of cytotypes may have bearing on our understanding of speciation in the Cyperaceae. It is for these purposes that the chromosome data contained here are reported.

The genus *Scirpus* (*sensu lato*) is a diverse assemblage of unrelated species groups which eventually will be treated as different genera. The species in this paper belong to two such groups and are designated here as leafy and aquatic species. Generally the leafy species have more conspicuous leaves and grow in drier conditions than the aquatic species.

Materials and Methods

Juvenile inflorescences were collected in 4:3:1 chloroform: ethyl alcohol: glacial acetic acid and refrigerated at 2–4°C for various lengths of time. Anther squashes were made in aceto-carmine. Observations were mostly confined to meiotic metaphase I figures because they were the most suitable for number determinations and most of the counts reported here (Tables 1 & 2) are based on several such figures. It was not possible to be certain of the detailed structure of the units observed in meiosis (e.g., whether they were univalents or bivalents) so they are merely referred to as meiotic units. In most cases, if not all, the number of meiotic units is probably equivalent to the haploid number of chromosomes.

Results and Discussion

In *Scirpus georgianus* Harp., 25, 26, and 27 units were observed in plants from 25 localities in New Jersey, North Carolina, and Pennsylvania (Table 1 & Schuyler, 1967). As a result of work conducted from 1965 to 1975 in counties within an 80 kilometer radius of Philadelphia, it was found that 18 localities had plants with 27 units, 2 had plants with 26 units, 2 had plants with 25 units, and

1 had plants with both 25 and 26 units. Thus, at least in the Philadelphia area, the 27 unit cytotype appears to be the most abundant. Further work is being done on the morphological and ecological differentiation among these cytotypes.

I previously reported difficulty in obtaining meiotic figures of *Scirpus atrovirens* Willd. (Schuyler, 1967 & 1969) and suggested that this may be evidence that *S. atrovirens* is of hybrid origin. It now appears that the difficulty was due to collecting plants too young for suitable meiotic figures. Twenty-eight units were observed in plants collected in Berks and Chester Counties, Pennsylvania, and the same number was reported by L. J. Harms (pers. comm.) in plants from Beltrami County, Minnesota (*Harms 3051*, PH).

TABLE 1. — Meiotic Units Observed in Pollen Mother Cells of Leafy Species of *Scirpus*

Taxon	Meiotic Units	Voucher Specimens[a]	Remarks
S. georgianus	25	NJ: Hunterdon Co.: *4575;* PA: Lehigh Co.: *4076*	
	26	PA: Lehigh Co.: *3961,* Montgomery Co.: *4386*	*3961* previously cited with photograph (Schuyler, 1969)
	27	NJ: Burlington Co.: *3930, 3942,* Hunterdon Co.: *4309, 4572, 4574;* NC: Durham Co.: *3923, 3924;* PA: Berks Co.: *4489, 4561, 4562,* Bucks Co.: *4571, 4577, 4579,* Delaware Co.: *3943, 4308,* Montgomery Co.: *4565, 4567, 4569, 4570*	*3930* previously cited with photograph (Schuyler, 1969)
S. atrovirens	28	PA: Chester Co.: *4258,* Berks Co:. *4492*	
S. polyphyllus	29	PA: Wayne Co.: *4195*	
S. microcarpus	33	NY: Cattaraugus Co.: *4074*	
S. pedicellatus	34	PA: Potter Co.: *4073*	

[a] All are collections by the author preserved at the Academy of Natural Sciences.

The numbers reported for *Scirpus polyphyllus* Vahl, *Scirpus microcarpus* Presl, and *Scirpus pedicellatus* Fern. (Table 1) corroborate numbers I previously reported (1967) for plants from different localities. However Taylor & Mulligan (1968) reported 32_{II} in meiotic material of *S. microcarpus*[1] from British Columbia instead of the 33 units reported here. This difference is not surprising since *S. microcarpus* is a variable species — western North American plants are generally more robust and have larger achenes than eastern North American plants. Further investigation may show a more precise correlation between such morphological and cytological variation and geographical distribution.

The presence of 35 and 37 units in *Scirpus torreyi* Olney and *Scirpus subterminalis* Torr. respectively (Table 2) helps confirm that they are closely related

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[1] Taylor & Mulligan used the name *Scirpus sylvaticus* ssp. *digynus* (Böckel.) Koy. which is a synonym of *Scirpus microcarpus.*

but distinct species. These numbers are also close to the n = 38 reported by Tanaka (1942) for plants of the closely related *Scirpus nipponicus* Mak. from Japan.

The 19, 19, and 21 units reported here for *Scirpus heterochaetus* Chase, *Scirpus acutus* Muhl. ex Bigel., and *Scirpus validus* respectively (Table 2) for plants from the eastern United States agree with the numbers reported by Ward & Barker (1971) for plants from North Dakota. However there are some discrepancies with the numbers reported by Hicks (1928) for New England plants of *S. heterochaetus* and *S. acutus*. His report of n = 18 for *S. heterochaetus* and n = 20 for *S. acutus* may have been due to poor resolution of overlapping units and inadvertently working with hybrids. Hicks mentioned that, "on one occasion there appeared to be 19 chromosomes," in his material of *S. heterochaetus* and that the pollen of *S. acutus* was "exceedingly bad, with disintegrating protoplasmic contents." The latter characteristics of *S. acutus* suggest that he had a hybrid. The number he reported is within the range of numbers Smith (1969) reported for putative hybrids between *S. acutus* and *S. validus*.

TABLE 2. — Meiotic Units Observed in Pollen Mother Cells of Aquatic Species of *Scirpus*

Taxon	Meiotic Units	Voucher Specimens[a]	Remarks
S. torreyi	35	PA: Clinton Co.: *3849*	
S. subterminalis	37	NJ: Burlington Co.: *3741, 4049*	
S. heterochaetus	19	NY: Washington Co.: *3988*	previously cited with photograph (Schuyler, 1971)
S. acutus	19	NJ: Warren Co.: *4241*	
S. validus	21	PA: Northampton Co.: *3839*	
S. californicus	34	TX: Nueces Co.: *4034*	
S. americanus	39	NJ: Atlantic Co.: *4384*	
S. americanus × *pungens*	43–47	NJ: Atlantic Co.: *4385*	
S. pungens	39	NJ: Atlantic Co.: *4382*; NY: Essex Co.: *3992*	*3992* previously cited with photograph as *S. americanus* (Schuyler, 1970)
S. deltarum	39	LA: Plaquemines Par.: *4019*	previously cited with photograph (Schuyler, 1970)

[a] All are collections by the author preserved at the Academy of Natural Sciences.

Scirpus heterochaetus, S. acutus, and *S. validus* are members of the *Scirpus lacustris* complex (Smith, 1969; Ward & Barker, 1971), a group which needs study on a worldwide scale. Both *S. heterochaetus* and *S. acutus* have one meiotic unit which is about three times larger than any of the other units (as shown in Schuyler, 1971). The presence of the same number and a similar large unit in Japanese plants identified as *S. lacustris* (Tanaka, 1938) suggests the need for a closer evaluation of the relationships between Japanese and North American plants. *Scirpus californicus* (Mey.) Steud., which resembles plants in the *S. lacustris* complex, differs from them cytologically by having 34 meiotic units (Table 2).

Scirpus americanus Pers., *Scirpus pungens* Vahl, and *Scirpus deltarum* Schuyl., all with 39 units (Table 2), represent a group of closely related species which are also cytologically cohesive. The number reported here for plants of *S. pungens* from the eastern United States agrees with that given by Otzen (1962) for European plants[2] but differs from that ($n = 38$) given by Hicks (1928) for New England plants. The number ($n = 39$) reported by Hicks for *S. americanus*[3] agrees with that reported here. Putative hybrids between *S. americanus* and *S. pungens* were difficult to interpret because there seemed to be variable degrees of clumping of the units. The 43–47 units reported here differ from the $n = 50–64$ reported by Hicks (1928) for the same interspecific hybrid. Such cytological variation is difficult to interpret but does provide additional evidence that the plants are of hybrid origin.

ACKNOWLEDGMENTS

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[2] Otzen and Hicks used the name *S. americanus* for the plants they studied. Most botanists have applied the name *S. americanus* to plants of *S. pungens* and undoubtedly they did too (Schuyler, 1974).

[3] Hicks applied the name *Scirpus olneyi* Gray to the plants he studied. *S. olneyi* is a synonym of *S. americanus* (Schuyler, 1974).

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THE FLORA OF SUNRISE MILL PARK, MONTGOMERY COUNTY, PENNSYLVANIA [1]

ANN NEWBOLD

Bechtelsville, Pennsylvania

Sunrise Mill, located west of Zieglerville on the West Branch of Swamp Creek at the junction of three townships — Limerick, Lower Frederick, and Upper Frederick — was recently purchased by Montgomery County for a projected nature-oriented public park. The 150 acre Sunrise Mill Park has flood plain, steep hillside, two open pipe line areas, and both conifer and deciduous woodland.

This area was visited approximately four hours once every three weeks from March through November. The count for 1975 was 83 families, 255 genera, and 405 species. In 1976 the study will be continued with emphasis on grasses and sedges.

Zone 1 of Sunrise Mill Park, starting at the junction of the park road with Grebe Road, encompasses the steepest part of the park, a scarcely climbable slope. The area south of the creek, facing north, is primarily covered by *Tsuga canadensis.* Among the hemlocks are also found *Amelanchier canadensis, Fagus grandifolia, Castanea dentata, Carpinus caroliniana, Ostrya virginiana,* with understory and edges of *Cornus florida, Vaccinium stamineum* and *angustifolium, Kalmia latifolia, Viburnum acerifolium, dentatum,* and *prunifolium,* and *Diervilla lonicera.* On the bend of the Park Road stands a large butternut, *Juglans cinerea,* with its white trunk quite in evidence. The carpet of this area is moss, *Mitchella repens, Maianthemum canadense, Aralia nudicaulis, Goodyera pubescens, Chimaphila maculata, Monotropa uniflora, Paronychia canadensis, Epifagus virginiana, Heuchera americana, Saxifraga virginiensis, Antennaria plantaginifolia, Polystichum acrostichoides, Polypodium virginianum,* and *Botrychium dissectum,* var. *obliquum* and var. *dissectum.*

The *Tsuga* copse gradually changes to deciduous woodland to the West. There the trees are *Betula lenta, Quercus alba, rubra,* and *velutina, Acer rubrum,* and *saccharum, Fraxinus americana, pennsylvanica* var. *pennsylvanica* and var. *subintegerrima.* At the edges near the road are *Sambucus canadensis* and *Corylus americana.* Here, the floor is covered with *Geum canadense, Agrimonia rostellata, Allium vineale, Circaea quadrisulacta, Galium aparine, circaezans,* and *lanceolatum, Stellaria pubera, Cimicifuga racemosa,* and a smattering of *Hepatica ameri-*

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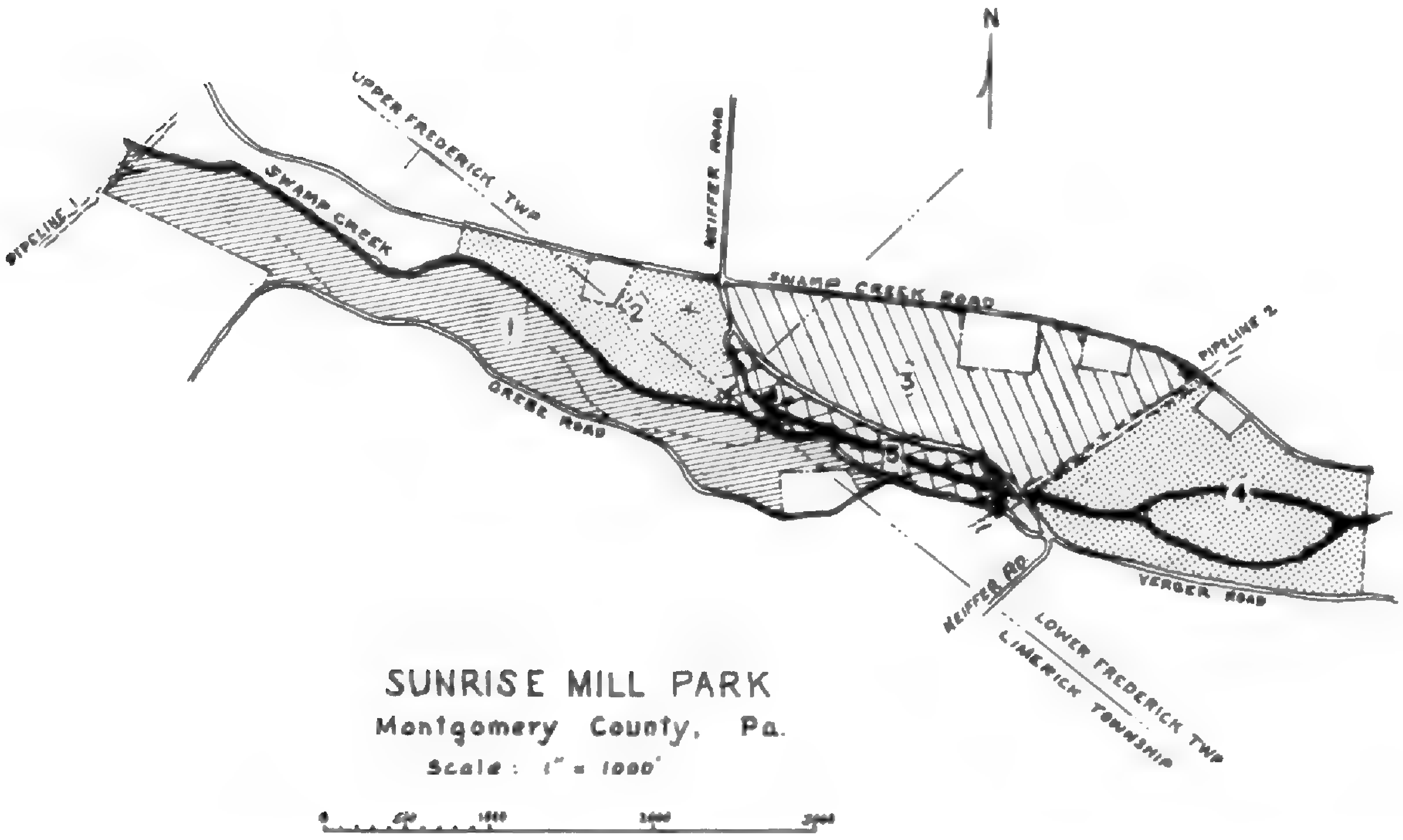
[1] This study was authorized by the Perkiomen Valley Watershed Association through the office of the Superintendent of the County Park System. The members of the Wild Flora Committee involved in this project are Anna Felton, Chairperson, George Dunkle, Gordon Krieble, and Ann Newbold. Additions to the list from Philadelphia Botanical Club members and other interested parties would be appreciated.



cana. By the stream in the wooded part of this area, there is a tremendous patch of *Mertensia virginica* and in the wet open area of the pipe line there are the three damp-land grasses, *Glyceria striata, Alopecurus pratensis,* and the ever-invading *Microstegium vimineum.*

On Pipe Line No. 1, the park's western boundary, there is a jungle of *Rubus allegheniensis, phoenicolasius,* and *occidentalis, Rosa multiflora, Oenothera biennis, Rumex crispus* and *obtusifolius, Stellaria longifolia, Polygonum scandens, Desmodium dillenii, paniculatum,* and *canescens, Medicago sativa, Melilotus alba, Acalypha virginica, Apocynum cannabinum, Asclepias syriaca, Convolvulus sepium, Cuscuta gronovii.* The grasses are *Poa pratensis* and *trivialis, Dactylis glomerata, Phalaris arundinacea, Deschampsia flexuosa, Echinochloa crusgalli, Arrhenatherum elatius, Panicum virgatum,* and *Triodia flava.*

Across the creek and up the far less steep hillside of Zone II the growth is younger and the area dryer and warmer. In addition to the *Quercus* seen on the other side, there are also *Q. coccinea, palustris,* and *prinus. Carya ovata, tomentosa,* and *cordiformis, Cercis canadensis, Liriodendron tulipifera,* and a stand of *Pinus virginiana* are noticeable here, together with *Cornus amomum* near the water and *C. racemosa* at the top. *Anthoxanthum odoratum, Bromus inermis,* and *Phleum pratense* are the predominant grasses. On the floor of the woods are found *Carex platyphylla* and *C. grayii, Arisaema triphyllum, Luzula campestris* var. *echinata, Ornithogalum umbellatum* at the edges, *Polygonatum biflorum* and *pubescens,* and the great Solomon's Seal, *P. canaliculatum. Smilacina racemosa* is present too. One little plant found in quantity at the edge of the dirt road is *Cunila origanoides. Collinsonia canadensis,* the lush, beautiful *Oxalis violacea, Geranium maculatum, Galium concinnum* and *asprellum,* and *Solanum dulcamara* accent the undergrowth on the open woodsy growth. Next comes a little patch of ruderal plants — in a vacant lot of two or three years' edges. *Gnaphalium obtusifolium* seems to be its choicest offering in September, amidst quantities of *Setaria faberii, Rubus* spp., and the empty "sickle pods" of *Arabis canadensis.*

Across Neiffer Road on the dry open corner, a small *Gymnocladus dioica* is being encroached upon by *Celastrus scandens.* Zone III is primarily an area of *Juniperus virginiana* with *Lonicera japonica* infestation. Along the southern side near Neiffer Road, there are three Anacardiaceae — *Rhus radicans, glabra,* and *typhina.* One lone plant of *Eupatorium album* seemed unusual. *Ailanthus altissima, Tilia americana* and *heterophylla* seemed right.

On the north side of this zone, along Swamp Creek Road, are *Ulmus americana, Hamamelis virginiana,* and *Ilex verticillata.* Three *Prunus* species — *avium, serotina,* and the much rarer for Montgomery County, *virginiana* — grow here. The *Cornus* and *Viburnum* are overgrown with *Smilax glauca* and *rotundifolia.* But farther east the character changes and a rash of ferns appear: *Asplenium platyneuron, Cystopteris fragilis, Dennstaedtia punctilobula, Dryopteris marginalis, spinulosa,* and *cristata, Onoclea sensibilis, Thelypteris noveboracensis* and *palustris.* Along with the ferns at the very edge of the black top a familiar aroma, though in an unfamiliar setting, reveals the presence of *Hedeoma pulegioides.*

Farther east on Swamp Creek Road, Pipe Line No. 2 ending Zone III, crosses the park area down to Neiffer Road and offers, at the bottom, *Muhlenbergia schreberi,* at the top, *Andropogon scoparius* and *virginicus, Sorghastrum nutans, Panicum latifolium, Viola primulifolia,* an escaped *Lonicera maackii, Chenopodium album* and *ambrosioides,* much *Daucus carota, Potentilla canadensis, simplex,* and *recta, Rubus flagellaris* and *pensilvanicus, Hypericum perforatum* and *punctatum, Valerianella olitoria, Artemisia vulgaris, Ipomoea hederacea, Centaurea maculosa, Erechtites hieracifolia, Solidago nemoralis* and *ulmifolia,* and *Prunella vulgaris.* Both east and west (Zones III and IV) of the Pipe line, Junipers are the mainstay vegetation and between the junipers at the highest elevation grow large patches of moss and *Lycopodium complanatum* var. *flabelliforme.*

Last but certainly not least of the distinct habitats of Sunrise Mill Park come the creek banks and adjacent open bottom lands found in Zones IV and V. These are the areas which must have inspired the naming of Swamp Creek.

From the farthest point east of Zone IV along both sides of the stream, masses of *Saururus cernuus* are growing in the water and on the mud flats. *Equisetum arvense* grows farther up the bank. *Danthonia spicata, Elymus riparius, Hystrix patula* are the new grasses found there. And in the flat wet bottom land stands another *Gymnocladus dioica,* a tall, straight, mature tree, in habitat strikingly dissimilar to the hard dry corner of Zone III. On the south side of the creek, *Boehmeria cylindrica, Pilea pumila* and the only alternate leafed Urticaceae, *Laportea canadensis,* are in great abundance. As the land rises to Yerger Road, there are *Anemonella thalictroides, Ranunculus abortivus* and *bulbosus, Thalictrum polygamum.* Many *Platanus occidentalis* shade *Podophyllum peltatum, San-*

guinaria canadensis, and *Dicentra cucullaria.* Cruciferae found in Zone IV are *Alliaria officinalis, Arabidopsis thaliana, Cardamine hirsuta, Dentaria laciniata,* and *Capsella bursa-pastoris.*

Along a path, leading from the stream to the road and having the appearance of being near a former homesite, are found *Salix discolor, Elaeagnus umbellata,* a *Viburnum cultivar,* and a *Philadelphus* species.

The ground cover on the island is largely *Asarum canadense* and *Viola striata. Smilax herbacea, Symplocarpus foetidus, Claytonia virginica, Anemone quinquefolia* and *virginiana* and *Clematis virginiana* are also represented.

On the north side of the island, vegetation is lush. There is one — seemingly only one — *Gleditsia triacanthos,* overhanging the stream. *Nyssa sylvatica* is there where it should be and also *Betula nigra, Salix fragilis* and *Alnus serrulata* along with the sycamores. The black alluvial soil produces *Asclepias incarnata, Verbena hastata* and *urticifolia, Hackelia virginiana, Physalis heterophylla, Leonurus cardiaca* and *marrubiastrum, Lycopus virginicus,* both species of *Pycnanthemum* — *tenuifolium* and *virginianum, Teucrium canadense, Mentha arvensis* and *piperita, Chelone glabra, Scrophularia marilandica, Dipsacus sylvestris, Lobelia inflata* and *siphilitica, Bidens cernua* and *frondosa, Eupatorium fistulosum, perfoliatum,* and *purpureum, Helenium autumnale, Helianthus decapetalus, Prenanthes altissima* and *trifoliolata,* and *Vernonia noveboracensis.*

Zone V provides the lushest and most varied section of the park vegetation. In the sunny open triangle of the junction of Neiffer and Grebe Roads there dwell the sun-loving members of the Aster family — *Aster novae-angliae, pilosus* var. *pilosus,* var. *demotus,* and *simplex.* In the spring it is *Krigia biflora* and *Erigeron annuus.* A group of *Phlox paniculata* and *Hemerocallis fulva* provide summer interest. *Epilobium coloratum, Ludwigia palustris,* and the tiny Pontederiaceae, *Heteranthera reniformis,* are by the water's edge. Between the south side of the creek and the north side of Grebe Road there is a deciduous wooded area where the shade-loving members of the Aster family dwell — *Aster cordifolius, divaricatus, lateriflorus,* and *Solidago caesia* and *flexicaulis,* encumbered by a bit of *Amphicarpa bracteata.*

Across the creek at the easterly edge of Zone V stands a plant not recorded in Wherry's Montgomery County Check-list (Bartonia 41: 71–84) — a nine-foot-high pistillate bush of the composite *Baccharis halimifolia.* It is extremely hard to imagine from its impossible location that it could have been deliberately planted there. It is equally difficult to imagine how it arrived there otherwise. A specimen has been placed in the herbarium of the Academy of Natural Sciences.

There on the north side of the creek, rushes and sedges grow in abundance — *Juncus effusus, Cyperus esculentus, Scirpus cyperinus* and *validus, Rhynchospora capitellata, Eleocharis obtusa, Carex festucacea, argyrantha, crinita, typhina, scoparia, cephalophora, hirsutella,* and *lurida.*

Farther along the north side of the creek, the bladdernut, *Staphylea trifolia,* and two species of *Sanicula* are most evident — *gregaria* and *marilandica.* This area makes a good home for other Umbelliferae — *Cryptotaenia canadensis, Osmorhiza longistylis,* and *Zizia aurea.* West of the old S.M.P. bridge — a relic closed to vehicles but open to foot travelers — in the vicinity of the old mill house and barn, a few taxa smack of civilization — *Picea abies, Pinus strobus* and *sylvestris, Euonymus alatus, Ligustrum ovalifolium, Sedum acre, sarmentosum,* and *telephium, Hesperis matronalis, Aralia spinosa, Acer negundo, platanoides,* and *saccharinum, Viola sororia, hirsutula, pubescens,* var. *pubescens* and var. *eriocarpa,* and *striata, Lysimachia nummularia, Vinca minor, Rudbeckia hirta, Tanacetum vulgare, Specularia perfoliata, Senecio aureus,* and *Digitaria sanguinalis.*

Across the drive opposite the house and next to the mill along the bank of the stream there is another huge patch of *Mertensia virginica.* Early in March this area is covered with Limnanthaceae's sole species in our parts, the False Mermaid, *Floerkea proserpinacoides,* a charming wet-ground cover. *Myosotis scorpioides, Commelina communis, Muscari botryoides, Erythronium americanum, Mimulus ringens, Trifolium hybridum, Lysimachia ciliata,* and *Salix sericea* are all well represented with *Sicyos angulatus* climbing over their tops. Here too the buckwheat family is in profusion — *Polygonum arifolium, hydropiper, pensylvanicum, persicaria, sagittatum,* and *Tovara virginiana.* Also, on this bank are *Veronica hederacea* and *serpyllifolia. Impatiens pallida* and *capensis* grow side by side — an unusual occurrence. With the *Parthenocissus quinquefolia* and the *Vitis labrusca* and *vulpina* grow quantities of *Rudbeckia laciniata.* Across the drive again, there is the prodigiously prolific area north of the drive and south of Neiffer Road. A *Cornus alternifolia* stands out; here too are found *Celtis occidentalis, Ulmus rubra,* the aforementioned *Viburnum, Morus alba, Berberis thunbergii, Ribes cynosbati, Lonicera morrowi, Symphoricarpos orbiculatus, Lindera benzoin, Sassafras albidum,* and *Juglans nigra.* In the dry open space surrounding the junction of the driveway with Neiffer Road there is *Eragrostis spectabilis, Setaria viridis, Oxalis europaea* and *stricta, Cerastium vulgatum, Dianthus armeria, Lychnis alba, Saponaria officinalis, Stellaria media, Rumex acetosella, Barbarea verna* and *vulgaris, Lepidium campestre* and *virginicum, Sisymbrium altissimum, Agrimonia parviflora, Cassia fasciculata, Medicago lupulina, Euphorbia maculata, Hibiscus trionum, Glechoma hederacea, Perilla frutescens, Satureja vulgaris, Linaria vulgaris, Penstemon hirsutus, Verbascum blattaria* and *thapsus, Veronica officinalis, Plantago lanceolata, major,* and *rugelli, Solanum carolinense, Achillea millefolium, Ambrosia artemisiifolia* and *trifida, Arctium minus, Chrysanthemum leucanthemum, Cichorium intybus, Cirsium arvense* and *vulgare, Erigeron annuus, canadensis,* and *strigosus, Galinsoga ciliata, Hieracium florentinum, pilosella, pratense, Lactuca canadensis,* and of course plenty of *Taraxacum officinale.*

Along the clear southern edge of Neiffer Road, our list was increased by the addition of *Apocynum androsaemifolium, Coronilla varia, Lotus corniculatus, Lespedeza, procumbens, Trifolium agrarium* and *pratense,* and seven species of *Solidago* — *bicolor, altissima, canadensis, graminifolia, juncea, rugosa,* and *gigantea.*

REVEGETATION OF A 70 YEAR OLD SANDPIT IN SOUTHERN NEW JERSEY

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Reports of plant succession on disturbed sites often include species originating from buried perennating organs or dormant seeds present before disturbance occurred. Succession in abandoned sandpits is unique because the plants arise only from propagules dispersed from another area. The pits are excavated 10 to 20 feet below the surrounding land surface and the material which supported the previous vegetation is transported from the site. Plants on the new surface represent true colonization and indicate how readily various species disperse and establish from propagules originating some distance away. The development of soil profile can also be studied.

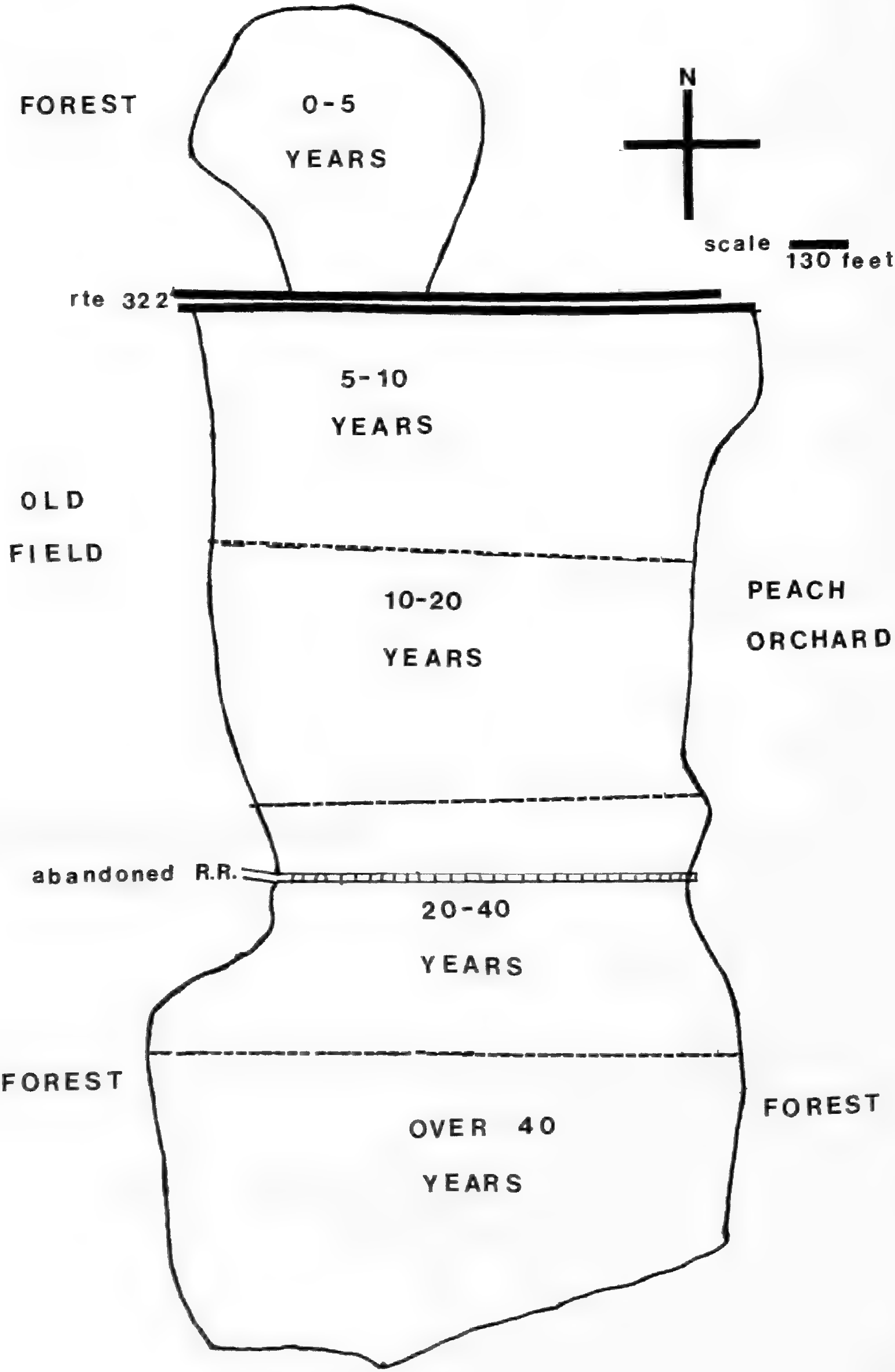
An excellent study site for this purpose is a sandpit in Downer, Gloucester County, New Jersey which has been operated since the turn of the century. As water level was approached in the section being dug, the operators would move on to an adjacent area. The pit is presently about one mile long by 400 yards wide and represents various stages of abandonment from 0 to 70 years. It has always been owned by the Downer family and Mr. Downer was able to point out the ages of different sections of the pit.

DESCRIPTION OF STUDY SITE

A sketch of the pit is shown to scale in Figure 1. The soil type surrounding the pits are Aura and Sassafras sandy loam (U.S.D.A., 1962). These soils are of coarse to medium loamy sand texture with a natural pH below 5. The subsoils are less firm and more friable than the surface horizons. Surrounding the newest and the oldest sections of the pit is oak forest with ericaceous shrubs and understory. As shown in Figure 1, the medium-aged sections are adjacent to a peach orchard on the east and a weedy field with probable agricultural history on the west side.

METHODS

The pit was divided into the following sections according to length of abandonment: 0–5 years, 5–10 years, 10–20 years, 20–40 years, and over 40 years. Each section was explored once or twice a month throughout the growing seasons of 1971 and 1972. Species present were recorded following the nomenclature of Fernald (1950). Since many sites were close to the water table, it was noted whether each species was growing on soil dry or moist through most of the season. A visual estimate of the amount of vegetative cover was made in each section.


FOREST
0-5
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YEARS
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YEARS
PEACH
ORCHARD
abandoned R.R.
20-40
YEARS
FOREST
OVER 40
YEARS
FOREST

Soil development was investigated. Holes were dug 30 cm. deep to look for developing horizons. Soil samples were taken from various-aged sites 4–6 cm below the surface. These were air-dried and weighed. They were then dried to constant weight in an oven and the new weights recorded. The percent weight lost as water was considered to represent the water-holding capacity of the soil. The samples were then incinerated in a high-temperature furnace. They were again weighed and the weight loss after combustion divided by the oven-dried weight represented the fraction of organic matter that had been present in the soil. A portion of each original soil sample was mixed with distilled water and the pH determined with a Coleman pH meter. Three soil samples from different sites were sent to the Soil Testing Laboratory at Rutgers University to be tested for potassium, phosphorus, and nitrate-nitrogen.

RESULTS

Table 1 lists the species present in each section of the pit and the moisture conditions under which they grow. The 0–5 years section is not as deeply excavated as the older areas and consists primarily of bare heaps of shifting sand. The most vegetated area in this section contained 20 clumps of grass in 356 m^2. In the entire section there was one sapling of *Pinus rigida* 1 meter high and two saplings of *Acer rubrum,* both under two meters. The maples had several stems each, and half the stem length was covered by sand.

Vegetation is still very thin in the 5–10 years section. The slopes and drier areas have less than 5% vegetative cover. The permanently wet areas of the pit are 50% covered, mostly with sedges, cranberries, and *Hypericum canadense.* Trees form an irregular line where the bottom of the pit meets the sloping edges. They are about 3 meters high. The line of trees continues through the 10–20 years section, but here the tallest trees are 5–7 meters high. Vegetative cover on the drier areas of the bottom is about 50% in the 10–20 years section. The permanently wet areas are 80% covered or more where there are dense mats of *Gratiola aurea.* The slopes are still almost bare.

In the 20–40 years section *Andropogon scoparius* replaces *Panicum virgatum* in the drier areas of the pit. These clumps give the ground a bumpy relief and almost cover it completely. Scattered trees and shrubs are present. The slopes are about 50% covered and are gullied and steep.

The section 40 years and over resembles the surrounding forest, although it is about 20 feet lower. It is presently used as an archery range which may hinder complete establishment of trees and prolong the grassy stage. The ground and even the slopes are completely covered with litter, grass, shrubs, and trees.

Table 2 shows the pH, soil moisture content, and organic matter percent of soil samples from various sections of the pit. The levels of nitrogen, phosphorus,

FIG. 1. — Downer Sandpit.

Table 1. — Plant Species in Downer Sandpit, Gloucester County, New Jersey.

	Site Drainage	Age of Section (years)				
		0–5	5–10	10–20	20–40	Over 40
Acer rubrum L.	dry, wet	x	x	x	x	x
Diodia teres Walt.	dry	x	x	x	x	
Panicum virgatum L.	dry, wet	x	x	x	x	
P. sphaerocarpon Ell.	dry	x	x	x		
P. boscii Ell.	dry	x	x			
Pinus rigida Mill.	dry	x	x	x	x	x
Prunus serotina Ehrh.	dry	x	x	x	x	x
Rubus pensilvanicus Poir.	dry	x	x	x	x	x
Andropogon scoparius Michx.	dry		x	x	x	x
Aster pilosus Willd.	dry		x	x		
Comptonia peregrina var. *asplenifolia* (L.) Fern.	dry		x	x		x
Drosera intermedia Hayne	wet		x	x	x	
Eleocharis microcarpa Torr.	wet		x	x	x	
Hypericum canadense L.	wet		x	x	x	
Lycopodium inundatum L.	wet		x	x	x	
Lysimachia quadrifolia L.	dry		x			
Polytrichum juniperinum Willd.	dry, wet		x	x	x	x
Rhus copallina L.	dry		x	x	x	
Rumex acetosella L.	dry		x	x	x	
Rhynchospora capitellata (Michx.) Vahl.	wet		x	x	x	
Solidago tenuifolia Pursh.	wet		x	x	x	
Xyris torta Sm.	wet		x	x	x	
X. caroliniana Walt.	wet		x	x	x	
Eriophorum sp.	wet			x		
Betula populifolia Marsh.	dry, wet			x	x	
Hieracium pratense Tausch	dry			x	x	
Juniperus virginiana L.	dry			x	x	x
Nyssa sylvatica Marsh.	dry			x	x	x
Phragmites communis Trin.	wet			x		
Rhexia virginica L.	wet			x		
Sassafras albidum (Nutt.) Nees	dry			x	x	x
Strophostyles helvola (L.) Ell.	dry			x		
Vaccinium corymbosum L.	dry, wet			x	x	x
V. vacillans Torr.	dry, wet			x	x	x
V. macrocarpon Ait.	wet			x	x	
Viola lanceolata L.	wet			x	x	
Amelanchier canadensis (L.) Medic.	dry				x	
Apocynum cannabinum L.	dry				x	
Eupatorium hyssopifolium L.	dry				x	
Carya glabra (Mill) Sweet	dry				x	
Cornus florida L.	dry				x	
Gratiola aurea Muhl.	wet				x	
Juncus subcaudatus (Engelm.) Coville & Blake	wet				x	x
J. scirpoides Lam.	wet				x	
Lespedeza hirta (L.) Hornem.	dry				x	

TABLE 1 (*Continued*). — Plant Species in Downer Sandpit, Gloucester County, New Jersey.

	Site	Age of Section (years)				
	Drainage	0–5	5–10	10–20	20–40	Over 40
Lonicera japonica Thunb.	dry				x	x
Lycopodium complanatum var. *flabelliforme* Fern.	dry				x	x
Myriophyllum humile (Raf.) Morong	wet				x	
Pyrus arbutifolia (L.) L. f.	dry				x	
Salix nigra Marsh.	wet				x	
Quercus spp.	dry				x	x
Solidago odora Ait.	dry				x	
Utricularia sp.	wet				x	
Asplenium platyneuron (L.) Oakes	dry					x
Cypripedium acaule Ait.	dry					x
Baptisia tinctoria (L.) R. Br.	dry					x
Ilex opaca Ait.	dry					x
Kalmia latifolia L.	dry					x
Lechea leggettii var. *leggettii* Britt. & Hollick	dry					x
Chimaphila maculata (L.) Pursh	dry					x
Lespedeza cuneata (Dumont) G. Don	wet					x
Eupatorium rotundifolium L.	dry					x
Onoclea sensibilis L.	dry					x
Populus grandidentata Michx.	dry					x
Sphagnum spp.	wet					x
Spirea tomentosa L.	wet					x

and potassium in three samples are given in Table 3. Percent organic matter and water-holding capacity increase with time, although less so in wet sites than in equal-aged dry sites. Mineral content and some pH values are lower in the older sections than in the more recently abandoned sites. More extensive sampling is needed to determine if the differences are significant. However, extent of surface leaching and composition of the vegetative cover are, no doubt, important in determining the ultimate characteristics of the soil.

Examination shows that although the sand surface layers became whiter with increased length of exposure, no stratification was evident till 20–40 years. Here, under predominantly *Andropogon* cover, the soil was dark gray for about 15 cm. and then yellowish-white below. A black mat 4–5 cm thick covers the marshy areas in the 10–20 and 20–40 year sections.

DISCUSSION

Notably absent from the pit are the introduced ruderals usually present in recently disturbed sites, e.g., ragweed, wild carrot, chicory, *Polygonum* spp., etc. The necessary seed source is not lacking, because these weeds are abundant in adjacent roadsides and fields. The sandpit does not differ in pH or nutrient content from these adjacent sites, and it seems most likely that establishment of these

TABLE 2. — Soil pH, Water-holding Capacity and Organic Matter Content in Different-aged Sections of Downer Sandpit.

Age of Section in Years	Vegetation Type	Site Drainage	Number Samples	pH ± S.E.	Percent Water Capacity ± S.E.	Percent Organic Matter ± S.E.
0	none	dry	2	5.4 ± .5	0.9 ± .1	.44 ± .04
5–10	*Panicum* spp.	dry	2	5.0 ± .1	1.1 ± .1	.61 ± .04
5–10	sedges, *Hypericum*	wet	1	5.4	0.3	.45
10–20	*Panicum, Acer, Nyssa*	dry	4	5.0 ± .2	1.8 ± .4	.99 ± .28
20–40	*Andropogon*	dry	1	4.3	3.8	2.70
	Pinus	dry	1	4.2	2.4	1.60
	Carya	dry	1	5.7	7.0	5.51
	total dry			4.7 ± .5	4.4 ± 1.0	3.25 ± .74
	Panicum, sedge	wet	1	5.4	.75	.55
Over 40	*Andropogon, Quercus*	dry	2	4.4 ± .1	5.8 ± 1.4	4.67 ± 1.70
	Sphagnum spp.	wet	1	4.7	1.9	1.9

plants cannot occur in the shifting dry sands of the newly abandoned pit. However, most species in the pit do not establish until the sand is stabilized by the roots of *Panicum virgatum* and various trees. Yet even in these stabilized areas, introduced weeds are absent. Almost all plants present are typical native Coastal Plain species.

TABLE 3. — Results of Soil Analysis.

			Pounds per Acre [a]		
Site	Texture	pH	Phosphorus	Potassium	Nitrate-N
5-10 year section	loamy sand	6.6	72 VH	216H	16L
10-20 year section	loamy sand	5.5	20 M	99L	16L
Over 40 years	sandy loam	4.2	20 M	72L	16L

[a] L = low M = medium H = high VH = very high

The area surrounding the sandpit was explored one or two miles in depth to find possible sources for the plants found in the pit. Forest species present in the over 40 years section were those of species adjacent to the pit. However, only one marsh area was discovered in the surrounding region and it lacked many of the species present in the 10 and 20 year-old wet sites of the pit. Unless closer marshes existed in the past which have since been destroyed, these species must have originated from sources at least a few miles distant. I suspect that birds are significant dispersal agents. They frequent the pit even in the youngest sections where bank swallows build nests in the steeper slopes. Herons and killdeer were often seen in the wet sites and may have flown in a wide variety of seeds from more distant marshes.

It is encouraging that sandpit operations, unlike much other commercial mining, do not permanently scar the landscape. In less than half a century the regional vegetation has moved in and completely covered the area.

Acknowledgments

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SEED GERMINATION OF ARROW ARUM (*PELTANDRA VIRGINICA* L.)

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Peltandra virginica L. (Arrow arum), a species common to streams, ponds, and marshes (Fairbrothers and Moul, 1965; Gleason, 1963; Sculthorpe, 1967), is one of the most common plants in New Jersey marshes (Robichaud and Buell, 1973). Arrow arum berries are shed intact and consist of a thick fruit wall that contains a large seed which has a well developed and slightly curved embryo embedded in a massive endosperm. A translucent seed coat surrounds the embryo and there is a 2–3 mm thick layer of mucilage between the seed coat and pericarp. Seed dispersal is hydrochoric.

Biomass and primary production of arrow arum have been measured (Good and Good, 1975; McCormick, 1970; McCormick and Ashbaugh, 1972; Whigham, 1974; Whigham and Simpson, 1975), but there has been little work on the species life cycle (Edwards, 1933; Hart, 1928; Muenscher, 1936). While studying the northernmost Delaware River freshwater tidal marsh, a 500 hectare marsh located near Trenton, New Jersey, we noticed that a few arrow arum seeds germinated after they were shed in the fall but that most did not germinate until spring. This study was undertaken to determine germination requirements of arrow arum and to determine the function of the mucilage that is located between the seed and fruit wall.

MATERIALS AND METHODS

Peltandra seeds were collected from the Hamilton Marshes between early September and November 1974 and stored in distilled water at room temperature.

Experiments (20 seeds per replicate and 3 replicates per experiment) were designed to determine if germination was affected by the removal of various fruit parts. Lots of seeds were treated as follows: (1) fruit walls removed, seed coats, and mucilage still intact; (2) fruit walls and mucilage removed; (3) fruit walls, mucilage, and seed coats removed from the plumule end of the embryos; (4) fruit walls, mucilage, and seed coats removed from the radicle end of the embryos; (5) fruit walls, mucilage, and entire seed coats removed from the embryos; (6) control, seeds intact. Treated seeds were placed in petri dishes half-filled with distilled water. The petri dishes were stored in the laboratory at room temperature and germination percentages recorded during the next 2 weeks.

In a second experiment we determined the effect of temperature on germina-

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tion. Fruit walls, mucilage, and seed coats were removed from 100 seeds. Twenty seeds were placed into each of 5 petri dishes. One dish was placed in a refrigerator at 0°C and the others in incubators at 5°C, 10°C, 20°C, and 24°C. Dark germination percentages were recorded after 2 weeks. In addition, various fruit parts were removed from additional seeds which were then stratified at 5°C for one to four weeks. Ten seeds of each treatment group were removed weekly and stored in water-filled petri dishes at room temperature after all remaining fruit and seed parts were removed. Germination percentages were determined after 2 weeks at room temperature. Treatments were as follows: (1) fruit walls removed; (2) fruit walls and mucilage removed; (3) fruit walls, mucilage, and seed coats removed; (4) control, seeds intact.

The effect of desiccation on germination was determined. One hundred intact fruits, 40 fruits with fruit walls removed, and 40 fruits with fruit walls and mucilage removed were placed on filter paper at room temperatures. Periodically the remaining fruit components of intact seeds and seeds with fruit walls removed were removed and the seeds placed in petri dishes half-filled with distilled water. Germination percentages were determined after 2 weeks at room temperature.

RESULTS

Removal of various parts of the fruit and seed affected germination (Table 1). Only 10% of the intact fruits germinated after 4 weeks. With removal of the fruit wall, 50% of the seeds germinated within a week and 75% by the end of 15 days. With the fruit wall and mucilage removed, 40% of the seeds germinated after five days and 83.3% after 15 days. Partial or entire removal of the seed coat reduced the time required for germination. With partial removal

TABLE 1. — Germination Percentages of Arrow Arum Seeds at Room Temperature after Removal of Various Parts of the Fruit. Values Are Means of 3 Replicates–20 Seeds per Replicate

Time (Days)	Intact Fruits	Fruit Wall Removed	Fruit Wall and Mucilage Removed	Fruit Wall, Mucilage, and Seed Coat Removed from Plumule End of Embryo	Fruit Wall, Mucilage, and Seed Coat Removed from Radicle End of Embryo	Fruit Wall, Mucilage, and Entire Seed Coat Removed
1	0	0	0	0	0	25
2	0	0	0	0	21.7	45
4	0	0	0	20	40	56.7
5	0	0	40	55	70	70
7	0	50	46.7	63.3	80	80
10	0	70	81.7	88.3	81.7	80
14	3.3	—	—	—	—	—
15	—	75	83.5	88.3	96.7	81.7
21	8.3					
28	10.0					

TABLE 2. — Germination Percentages of Arrow Arum Seeds after Two Weeks at Room Temperature following Stratification at 5°C for 1–4 Weeks.

Stratification Period (Weeks)	Intact Fruit	Fruit Wall Removed	Fruit Wall and Mucilage Removed	Fruit Wall, Mucilage, and Entire Seed Coat Removed
1	80	90	100	90
2	90	90	76	80
3	100	70	60	90
4	90	80	90	80

TABLE 3. — Germination Percentages of Arrow Arum Seeds Subject to Various Periods of Desiccation. Drying Was at Ambient Room Conditions

Length of Drying Period (Days)	Intact Fruits	Fruit Wall Removed	Fruit Wall and Mucilage Removed
1	90	100	80
2		80	80
3		80	80
4		80	60
5	80	40	20
6			0
7	90	20	0
8		0	
9		0	
14	70		

of the seed coat near the radicle, 21.7% of the seeds germinated after only two days while 96.7% germinated in 15 days. When the entire seed coat was removed, 25% of the seeds germinated after 1 day, 45% after two days, and 81.7% after 15 days. A slower initial rate of germination occurred when the seed coat was partially removed from near the plumule end of the embryo. In four days 20% of the seeds had germinated, but after 15 days there was no difference between this and any other treatment.

Regardless of whether fruit and/or seed parts were removed, *Peltandra* seeds did not germinate at 0°C and 5°C. As temperatures increased there was an increase in germination with 10% at 10°C, 75% at 20°C, and 95% at 24°C. Although germination will not occur at temperatures below 5°C, it appears that the length of exposure to cold temperatures or the condition of the fruit and/or seed exposed to those temperatures has little effect on the ability of the seeds to germinate when placed at room temperature. Eighty to 100% of the fruits and/or seeds kept at 5°C for 1 to 4 weeks germinated after two weeks at room temperature (Table 2).

Results of experiments to determine the effects of desiccation on germination appear in Table 3. Intact fruits were able to tolerate drying but germination decreased with dry storage when the fruit walls were removed. Germination dropped abruptly after 5 days of desiccation and seeds failed to germinate after eight days. A similar pattern occurred when fruit walls and mucilage were removed.

DISCUSSION

Like many aquatic plants (Sculthorpe, 1967; Barton, 1965) dormancy in arrow arum is ectogenous and is primarily imposed by the intact fruit wall. Although Muenscher (1933) stated that arrow arum seeds must be stratified, our studies have shown that germination will occur soon after the fruit wall is broken if water and substrate temperatures are greater than 5°C. Germination also occurs sooner if the mucilage and pericarp are removed (Table 1). Edwards (1933) made similar observations when he was studying germination and growth of *Peltandra* in the absence of oxygen.

Temperatures of 5°C or less can hold arrow arum seeds in a dormant condition and, in the field, germination would begin when water and substrate temperatures approach 10°C. Obviously, dormant seeds are able to survive low winter temperatures for fruits and seeds stratified for 1–4 weeks at 5°C all showed high germination once they were placed at room temperatures and the fruit coats, if present, removed (Table 2). Presence or absence of mucilage and the pericarp did not affect the ability of cold stratified seeds to germinate (Table 2).

Gutterman et. al. (1967) have suggested that mucilage protects seeds from desiccation. Such is not the case for arrow arum (Table 3). When the fruit wall was removed the mucilage quickly dried and flaked off of the embryo and all seeds failed to germinate after seven days. When the mucilage was removed prior to the drying period, the seeds dried out slightly faster and no germination occurred after five days (Table 3). Intact seeds remained viable even after six weeks of dry storage. Examination of those seeds showed that the fruit wall remained pliable and that the mucilage had shrunk but was still in the gel state. This suggests that the mucilage may be capable of keeping both the seed coat and embryo from drying out if the fruit wall is intact. This adoption may seem to be unimportant in a marsh but we frequently observed fruits that had been exposed on debris, primarily mats of vascular plant litter, which was above the mean high tide line. Intact fruit walls are also important for seed dispersal because *Peltandra* seeds lose their buoyancy when the fruit wall is removed.

Both Kozlowski (1972) and Ferry (1959) stated that seed mucilages have a large capacity to absorb water and swell. This is especially true for *Peltandra* where, on the average, the seed mucilage is capable of absorbing better than twice its weight in water. Field observations showed that about ten percent of the seeds collected during early December had some mucilage exuding through the fruit wall. This indicates that by swelling the mucilage aids in the mechanical breaking of the fruit wall. It has not been determined whether or not the mucilage expands because water had moved across the fruit wall or whether the water was generated internally via respiration. Preliminary studies of arrow arum seed metabolism (West, unpublished) have shown that respiration rates increased sharply just prior to germination. Some internal metabolically generated water may thus cause the mucilage to swell.

SUMMARY

Dormancy in *Peltandra* is ectogenous and is affected by the fruit wall. When fruits are shed in late summer and early fall, few seeds will germinate because the fruit walls are intact. A few seeds will germinate in the fall and this is most likely due to mechanical breaking of the fruit wall. It is also possible that the fruit wall breaks because of expansion of the mucilage. Seeds in this condition will continue to germinate until water and substrate temperatures drop to approximately 5°C. By January, fruit walls are broken on most seeds but they will not germinate until water and substrate temperatures increase in the spring.

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CONE, SEED, AND GERMINATION CHARACTERISTICS OF PITCH PINE (*PINUS RIGIDA* MILL) FROM THE PINE BARRENS OF NEW JERSEY

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The Pine Barrens, a pitch pine (*Pinus rigida*) and oak (*Quercus* spp.) dominated forest, occupies the greater part of the Outer Coastal Plain of southern New Jersey (Good and Good, 1975). It covers approximately 2000 sq. miles or about one quarter of the area of the State. The most characteristic forest community of the Barrens is a fairly open stand of pitch pine (*Pinus rigida*) with some shortleaf pine (*P. echinata*) in the canopy with oaks: blackjack oak (*Quercus marilandica*), post oak (*Q. stellata*), black oak (*Q. velutina*), scarlet oak (*Q. coccinea*), white oak (*Q. alba*), and chestnut oak (*Q. prinus*) forming the subcanopy. Scrub oaks (*Q. ilicifolia* and *Q. prinoides*) and heaths (*Gaylussacia baccata, G. frondosa, G. dumosa,* and *Vaccinium vacillans*) are the dominant shrubs (Braun, 1950).

Three areas of the Barrens [West (Upper) Plains, East (Lower) Plains, and Spring Hill Plains], supporting a dwarf pitch pine-oak community known as the Pine Plains, cover about 12,200 acres or about 8% of the Pine Barrens (McCormick and Buell, 1968). Plains vegetation differs from Barrens vegetation in both growth form and species composition. The Plains are composed mainly of pitch pine, and blackjack and scrub oak which are about 4–6 feet in height. Many of the oaks common to the Barrens (e.g. black oak, scarlet oak, white oak, and chestnut oak), as well as short-leaf pine, are rarely found in the Plains. Plains pitch pine assumes a shrub like form, the result of stump sprouting which develops after fire. Most of the Plains pitch pine (98–100%) have cones which are serotinous (Ledig and Fryer, 1972). Barrens pitch pine contain both serotinous and non-serotinous cone trees as well as trees bearing both cone types.

The Pine Plains has been an area of interest to workers for many years. Explanations for the occurrence and development of the Plains have been reported since 1868 and a variety of causative factors for the stunted growth have been suggested (McCormick and Buell, 1968). Soil conditions (e.g. infertility, hardpan formation, and aluminum toxicity) have long been considered as factors causing stunted growth in the Plains. Workers have shown, however, that soil conditions are not the cause of Plains vegetation development (Lutz, 1934; Andresen, 1959). Most workers feel that fire is the principal causative factor in the development of Plains vegetation (Lutz, 1934; Andresen, 1959; McCormick and Buell, 1968). Lutz (1934) estimated that fires were twice as frequent in the Plains

(6–8 years) as in the Barrens (16–26 years). Little and Somes (1964) reported that dwarf pitch pine sprouts from the Plains did not seem to have the ability to develop into normal size trees in the absence of fire but that seedling progeny might be able to grow to normal size. Little (1972) showed that over a six year period, seeds from dwarf pitch pine grown in the Plains often developed into dwarf trees with many crooked and flat topped stems, and lacking a well defined terminal shoot. Good and Good (1975) grew Plains and Barrens pitch pine from seed under uniform environmental conditions (greenhouse, nursery, and phytotron). Their results revealed significant differences between Plains and Barrens trees with Plains progeny being shorter, having less biomass, developing cones earlier, and often having poor shrubby growth form. These more recent studies indicate that fire frequency is not the only factor causing the stunted growth of Plains pitch pine, but that there are inherent differences between Plains and Barrens pitch pines.

The differences in the growth of Plains and Barrens pitch pine can be attributed to one of two possibilities. One is the preconditioning of seeds of the parent by the environment as suggested by Rowe (1964) and Baskin and Baskin (1973). The other possibility is that such differences are genetic as shown by Ledig and Fryer (1972) in connection with cone serotiny in pitch pine. Little (1972) felt that Plains pitch pine was a special race which was favored by the fire history of the Plains although he did not prove that there were genetic differences.

Not only in the Pine Barrens does one find variation in pitch pine. Throughout its entire range pitch pine is a highly variable species, the result of phenotypic plasticity, genetic variation, or both (Ledig and Fryer, 1974). The range of pitch pine is from Maine south to Georgia. South of Maryland, however, pitch pine is restricted to discontinuous patches in the Appalachian Mountains and the western edge of the Piedmont. The most extensive stands are found on the Coastal Plain of the Northeast (Ledig and Fryer, 1974). At the northern extreme, maximum tree height is about 10m with maximum diameters of about 30cm. Maximum height is over 25m with diameters over 75cm at the southern extreme (Ledig and Fryer, 1974). Cone length and width is smallest in the Northeast and increases southward (Perry and Coover, 1933). Wood properties such as mean tracheid length and mean specific gravity also show range variation (Ledig and Fryer, 1974; Saucier and Clark, 1970). It has not been shown whether these variations are the result of phenotypic plasticity or genetic variation. In addition to the results obtained by Good and Good (1975), evidence of genetic variation in pitch pine has been shown by Vaartaja (1959) who demonstrated ecotypic variation in response to photoperiod and bud breaking.

Since it has been shown that inherent differences are found in growth form and biomass of pitch pine in the New Jersey Pine Barrens and Plains (Good and Good, 1975), this study was conducted to determine if significant differences occur in four pitch pine populations in the Barrens and Plains with respect to several morphological and physiological characteristics. Characteristics studied were cone size and weight, cone serotiny, seed size and weight, number of seed per cone, and seed germination.

METHODS

Pitch pines were divided into four populations based on growth form and cone serotiny. They were Plains closed cone (PCC), Barrens open cone (BOC), Barrens closed cone (BCC), and Barrens intermediate cone (BIC). BIC trees had both open and closed cones.

PCC trees were sampled in the West Plains at a site 0.9km SW of state Rt. 72 in Burlington Co., N.J. BOC, BCC, and BIC trees were sampled in Lebanon State Forest, Burlington Co., at a site 0.8km NE of the junction of Rt. 72 and the Jersey Central Railroad. The Plains and Barrens sampling sites were about 12.9km apart.

Collections were made on October 4–5, 1975. Ten trees of each type were selected at random and 10 mature cones were removed from each tree. Cones were individually tagged, weighed, and measured (length and width). Insect damaged and physically deformed cones were eliminated. All BOC cones were placed in a forced air drying oven at 30°C. BOC cones were collected approximately 1–2 weeks before they normally open in the field. While BOC cones will open at room temperature upon maturity, they were placed in 30°C drying ovens to facilitate cone opening. Cones were checked for opening at approximately 12 hour intervals until all cones had opened. PCC, BCC, and BIC cones were divided into four lots and placed into forced air drying ovens at 30°C, 35°C, 40°C, and 45°C. Cones were checked daily for opening over a period of two weeks. After two weeks, unopened cones at 30°C and 35°C were placed in a 40°C oven. After one week, all unopened cones at 40°C were moved up to 45°C. Every two weeks thereafter, the temperature was increased by 5°C until all cones had opened.

After the cones had opened, the number of seeds per cone was determined. Ten seeds from every cone were selected at random, weighed, and measured. Another five seeds from every cone were selected at random and placed in petri dishes with filter paper moistened with 5 ml of distilled water. The dishes were placed in a growth chamber with a 14½ hour photoperiod and a 24°C/21°C temperature regime. After 10 days incubation, germination percentages were determined. Results were evaluated by analysis of variance and least significant difference methods.

RESULTS AND DISCUSSIONS

Cone dimensions and weight.—Table 1 lists the means and standard error for cone characteristics of the four populations. With the exception of BOC and PCC cone lengths, all means were significantly different from each other in all categories. The greatest difference was found in cone weight where BIC cones were almost twice as heavy as PCC cones. For length, width, and weight: BIC > BOC > BCC > PCC.

Cone size was fairly uniform for an individual tree but varied from tree to tree (Table 2). Similar observations were reported by Perry and Coover (1933) over the entire range of pitch pine. It cannot be determined from this study, however, whether the significant differences observed in cone size and weight are the result of phenotypic plasticity or genetic variation.

Cone opening. — All BOC cones opened within 210 hours (approx. 9 da.) at 30°C. Cones from individual trees, however, normally opened within a much shorter time span (Avg. 44 hrs, Table 3). For PCC, BCC, and BIC cones, it appears that a minimum temperature of 40°C is required for cone opening (Table 4). The percentage of cones that open at that temperature, however, varies considerably among populations (11.9% for PCC cones to 60.5% for BIC cones, Table 4). The minimum temperature for maximum cone opening varies from 45°C for BIC cones to 50°C and 55°C for BCC and PCC cones respectively (Table 4).

Cone serotiny is probably controlled by a single gene pair (Teich, 1970; Sittmann and Tyson, 1971). Ledig and Fryer (1972) found serotiny in pitch pine was largely restricted to the Pine Plains and decreased rapidly as one moves away

TABLE 1. — Length, Width, and Weight Measurements of Cones from the Barrens (BOC, BIC, BCC) and Plains (PCC) Populations.
All Groups Differed Significantly at the 5% Level for All Characters Except Where Noted.

Population	Length CM	Width CM	Weight G
BOC 76[a]	5.40 ± .08[b]	3.45 ± .05	25.70 ± .91
BIC 62[a]	6.00 ± .05	3.85 ± .05	32.23 ± 1.12
BCC 59[a]	5.63 ± .13	3.63 ± .05	28.50 ± 1.16
PCC 80[a]	5.29 ± .08[b]	3.25 ± .03	18.38 ± .47

[a] Number of cones sampled.
[b] Not significantly different at the 5% level.

TABLE 2. — Variation in Cone Length and Width Both by Tree and Population.

Population	Avg. Variation in Cone Length (Tree) CM	Variation in Cone Length (Populaton) CM	Avg. Variation in Cone Width (Tree) CM	Variation in Cone Width (Population) CM
BOC	1.29	3.57	.97	2.62
BIC	.73	2.09	.53	1.81
BCC	1.10	3.93	.67	1.67
PCC	1.29	3.11	.53	1.28

from the Plains. They also stated that serotiny in pitch pine is most likely controlled by a single gene pair. Three of the four populations in this study had serotinous cones. Each population, however, had a different minimum temperature for maximum cone opening (45°C for BIC, 50°C for BCC, and 55°C for PCC). The lower temperature for BIC cone opening is probably due to the heterozygous condition for serotiny in this population. BIC trees have both open and closed cones, a condition considered to be heterozygous by Ledig and Fryer, 1972. It appears that heterozygotes do not show complete dominance, therefore, trees which are heterozygotes show characters intermediate of homozygous closed and open cone trees. Differences between PCC and BCC cone opening tempera-

TABLE 3. — Time Span Required for Opening of Multiple Cones from BOC Trees at 30°C.

Tree	Number of Cones	Opening Interval Time Hr.
A	6	61.5– 85.5
B	9	38.5– 85.5
C	10	70.5–108
D	7	38.5–108
E	10	0 – 61.5
F	10	70.5–210.5
G	10	65.5– 85.5
H	6	38.5– 85.5
I	7	38.5– 85.5

TABLE 4. — Relationship Between Temperature and Percent of Cone Opening for Barrens (BIC, BCC) and Plains (PCC) Populations.

Population	Temperature, °C	Percent Opened
BIC	30	1.6
	35	1.6
	40	60.5
	45	96.7
	50	100
BCC	30	0
	35	1.7
	40	42.6
	45	62.1
	50	91.4
	55	100
PCC	30	0
	35	0
	40	11.9
	45	34.2
	50	74.7
	55	100

tures cannot be explained in this manner since both are considered homozygous for serotiny.

Serotinous cones open after fire as a result of melting of the resin seals which hold the cone scales together. It is theorized that frequent fires in the Plains have acted as a selective pressure for the establishment of closed cone trees in the Plains (Ledig and Fryer, 1972).

While serotinous cone trees have no obvious adaptive value in areas of lower fire frequency, serotinous cone trees are present in the Barrens. It is the high dispersal potential of pine seed and pollen which establishes a cline for cone serotiny surrounding the Pine Plains. This results in the occurrence of closed cone trees in areas where serotiny is not an adaptive advantage (Ledig and Fryer, 1972).

Number of seeds per cone. — Seeds per cone means are significantly different from each other at the 5% level with the exception of BIC and PCC cones; BOC(102) > PCC(94) > BIC(87) > BCC(77).

There appears to be no correlation between cone size and weight and the number of seeds per cone (Table 1). Thus, small cone size does not mean a sacrifice in seed number (e.g. PCC cones). Many seedless wings were found in all cones examined, but there appeared to be no significant differences between populations. Similar findings were reported by Good and Good (1975). It was also observed in this study that the seedless wings were found primarily in the upper and lower thirds of the cone. This appears to be an adaptive feature in that cone scales of the lower third of the cone open at an angle so that the scales seal off scales below.

Seed dimensions and weight. — With the exception of BCC and BIC seed lengths and widths, all population means for seed characteristics are significantly different from each other (Table 5). For length, width, and weight of seeds: BIC > BCC > BOC > PCC.

As with cone size and weight, it cannot be determined from this study whether the significant differences observed for seed size and weight are due to phenotypic

TABLE 5. — Length, Width, and Weight Measurements of Seeds from the Four Populations. The Groups Differed Significantly at the 5% Level for the Characters Except Where Noted.

Population	Length MM	Width MM	Weight MG
BOC 750[a]	4.6 ± .01	2.6 ± .01	6.7 ± .05
BIC 610[a]	4.8 ± .02[b]	2.8 ± .01	8.3 ± .03[b]
BCC 555[a]	4.8 ± .02[b]	2.7 ± .01	8.2 ± .08[b]
PCC 800[a]	4.2 ± .01	2.4 ± .01	5.9 ± .04

[a] Number of seeds sampled.

[b] Not significantly different at the 5% level.

plasticity or genetic variation. Cone size and seed size appear to be directly related with large cones containing large seeds and small cones containing small seeds (Tables 1 and 5). Perry and Coover (1933) reported similar findings.

Seed germination. — Germination percentages for the four populations were BOC(96.9), BIC(84.8), BCC(80.8) and PCC(59.0). Although considerable variation in germination percentages was observed seeds of all populations germinated readily without pretreatment. Germination percentages were very high for the three Barrens populations, especially BOC seeds (96.9% germination in 10 days). This is nearly identical with the results reported by Good and Good (1975) of 96% germination. Germination of PCC seeds however, was much lower (59.0%) which does not agree with results reported by Good and Good (1975): 86% germination. While germination was nearly complete after 1 week for the Barrens populations, germination was just starting in the PCC seeds. Greater germination might have occurred in the PCC population if the experiment was longer than 10 days. One factor which may have affected germination in PCC seeds is the temperature and length of exposure to that temperature in the cone opening experiment. Many of the PCC cones were exposed to a 45°C–50°C temperature range for a period of 7 weeks. It is possible that this long exposure time may have affected seed germination (Wakeley, 1954). Seeds used by Good and Good (1975) were obtained from cones subjected to 70°C–80°C temperature for less than 1 hour (Good, personal communication).

SUMMARY

Cone and seed characteristics of the four visually distinctive pitch pine groups (Barrens open cone, Barrens intermediate cone, Barrens closed cone, Plains closed cone) were significantly different for most characters studied. The groups differed mainly in regard to cone weight but also differed in cone length and width. Cone size and weight were not correlated with number of seeds per cone. Each of the three populations with closed cones had a different minimum temperature for maximum cone opening. Plains closed cones required more heat to induce opening than Barrens closed cones. Plains seeds did not germinate as quickly as Barrens seeds. It is concluded that significant variation in cone and seed characters exist in these Plains and Barrens populations. Fire is generally regarded as the major selective force favoring serotinous populations.

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ASPECTS OF THE INTERTIDAL ZONES, VEGETATION, AND FLORA OF THE MAURICE RIVER SYSTEM, NEW JERSEY

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A five year study of the freshwater and brackish intertidal zones, vegetation, and flora of southern New Jersey, southeastern Pennsylvania, and Delaware has revealed aspects that characterize each of the major river systems which occur in this region. The Maurice River and its tributaries are one of these systems. The habitat, vegetation, and floristic data acquired in this study are descriptive in nature and have been obtained from field work, herbarium specimens and the literature.

THE MAURICE RIVER SYSTEM

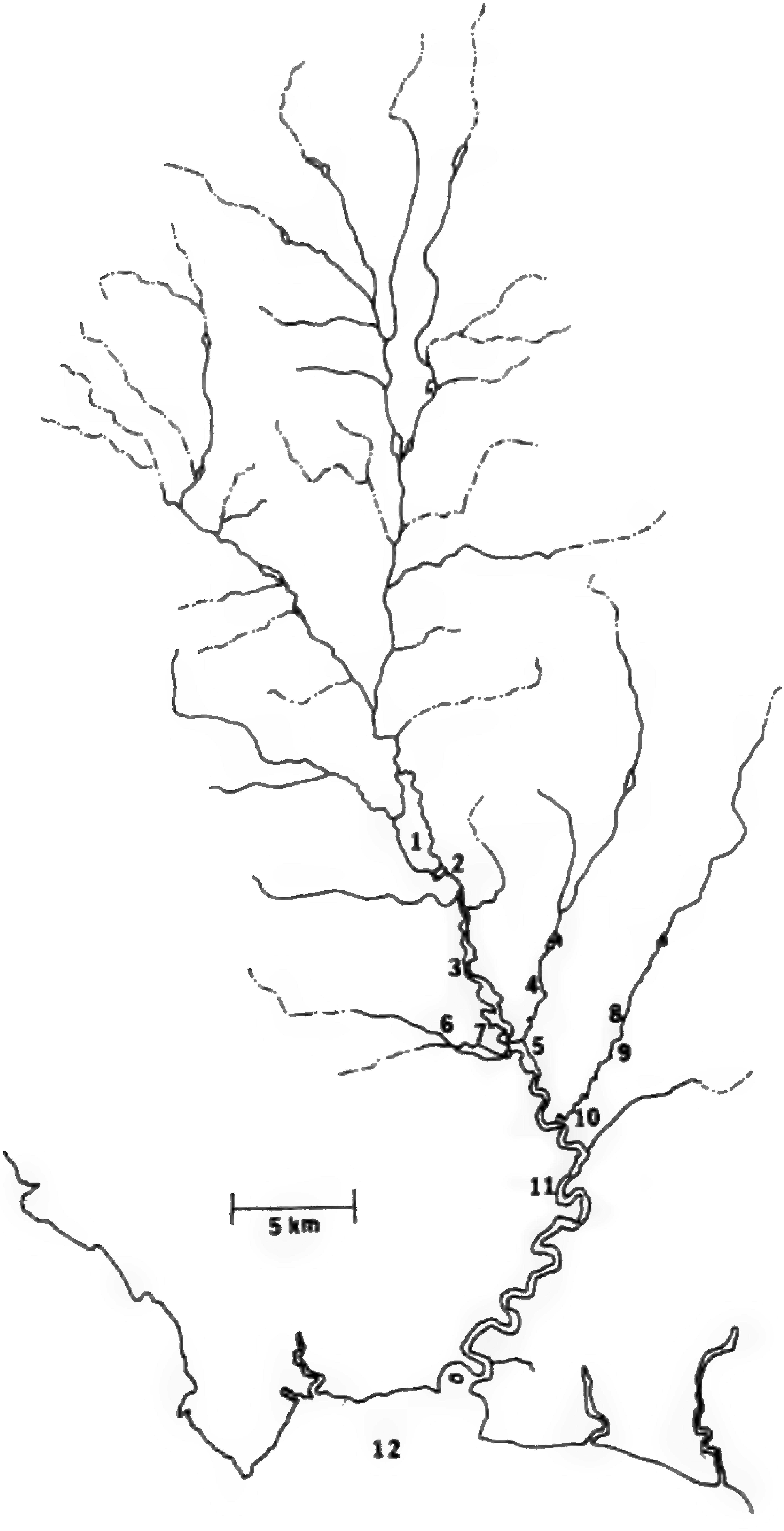
The Maurice River system (Fig. 1), one of the principal tributaries of the Delaware River estuary, flows through portions of Gloucester, Salem, Atlantic, and Cumberland Counties, New Jersey. Of the three large river systems in the southern half of the state, it is the only one with a general southern drainage to the Delaware Bay. The other two, the Mullica and Great Egg Harbor River systems, flow east and southeast to the Atlantic Ocean. However, all three are confined to the Outer Coastal Plain and occur within the pine barrens.

The Maurice River is tidal below Union Lake, Millville. The freshwater to slightly brackish intertidal zones occur downstream to the vicinity of Port Elizabeth and Mauricetown and extend up the two important tidal tributaries: Manantico Creek and Manumuskin River. Walton & Patrick (1973) have reported that, excluding the immediate vicinity of Millville, this portion of the Maurice River system has some organic enrichment not degrading of the water quality, has had little development, is in a healthy condition, and supports a diverse flora.

HABITATS AND VEGETATION

Three important habitats occur in the freshwater to slightly brackish portion of the Maurice River system. Sand and gravel shorelines comprise one such habitat and usually occur on undercut slopes of river meanders where sand and gravel sediments have been exposed. The shoreline just above Buckshutem Creek

FIG. 1. — The Maurice River system and vicinity. 1. Union Lake; 2. Millville; 3. Maurice River; 4. Manantico Creek; 5. Manantico; 6. Buckshutem Creek; 7. Laurel Lake; 8. Manumuskin River; 9. Manumuskin; 10. Port Elizabeth; 11. Mauricetown; 12. Delaware River estuary.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is a good example, having a steep bank above the shore into which the river is eroding. *Scirpus pungens* Vahl. usually dominates the mid-tidal portion of this habitat, although *Spartina alterniflora* Loisel becomes important downstream with the increase in salinity. Towards the upper tidal limit there is frequently a vegetation of mixed aquatic species which approaches the diversity of the freshwater tidal marshes in this system.

The Maurice River system has an abundance of mud and silt associated with its intertidal zones, and numerous mud flats, a second habitat, apparently result from an accumulation of the fine-grained sediment in protected areas along the river. Such areas include the slip-off slope of the Maurice River meander immediately above the mouth of the Manumuskin River and below the sand and gravel shore of an old undercut slope; a silted-in cut-off meander opposite Port Elizabeth; and a broad cove above the mouth of Manantico Creek. The mud flats have been found either to support pure stands of *Zizania aquatica* L.; to be dominated by patches of *Nuphar advena* (Ait.) Ait. f. and to occur below a firm upper tidal marsh of mixed aquatic species; or to be largely barren of vegetation excepting a rim of vegetation that is usually dominated by *Peltandra virginica* (L.) Schott and Endl., *Pontederia cordata* L., *Scirpus pungens,* and *Spartina alterniflora.*

Densely vegetated, peaty tidal marshes (Fig. 2) — fresh to brackish — are a third important habitat. The most upstream marsh of this kind occurs above City Park, Millville; extensive, contiguous marshland begins about 2.5 km below here. The upstream, freshwater marshes support a mixed aquatic vegetation which is

FIG. 2. — Freshwater tidal marsh along the Manumuskin River in late June.

quite variable, but which often includes *Amaranthus cannabinus* (L.) J. D. Sauer, *Bidens laevis* (L.) BSP., *Sagittaria latifolia* Willd., *Scirpus validus* Vahl, *Typha angustifolia* L. and *Zizania aquatica.* Marshes bordering upland vegetation frequently support *Acorus calamus* L. and *Rosa palustris* Marsh in addition to the above species. The general aspect of the freshwater tidal marshes of the Maurice River system appears to be similar to that of marshes from other areas of the Delaware estuary described and analyzed in detail by McCormick (1970), McCormick and Ashbaugh (1972), and Good and Good (1975).

Freshwater tidal marshes are transitional to brackish marshes between Port Elizabeth and Mauricetown: brackish marsh vegetation, including a mixture of *Spartina alterniflora, Peltandra virginica,* and *Pluchea purpurascens* var. *succulenta* Fern., reaches its upstream limit at the mouth of the Manumuskin River. However, some species characteristic of other brackish habitats are found further upstream: *Spartina alterniflora* occurs as a lower tidal shoreline species to within the Millville City Limit; *Scirpus cylindricus* (Torr.) Britt., a plant restricted to brackish shores and marshes of the Atlantic Coast of North America (Schuyler, 1975), has been collected from only one locality in the Maurice River system, an area about .5 km north of Manantico Creek (upper tidal marsh, 8 Aug 1973, *Ferren 1264* [1]) in the vicinity of the upstream limit for *S. alterniflora.*

The species diversity and vegetation of the above habitats are frequently dependent upon the substrate conditions. Walton and Patrick (1973), however, have summarized the vegetation across habitat boundaries within the intertidal zones of the Maurice River. They reported that *Zizania aquatica* dominated both shores of the river above the vicinity of Port Elizabeth, that *Pontederia cordata* and mixed freshwater species were secondary, and that there were small stands of *Nuphar advena* and *Peltandra virginica.* The area from the vicinity of Port Elizabeth downstream to Mauricetown was dominated by *Zizania aquatica* and *Phragmites australis* (Cav.) Trin. ex Steudel with mixed freshwater and mixed saltwater species and *Spartina alterniflora* secondary. *S. alterniflora* was dominant below Mauricetown.

THE INTERTIDAL FLORA

One of the characteristics of the Maurice River system is the presence of three species whose current frequency and abundance in New Jersey is greatest in the intertidal zones of this river system. *Aeschynomene virginica* (L.) BSP., reaches its northern limit of distribution in North America along the Wading River, Burlington County, New Jersey (sandy gravelly shore by bridge at the village Wading River, 10 Sep 1919, *Long 10818;* and, firm peaty edge of tidal marsh on south shore, 27 Sep 1974, *Ferren 1371*). Specimens in the herbarium of the Academy of Natural Sciences of Philadelphia indicate that *A. virginica* was once more

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[1] All specimens cited herein are in the herbarium of the Academy of Natural Sciences of Philadelphia.

FIG. 3.—*Aeschynomene virginica* (arrow) in a freshwater tidal marsh along the Manumuskin River.

widespread in the Delaware River system than it is at present. There are about 20 localities recorded before 1935 for *A. virginica* in this river system; Tatnall (1946) states that this plant was formerly frequent on tidal shores of the Delaware River from Holly Oak to Delaware City, Delaware. Today *A. virginica* is known to occur in New Jersey only from the Wading River where it is scarce at the above locality, and from the Maurice River system. It is infrequent along the Maurice River above Port Elizabeth (sandy tidal shore just N of the mouth of Manumuskin River in a dense mixed aquatic band which included *Spartina alterniflora, Aster subulatus* [Michx.], *Scirpus validus, Polygonum punctatum* [Ell.], and *Zizania aquatica,* 23 Aug 1973, *Ferren 1289*). It reaches its known maximum abundance in New Jersey on the Manumuskin River at Manumuskin (firm peaty freshwater marsh just below the railroad bridge, 2 Aug 1975, *Ferren 1416*) (Figs. 3 & 4). Here it is associated with a diverse flora among which includes the following:

Apios americana Medic.
Bidens laevis
Carex stricta Lam.
Cephalanthus occidentalis L.
Cicuta maculata L.
Cinna arundinacea L.
Dulichium arundinaceum (L.) Britt.
Hypericum mutilum L.

Impatiens capensis Meerb.
Juncus acuminatus Michx.
Leersia oryzoides (L.) Sw.
Lobelia cardinalis L.
Oxypolis rigidior (L.) C. & R.
Peltandra virginica
Polygonum arifolium L.
Polygonum sagittatum L.
Pontederia cordata
Rosa palustris
Sagittaria latifolia Willd.
Scirpus validus
Sium suave Walt.
Zizania aquatica

Gratiola virginiana L. (Fig. 5) is another plant which reaches its northeastern limit of distribution in southern New Jersey; it has been collected northward to Burlington County (Burlington, [1820–30?], [*Conrad?*]) and Ocean County (wet ditch E bordering swampy woods, Manahawkin, 21 Aug 1923, *Long 28846*). Although Fairbrothers and Hough (1973) consider this plant to be endangered in New Jersey and state that it is currently known from one station in Cape May County, it is frequent along the muddy and occasionally sandy tidal shores of the Maurice River, Cumberland County (tidal mud below an upper tidal marsh about 0.4 mi. N of mouth of Manantico Cr, 8 Aug 1973, *Ferren 1271;* muddy shore just N of Buckshutem Cr, E of Laurel Lake, 18 Sep 1972, *Ferren 1128;* clayey tidal marsh area at mouth of small creek about 1.5 mi. N of Laurel Lake, 23 Aug 1973, *Ferren 1295;* in dense shoreline vegetation along sandy tidal shore

FIG. 4. — *Aeschynomene virginica,* Manumuskin River.

FIG. 5. — *Gratiola virginiana* on the open, muddy, tidal shore of a cove along the Manumuskin River, Port Elizabeth.

about 0.25 mi. SE of Manantico Cr, 8 Aug 1973, *Ferren 1256;* and tidal mud NW of Manantico, Aug–Oct 1935, *Long 45586a, 45587, 47942*). It is locally abundant opposite Port Elizabeth in tidal mud of the Manumuskin River (shore under shade of tree, 19 Jul 1972, *Ferren 965;* and shore of cove, 8 Aug 1973, *Ferren 1273*). Although *G. virginiana* most frequently occurs in open tidal mud in the Maurice River system, it also has been collected from densely vegetated substrates. In tidal situations of this river system *G. virginiana* is usually associated with *Lindernia dubia* (L.) Penn., *Ludwigia palustris* L. and *Polygonum punctatum* and has always been found here growing with *Elatine americana* (Pursh) Arn. by the author.

Elatine americana has been recorded from several lakes and tidal river systems in New Jersey, including Lake Hopatcong, Morris County (25 Sep 1869, *Porter*) and the Delaware River system. Although there are numerous records from the latter, today it is only known to occur on Rancocas Creek (mostly barren clayey peaty creekside escarpment adjacent to tidal marsh, 8 Sep 1972, *Ferren 1075*); the Alloway Creek system (tidal clay and mud islands in sand and gravel stream bed, 1 mi. W of Alloway, 4 Oct 1973, *Ferren 1333*); and the Maurice River system. On the Maurice River it is found from Millville (sandy tidal shore, 23 Aug 1973, *Ferren 1292*), downstream to just north of the mouth of the Manumuskin River (sandy upper tidal shore, 23 Aug 1973, *Ferren 1278*);

on the Manumuskin River it has been collected opposite Port Elizabeth (muddy tidal margin of cove, 8 Aug 1973, *Ferren 1274*). Even though *Elatine americana* has been considered to be endangered in New Jersey (Fairbrothers & Hough, 1973), it is frequent on the muddy and occasionally sandy tidal shores above Port Elizabeth and is locally abundant at several localities in this area (Fig. 6). Under the above substrate conditions *E. americana* has been found growing on open shorelines or those dominated by scattered plants of *Scirpus pungens* and/or *Spartina alterniflora* and may be associated with *Lindernia dubia, Gratiola virginiana, Polygonum punctatum, Sagittaria graminea* Michx., *Isoëtes riparia* Engelm., *Eriocaulon parkeri* Rob., and *Myriophyllum humile* (Raf.) Morong.

The occurrence in the Maurice River system of *Bidens bidentoides* (Nutt.) Britt. and *Bidens frondosa* var. *anomala* (Porter ex Fern.) Fern. further enhances the floristic significance of this system. Within the study area these plants are characteristic of only the Delaware River system and among the predominantly pine barren rivers occur only on the Maurice River. *B. bidentoides* is restricted to freshwater to slightly brackish tidal shores of the Hudson and Delaware River systems (Fernald, 1950); it has been collected on the Maurice River in the vicinity of Millville (muddy shores, 7 Oct 1909, *Long*) and at Manantico (tidal shore, 20 Oct 1935, *Long 47875*). *B. frondosa* var. *anomala* is occasional from Que-

FIG. 6. — *Elatine americana* (arrows) with *Gratiola virginiana* and *Polygonum punctatum* in an open stand of *Scirpus pungens* and *Spartina alterniflora* along the mud- and algae-covered, sandy, tidal shore of the Maurice River above Port Elizabeth.

bec to Ontario and south to Washington, D.C. and Kansas (Fernald, 1950), and in southern New Jersey is restricted to the upper tidal zones of the Delaware River System, including the Maurice River at Millville (sandy muddy tidal shore, 8 Nov 1936, *Long 49372*), Manantico (crest of embankment along tidal shore at old brickyard, 20 Oct 1935, *Long 47881*), Laurel Lake (high tide limit at base of sandy bluff, 18 Sep 1972, *Ferren 1130*), and near Port Elizabeth (high tide limit of sandy shore just N of the mouth of the Manumuskin River, 18 Sep 1972, *Ferren 1132*).

Unlike *Bidens bidentoides, Bidens frondosa* var. *anomala, Gratiola virginiana,* and *Elatine americana* which are absent from the tidal habitats of all pine barren river systems, but the Maurice, one plant, *Eleocharis olivacea* f. *reductiseta* Schuyl. & Ferr., is known to be restricted within the study area to tidal habitats of those rivers (Schuyler & Ferren, 1975). It has been collected on the Maurice River at Manantico (sandy muddy tidal shore by old brickyard, 1 Nov 1939, *Long 49275*), the only locality for this plant in the Delaware River System.

The above suggests that the freshwater intertidal habitats of the Maurice River system are areas of transition between the flora characteristic of similar habitats in the Delaware River and coastal pine barren river systems. Furthermore, like other pine barren systems the Maurice River system lacks many of the intertidal plants that characterize the Delaware River. Among these are *Micranthemum micranthemoides* (Nutt.) Wettst. and *Limosella subulata* Ives. However, the occurrence of *Bidens bidentoides* and *Bidens frondosa* var. *anomala* demonstrate the association of the Maurice and Delaware River systems. The Maurice River system is distinguished among these river systems by the unusual frequency and abundance of *Aeschynomene virginica, Elatine americana,* and *Gratiola virginiana.* Continuity of the freshwater intertidal flora among all of the river systems of the study area is provided by the occurrence of *Aeschynomene virginica, Eriocaulon parkeri, Isoëtes riparia,* and *Zizania aquatica* in each of these systems.

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OBITUARY

William L. Dix (1875-1972). — William L. Dix, a member of the Philadelphia Botanical Club since 1942, died on December 26, 1972 at the age of 97. He was born on April 17, 1875 at Shehawken, Wayne County, Pennsylvania, oldest son of Alpheus and Janet Howell Dix.

Mr. Dix attended district schools at Shehawken and Starrucca, and received a Teacher's Certificate in the winter of 1892. He taught school in Connecticut for several years, and then entered Hotchkiss School, graduating in 1898. He then attended Yale University, graduating in 1902; in 1905 he received a Master of Arts degree at the same university.

In 1907 Mr. Dix became a teacher of English and Latin in Trenton, New Jersey. He was named principal of Jefferson School in Trenton in 1923, retiring from teaching in 1937.

After his retirement, Mr. Dix devoted most of his time to his avocation, Botany. Working out of the family home along the shore of Lake Shehawken, Mr. Dix collected plants from northeastern Pennsylvania for the University of Pennsylvania. He was engaged by the Academy of Natural Sciences of Philadelphia to curate its lichen collection. A writer of articles for publication, especially on ferns and lichens, he published accounts of the ferns of Wayne County and of the lichens of Pennsylvania. His work was published in Bartonia and The Bryologist.

Another avocation was local history in Northern Wayne County. He wrote many historical articles on the early residents of Preston and Scott Townships including a volume on the Dix family genealogy.

Mr. Dix enjoyed teaching children long after his retirement, often taking numerous children on his field trips. Residents of Shehawken will long remember William Dix for his contributions to the community.

Surviving are two daughters, Mrs. Charles Chase and Mrs. Edward Kurzenberger, four grandchildren, and two great-grandchildren.

Burial services were held in the Shehawken Cemetery not far from the Dix family home built a century ago. — *Patricia H. Christian.*

NEWS AND NOTES

Dr. Wherry's Birthday Celebrated. — On September 14, 1975, more than fifty members and friends of the Philadelphia Botanical Club honored Dr. Edgar T. Wherry on reaching his 90th birthday on September 10. Exhibited were specimens of Polemoniaceae and ferns annotated by Dr. Wherry. Also included were plants named by and for him, and specimens from The Edgar T. Wherry Collection. On display were some of his many publications including "The Wild Flower Guide" and "The Fern Guide".

Drs. James Mears, John M. Fogg, Jr., and Raymond Fosberg were the principal speakers, praising Dr. Wherry for his notable achievements as a mineralogist, naturalist, ecologist, and botanist. His students remember him for his patient, friendly interest in each individual. He is responsible for much of the work done on the "Atlas of the Flora of Pennsylvania".

Since the combined herbaria of the Academy of Natural Sciences and the University of Pennsylvania (both in the Academy) contain most of the plants recorded in the Flora of Pennsylvania, it seemed appropriate to have a plaque designed for display. It was presented by Dr. Mears who read the inscription: "This Collection Contains the Herbarium of the Vascular Flora of Pennsylvania Compiled Primarily by Dr. John M. Fogg, Jr., Dr. Edgar T. Wherry and Dr. Herbert A. Wahl. Dedicated September 14, 1975."

The celebration concluded after Dr. Wherry cut the traditional birthday cake and was greeted by guests. — *Grace M. Tees.*

Field Trip. — A field trip organized by the Herbarium Committee of the Philadelphia Botanical Club took place on June 21, 1975. The seven club members attending visited an interesting region of the pine barrens and oak-pine woodland in Cumberland County, New Jersey. The objective was to relocate and collect for the Local Herbarium specimens of the oaks and pines that were recorded for this area earlier in the century. Most of the day was spent along Dividing Creek Road from about 1.5 to 4 miles north of Dividing Creek. The habitats investigated included a dry, oak-pine woods and two rich flood-plain woods. The oaks that were located and collected are as follows: *Quercus alba* L., *Q. coccinea* Muenchh., *Q. falcata* Michx., × *Q. heterophylla* Michx. f., *Q. ilicifolia* Wang., *Q. marilandica* Muenchh., *Q. michauxii* Nutt., *Q. phellos* L., *Q. prinus* L., *Q. rubra* L., *Q. stellata* Wang., and *Q. velutina* Lam. *Quercus palustris* Muenchh. was seen but not collected and *Q. prinoides* Willd. and *Q. bicolor* Willd., previously collected, were not found. Pines collected were *Pinus echinata* Mill., *P. rigida* Mill., and *P. virginiana* Mill. *Pinus taeda* L. was not found. *Pinus rigida* ssp. *serotina* (Michx. f.) R. T. Clausen was found in a *Chamaecyparis*-pine-oak wet woods about 1.2 miles north of Hayleyville. — *Wayne R. Ferren, Jr.*

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ELEOCHARIS QUADRANGULATA (MICHX.) R. & S. IN TIDEWATER MARYLAND

WILLIAM S. SIPPLE

Maryland Department of Natural Resources

Numerous distribution data were collected in Maryland's tidal wetlands and shorelines by the author between 1971 and 1976 with the goal of documenting vascular plant species distributions. Observations were made throughout the sixteen tidewater counties and the City of Baltimore. Data from about six hundred sites were collected. From this work has come the discovery of *Eleocharis quadrangulata* (Michx.) R. & S. at four new stations in the Chesapeake Bay area (Fig. 1): at Plum Creek off the Elk River at Old Point Road (Cecil County); at about one-quarter mile north of Ferry Point Landing on the Patuxent River (Anne Arundel County); on Mataponi Creek about one-half mile from its confluence with the Patuxent River (Prince Georges County); at about one-quarter mile south of Douglas Point on the Potomac River (Charles County). Except for the collection near Douglas Point, these specimens were growing on freshwater marsh peat in the intertidal zone; the Charles County site has standing water but is not flooded by each tide because of a low berm between the marsh and the Potomac River. These plants were associated with various freshwater tidal-marsh species. Voucher specimens have been deposited in herbaria of the Academy of Natural Sciences of Philadelphia (PH) and the University of Maryland (MARY).

Eleocharis quadrangulata is not considered common in tidewater Maryland; to determine its recorded status (Fig. 1) the author consulted herbaria at the Academy of Natural Sciences (PH), the University of Maryland (MARY), the Patuxent Wildlife Research Center, and the National Museum of Natural History (US).[1] Collections were located from Maryland's tidal wetlands only from two localities: at Little Blackwater River in Dorchester County and at Kings Creek. The exact location of the latter site is doubtful since no county was listed on the voucher specimen examined and a number of Kings Creeks occur in tidewater Maryland. A site at Ocean City (1891) is probably non-tidal because saline waters are characteristic of most of Worcester County's tidal shoreline. A number of specimens have been collected in non-tidal conditions at Snowden Pond on the Patuxent Wildlife Research Center; according to Francis Uhler (Pers. Comm.) this species was planted there from Mississippi seed stock in the early 1940's. From Delaware, it was collected (1890's–1910) at a number of non-tidal sites, one of which is at Elise Pond (Sussex County), a tributary to Maryland's tidal Nanticoke River. One Virginia tidal collection site (1933) is at the mouth of Dogue Creek at its confluence with the Potomac

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[1] The author wishes to thank the curators of the above herbaria for the use of their facilities.

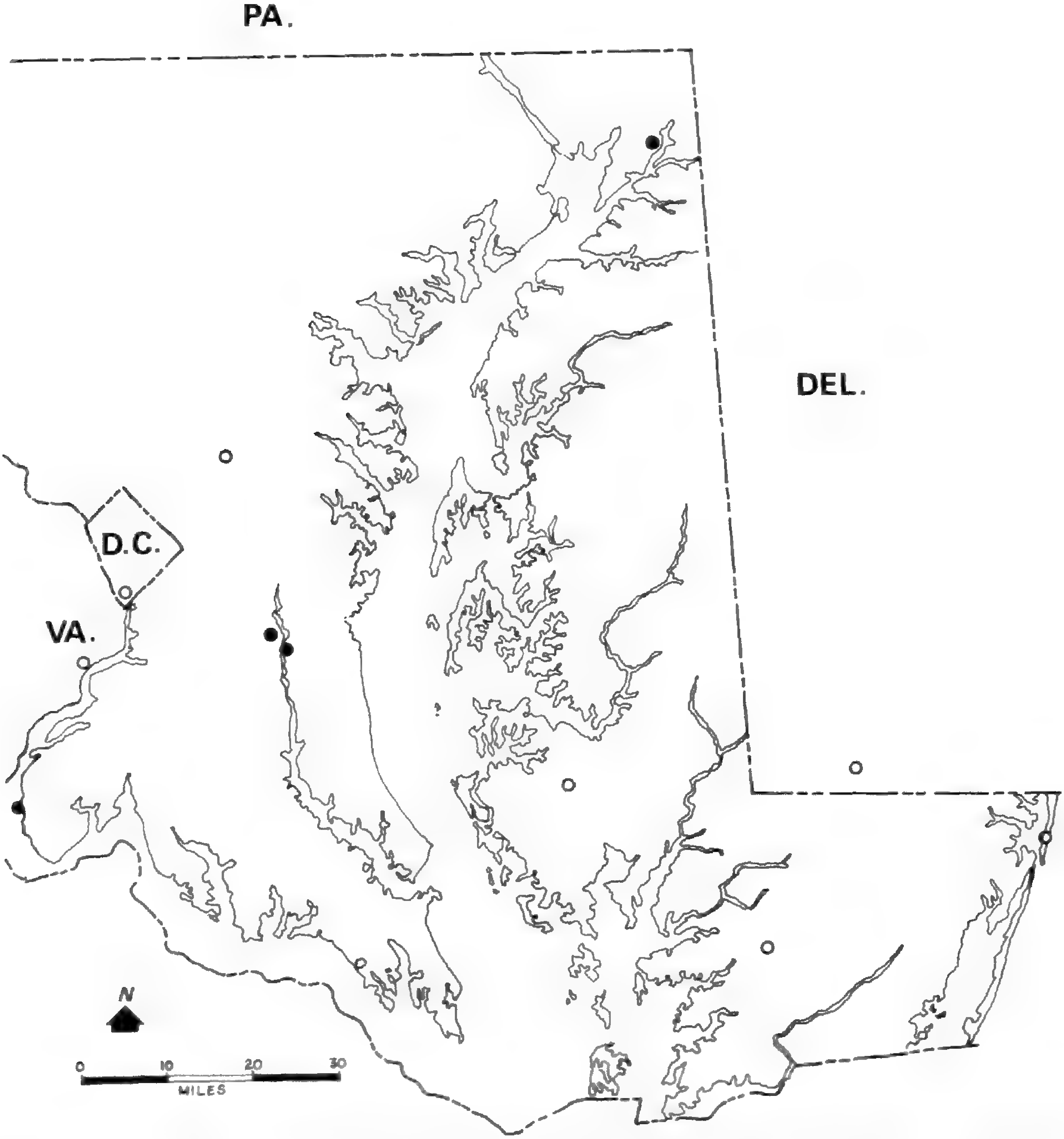

Fig. 1 — Map of tidewater Maryland indicating the author's collection sites of *Eleocharis quadrangulata* as dots and approximate documented herbarium collection sites as circles.

River (Fairfax County). A number of collections were also made from Washington, D.C. (1870's–1880's); these were probably non-tidal and undoubtedly no longer exist.

Fernald (1950) considered *E. quadrangulata* to occur in "pools and creeks (often tidal), chiefly of Coastal Plain, S.C. and Tenn. to Cape May, N.J." Variety *crassior* Fern. was considered by Fernald to occur from "n. Fla. to Tex., locally n. to Mass., Ct., N.Y., s. Ont., O., Mich., Wisc., Mo. and Okla." Tatnall (1946) considered it to occur infrequently in coastal plain swamps, streams, and ponds. In addition, Norton and Brown (1946) did list variety *crassior* for Maryland. This species was not, however, listed in an Anne Arundel County flora by Stieber (1971), a county in which it was collected by the author in 1975. In fact, it was listed for Maryland only in Dorchester County in literature reviewed by the author.

The past paucity of collections of *E. quadrangulata* in Maryland may be due to its superficial resemblance to a common marsh species—*Scirpus olneyi* Gray. However, it may be that *E. quadrangulata* is extending its range in Maryland's tidal areas. For example, Snowden Pond is a tributary to the non-tidal portion of the Patuxent River; it may be that the recent tidal collections documented here by the author may have received their propagules from the introduced Mississippi seed stock in the pond. The pond probably would not, however, account for the Cecil County collection which is in a different tributary to the Chesapeake Bay much farther to the north.

Few tidal stations were known to exist for *E. quadrangulata* in Maryland prior to my recent collections. Furthermore, the documented range of this species in Maryland is substantially increased; however, this species should still be considered rare or uncommon in Maryland's tidal wetlands.

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THE FERNS OF THE COUNTY LINE SERPENTINITE DIKE

Edgar T. Wherry
University of Pennsylvania

About ten miles northwest of the Philadelphia City Hall the Schuylkill River has cut through a dike of serpentinite rock, which must have long formed bluffs on both banks. Besides the serpentine it also contains masses of talc, a mineral so soft as to be known colloquially as soapstone, and veins of crystalline calcite and dolomite, which weather to calcareous soil, in which calcicolous plants grow. The Indians, and in time the white men, quarried out soapstone, leaving debris of the harder minerals. Roads and railroads were early constructed between the bluffs and the river shores. On the northeast bank just west of the dike there was built a railroad station, long known as Lafayette but now named Miquon. The line between Montgomery and Philadelphia counties northeast of the river follows the crest of the dike. The Philadelphia portion is now the property of the Schuylkill Valley Nature Center. On the southwest side of the river the construction of the Schuylkill Expressway destroyed the bluff.

In crevices of the bluffs the following ferns grew disjunctly: *Asplenium platyneuron* and *trichomanes, Asplenosorus ebenoides, Camptosorus rhizophyllus, Cheilanthes lanosa, Cystopteris bulbifera, Pellaea atropurpurea* and *glabella, Polypodium virginianum,* and *Woodsia obtusa.*

The presence of these ferns here began to attract the attention of amateur botanists in the mid-1830's. Their collections, originally preserved in their private herbaria, came in time into the comprehensive ones of the Academy of Natural Sciences of Philadelphia and the University of Pennsylvania, from which the data here assembled have been obtained. In order of their first collections they were:

1845, Dr. Gavin Watson, a temporarily-resident Scottish physician.
1860, William Wynne Wister, a Germantown banker, whose interest had been aroused by hearing lectures by Thomas Nuttall.
1861, Aubrey H. Smith, a Philadelphia lawyer.
1865, Robert Robinson Scott, an Irish-American Philadelphia printer, who discovered on the south-bank bluff the first native colony of the notable hybrid of *Asplenium platyneuron* & *Camptosorus rhizophyllus* which he named in 1866 *Asplenium ebenoides* (colloquially "Scott's Spleenwort.")[1]
1866, Charles F. Parker, a Camden bookbinder, enthused by conversations with C. S. Rafinesque.
1867, Isaac Burk, a Philadelphia tailor, advised by his physician to take up some outdoors activity.
1875, Charles E. Smith, a civil engineer who became president of the Philadelphia and Reading Railroad.

By now these plants have mostly vanished from the area.

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[1] He kept no type specimen, but there is a fragmentary clastotype in the University of Pennsylvania herbarium.

ADDITIONS TO THE CHECK-LIST OF THE FLORA OF MONTGOMERY COUNTY

ANN NEWBOLD

Bechtelsville, Pennsylvania

The following species comprise additions to Wherry's "Check-List of the Flora of Montgomery County, Pennsylvania," published in *Bartonia* 41:71-84; herbarium specimens have either been placed or found in the Local Herbarium of the Academy of Natural Sciences, Philadelphia, Pa. The total recorded taxa of the county now becomes 1831, of which 1230 are presumed to be indigenous and 601 introduced. Introduced taxa are surrounded by brackets. The species *Elsholtzia ciliata* is new to the records of the flora of the state of Pennsylvania.

GRAMINAE: *Alopecurus* [*pratensis*], [*Avena fatua*], *Setaria* [*glauca*], [*Sorgum halepense, vulgare*], *Vulpia* [*myuros*]. JUGLANDACEAE: *Carya laciniosa*. LILIACEAE: *Lilium* [*tigrinum*], [*Scilla sibirica*], [*Yucca smalliana*]. CARYOPHYLLACEAE: [*Lychnis alba*], *Silene* [*cucubalis*]. RANUNCULACEAE: *Ranunculus* [*ficaria*]. SAXIFRAGACEAE: *Heuchera americana*. HAMMELIDACEAE: [*Liquidambar styraciflua*]. ROSACEAE: *Potentilla* [*argentea, intermedia*]. LEGUMINOSAE: *Desmodium viridiflorum, Lespedeza* [*cuneata*], [*Trifolium agrarium, procumbens*]. GERANIACEAE: *Geranium* [*molle*]. VITACEAE: *Parthenocissus quinquefolia*. THYMELACEAE: *Dirca palustris*. ONAGRACEAE: *Epilobium* [*hirsutum*]. CONVOLVULACEAE: *Convolvulus* [*japonicus*]. LABIATAE: [*Elsholtzia ciliata*], *Mentha* [*crispa*]. *Stachys palustris*. SOLONACEAE: *Solanum* [*nigrum*]. SCROPHULARIACEAE: *Lindernia anagallidea*. COMPOSITAE: [*Picris hieracioides*], [*Taraxacum officinale*], [*Arctium lappa*], [*Baccharis halimifolia*], [*Carduus nutans*], *Cirsium pumilum, Helenium nudiflorum*, [*Matricaria matricarioides*].

NOTES OF LEAF TEMPERATURE BALANCE IN *SEDUM ADOLPHI* (CRASSULACEAE)

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A preliminary study of temperature balance was initiated under laboratory conditions for leaves of greenhouse-grown *Sedum adolphi* Hamet. (Crassulaceae), a succulent herb of Mexico. Conventional energy-balance theory (Gates and Benedict 1963, Gates et al 1965, Felger and Lowe 1967, Vogel 1970) was used to predict that: (1) large *Sedum* leaves reach higher equilibrium temperatures under high radiation loads than do small leaves; (2) horizontal orientation of the flat leaf surface relative to radiation source will maximize equilibrium temperature of the leaf; (3) large leaves will cool more slowly than small leaves when subjected to low temperatures.

Materials and Methods

Twenty *Sedum* leaves were excised. Leaf volumes ranged from 17 to 399 mm^3. Fine thermocouples (36 gauge, copper-constantan) were inserted into each leaf parallel to the long axis. Each leaf was supported by its base with a metal clamp insulated with plastic or cardboard. A 100 watt incandescent light bulb with reflector was placed 20 cm above each leaf.

Leaf temperatures were recorded with a potentiometer before heating began and after 9.5 minutes of heating. Preliminary measurements indicated that all leaves reached equilibrium during a period of 9.5 minutes. Each leaf was subjected to three separate heating periods: once with the flat surface facing the light (normal orientation), once with the edge facing the light, and once with the rounded surface facing the light (Fig. 1). Initial temperature varied among leaves. Data were therefore expressed as change in temperature between time 0 and 9.5 minutes. The experiment was repeated using an additional 20 leaves. In the second replicate leaves were oriented with the rounded surface facing the light.

Ten excised leaves of known weight were placed 10 cm below 100 watt incandescent bulbs. The cut base of each leaf was sealed with wax. After 3 hours the leaves were reweighed.

Twelve leaves of varying volume were supported inside a darkened, insulated container. Internal leaf temperatures were recorded after leaves reached constant temperature (20 minutes). This was done to determine if initial leaf temperature in the absence of radiation load was correlated with leaf volume.

Ten leaves were supported in a darkened freezer with air temperature of −6.9°C. No contact between leaves and freezer surface was permitted. Internal leaf temperature under ambient laboratory conditions was measured before cooling; time required to reach 0°C was then recorded.

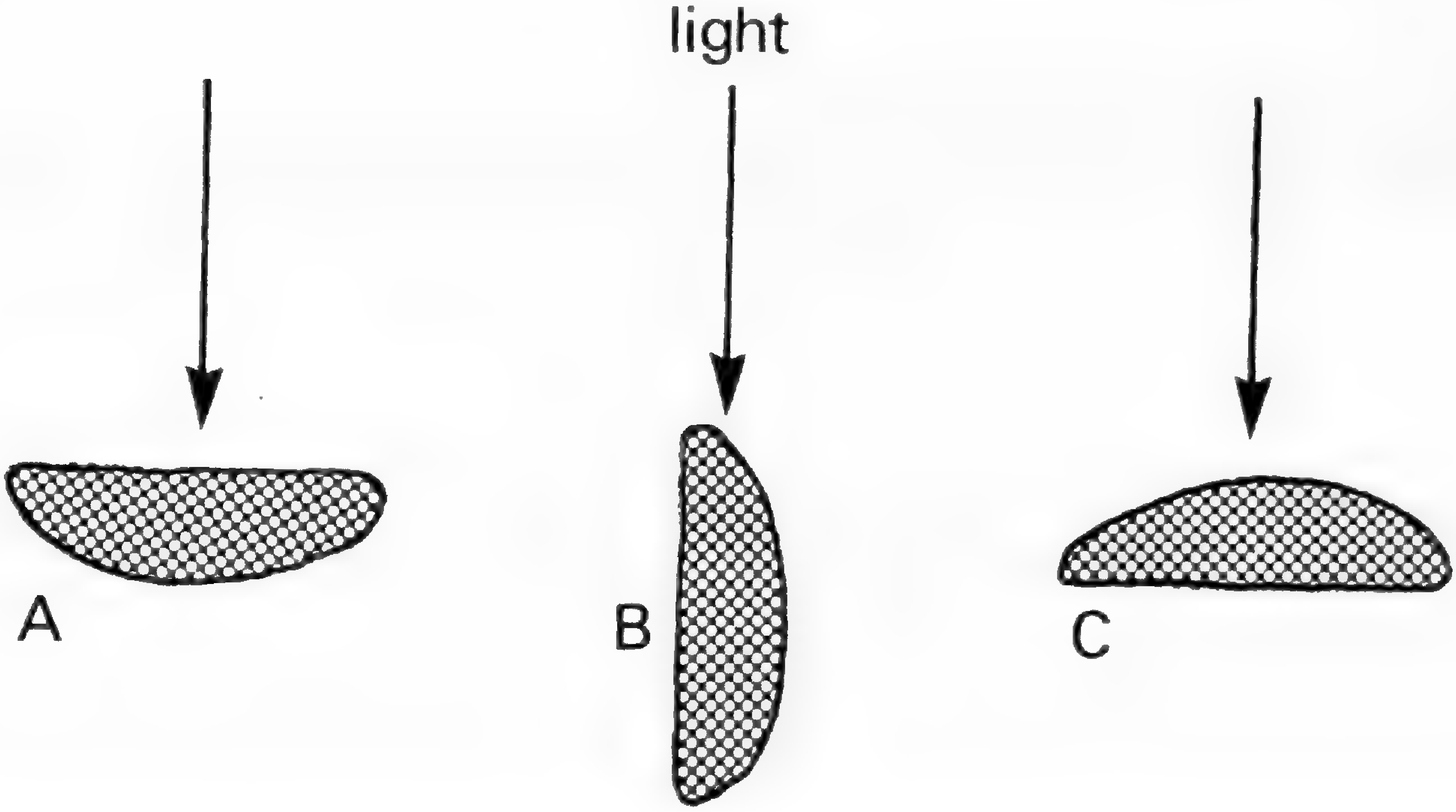

Fig. 1.—Orientation of leaves relative to light source. Drawn to scale.

RESULTS

Mean change in temperature for time 0 to 9.5 minutes under high radiation load was significantly affected by leaf orientation: a 3.7°C change when the flat surface was exposed, 2.9° when the round surface was exposed, and 2.0° when the leaf edge was exposed. These means are significantly different according to the *t*-test ($P < 0.025$). This result is consistent with existing theory (Vogel, 1970).

Mean change in temperature from time 0 to 9.5 minutes (y) was negatively correlated with leaf volume (x) ($y = -4.35 \cdot 10^{-3}x + 3.61$, $r = -0.72$, $P < 0.01$ for the first replicate; $y = -5.48 \cdot 10^{-3}x + 5.21$, $r = -0.82$, $P < 0.001$ for the second replicate) (Fig. 2). The rounded sides of the leaves were facing the light in both analyses. Thus, smaller leaves increased in temperature more than did large leaves, a result not predictable from energy budget theory. Initial internal leaf temperatures (y) were positively correlated with leaf volume (x) for unheated leaves in diffuse laboratory lighting ($y = 21.38x^{3.47 \cdot 10^{-2}}$, $r = 0.73$, $P < 0.01$, $n = 17$) and for leaves in an insulated darkened container ($y = 21.16x^{1.39 \cdot 10^{-2}}$, $r = 0.64$, $P < 0.05$, $n = 12$).

No significant leaf water loss occurred during 3 hours under high radiation load. Maximum weight loss recorded was from 0.7172 g initial to 0.7149 g final weight. Thus, evapotranspiration can be ignored as a source of short-term temperature control for these experiments. This result was expected, because *Sedum* in general is characterized by crassulacean acid metabolism, a photosynthetic pathway in which stomatal opening occurs primarily at night.

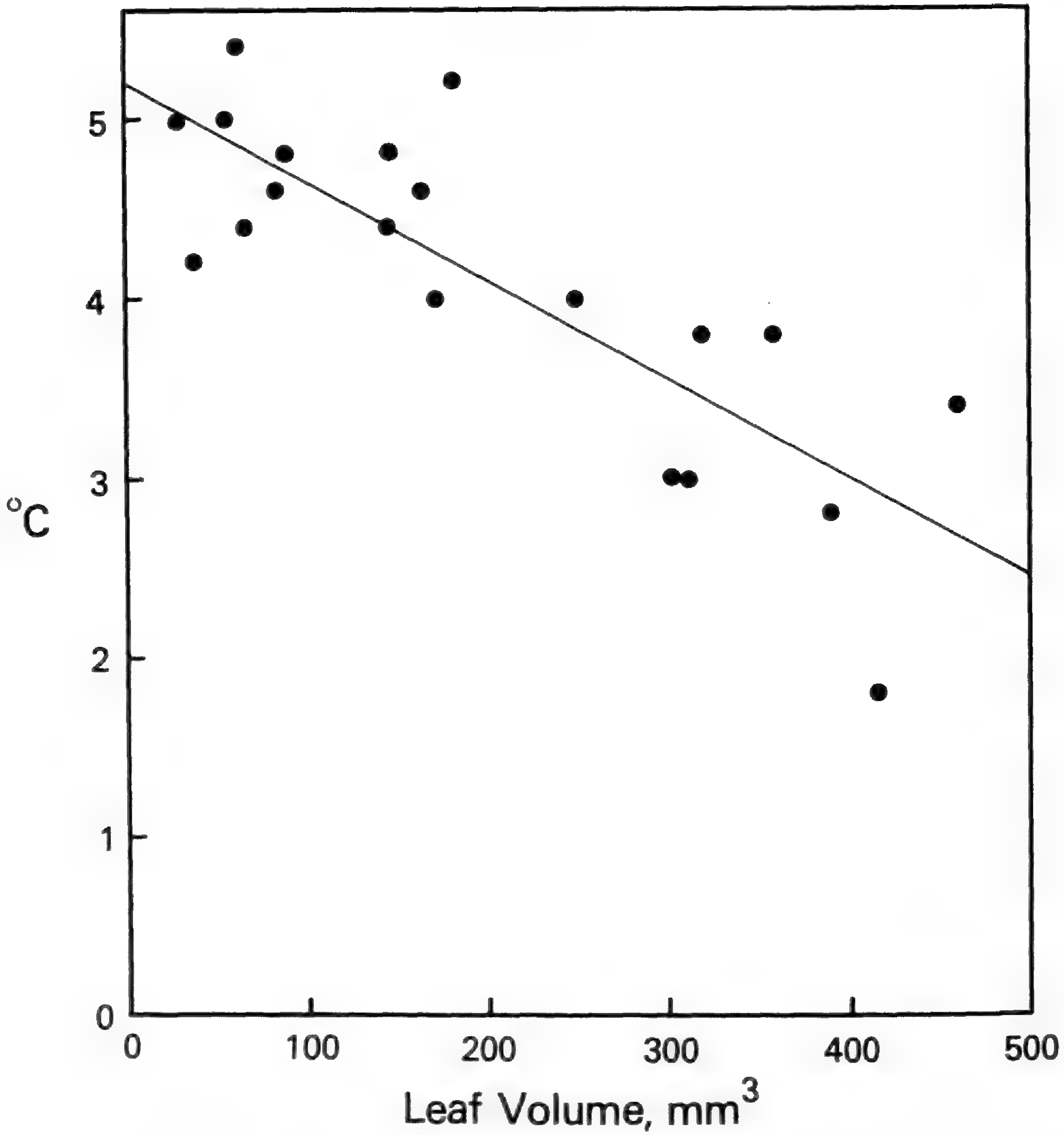

Fig. 2.—Relationship between leaf volume and change in internal temperature under high radiation load. Only the first replicate is shown.

Leaf dry weight expressed as a percent of wet weight (y) was negatively correlated with volume (x) ($y = 35.78x^{-0.240}$, $r = -0.96$, $P < 0.001$, $n = 12$). Thus, large leaves had higher water content than small leaves.

Time required for internal leaf temperature to reach 0°C was positively correlated with leaf volume (x) ($y = 0.04x + 5.19$, $r = 0.93$, $P < 0.001$, $n = 10$). (Fig. 3).

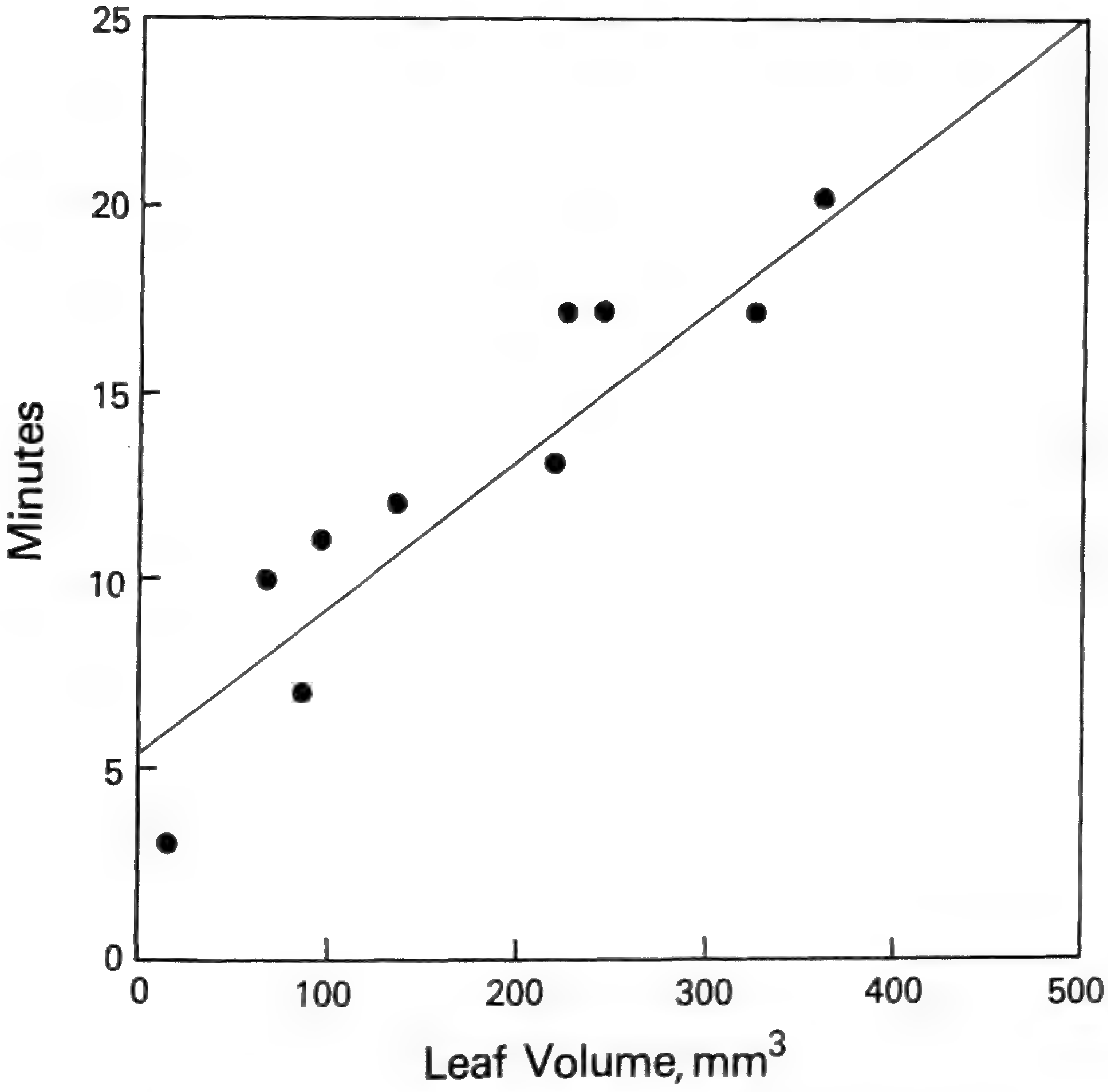

Fig. 3.—The relationship between leaf volume and time required for leaf to cool to 0°C.

Discussion

The positive correlation between leaf volume and initial leaf temperature was unexpected. It is possible that cell damage from thermocouple insertion increased respiration rates, causing measurable heat production. Larger leaves with low surface-volume ratios would retain more of this heat. This initial difference in leaf temperature probably explains the correlations between volume and patterns of heating. It may also explain in part the correlation between volume and leaf cooling. However, rate of cooling may also be related directly to leaf volume: lower rate of heat loss would be predicted for leaves with larger volumes, regardless of slightly different initial temperatures. In addition, larger leaves had higher water content and thus, higher thermal capacity, than did smaller leaves. This factor could also contribute to slower cooling in large leaves. However, it could not be related to lower equilibrium leaf temperatures of large leaves under high radiation load.

We present these results in order to demonstrate the need for extremely careful use of controls in studies of temperature balance of succulent leaves. Interpretation of results may be greatly complicated by subtle correlations of leaf volume with thermal properties and physiology.

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ESTABLISHMENT OF SEEDLINGS OF *POLYLEPIS SERICEA* IN THE PÁRAMO (ALPINE) ZONE OF THE VENEZUELAN ANDES

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Polylepis sericea Wedd. (Rosaceae) is a dominant component of subalpine forests of the Venezuelan Andes. It extends from 2400 m to 4200 m. Above 3200 to 3400 m (natural treeline) it generally occurs in small pockets of forest on east-facing or west-facing talus slopes. It has been suggested that these talus slopes provide a warmer soil microclimate than that of the surrounding páramo (tundra), thus permitting tree growth above the general treeline (Walter and Medina, 1969).

There are four other possible explanations for this distribution pattern. (1) Talus slopes may provide a habitat in which *Polylepis* avoids intense competition with the grasses, herbs, shrubs and caulescent rosette plants which form a dense vegetation cover in the open páramo. (2) Talus slopes are generally less accessible to cattle and to wood cutters than are open páramo areas. Forests on such sites may thus be the last eliminated by grazing or cutting. (3) These talus slopes are generally more sheltered from the prevailing wind than are most sites in the open páramo, perhaps resulting in reduced wind-cooling and reduced dry-season water stress. (4) Talus may reduce soil evaporation, providing a more favorable soil moisture regime during the dry season.

The present study was designed to determine if *Polylepis* seedlings can survive in the environment of the open páramo, and to determine which environmental factors affect survival.

MATERIALS AND METHODS

An experimental garden was established in the páramo at 3600 m, Mucubaji, Estado Mérida, 9°45′ N. The site was on a 3° E-facing slope, fully exposed to the prevailing winds. Vegetation was characterized by shrubs of *Hypericum laricifolium* (Guttiferae), caulescent rosette plants of *Espeletia schultzii* (Compositae), and many small grasses and herbs, including *Acaena cylindrostachya* (Rosaceae), *Aciachne pulvinata* (Gramineae), *Agrostis trichoides* (Gramineae), and *Geranium* sp. (Geraniaceae).

Six 1 m^2 quadrats were established in areas with dense herb-grass cover, but without mature *Espeletia* plants. All vegetation was removed from 4 of the 6 quadrats, and from a 1 dm buffer zone. Vegetation was undercut with a sharp-edged shovel, leaving the underlying soil surface smooth and solid. Two of these 4 quadrats were covered with rocks, in order to produce a more moderate micro-environment. Small rocks were fitted into the gaps between larger rocks, in order to completely cover the bare soil. The rock cover was approximately 10-15 cm thick. In order to prevent growth of roots into the bare soil and rock treatments, a sharp-edged shovel was driven into the ground along the perimeter of each quadrat. This procedure was repeated monthly.

Natural vegetation was left intact on two quadrats. Coverage by vegetation on these 2 plots was 74% and 75%.

Seedlings of *Polylepis* were collected in a closed-canopy *Polylepis* forest at Laguna Negra, 3500 m, approximately 1 km from the research site. The seedlings were growing in rocky areas with a thick, moist layer of moss and litter. Seedlings were very common in such sites. The plants were pulled out of the moss with little damage to the root systems.

The seedlings were transplanted on August 11, 1972, in the middle of the wet season. Twenty-five seedlings were transplanted to each of the six quadrats. They were planted in a regular pattern of 5 rows, with 5 equi-distant seedlings per row. There was a 20 cm interval between any two adjacent plants. Mean height of the transplanted seedlings, measured to the highest leaf tip, was 7.0 ± 0.35 cm (mean ± 95% confidence limit); mean number of leaves per plant was 3.8 ± 0.33. The quadrats were resurveyed periodically during the following year.

Twenty-five naturally-occurring seedlings were marked in the *Polylepis* forest at Laguna Negra. However, these seedlings were vandalized, and could not be resurveyed.

Climatic data were recorded regularly on a site approximately 10 m from the transplant gardens. A Taylor maximum-minimum thermometer was maintained inside an instrument shelter at ground level. A Bendix-Friez 3-cup anemometer was located 1 m above the ground. Data were recorded weekly. Soil moisture was measured gravimetrically for the area around the weather station. To minimize damage to the treatments, soil moisture of the experimental quadrats was measured only once, during the dry season. Soil surface temperatures were measured on a bare soil quadrat and a rock-covered quadrat, using thermocouples and a potentiometer. The data were recorded every 2–4 hours during a 24-hour period of clear weather, January 15–16, 1973.

RESULTS

Mortality data are presented in Table 1. With the exceptions of the vegetation treatment, mortality was restricted to the dry season period of December to April. On the vegetated quadrats, 8% of all mortality occurred in the wet season. In addition, 18% of the seedlings on vegetated quadrats appeared necrotic or chlorotic at the beginning of the dry season (December 16, 1972). On both the rock and bare soil quadrats, only 2% of the seedlings appeared unhealthy at this time. This difference was significant according to the chi-square test ($x^2 = 11.63$; $P < 0.005$). Total mortality during the year was 100% on bare soil and vegetated quadrats. Seven seedlings survived the full year on the rock-covered quadrats. This difference between treatments is significant according to the chi-square test ($x^2 = 9.33$;

TABLE 1. — Percent of the Original 50 Seedlings in Each Treatment Which Died During Each Sampling Period.

treatment	Aug 11– Oct 10	Oct 10– Dec 16	Dec 16– Mar 22	Mar 22– Apr 28	Apr 28– Aug 5	Aug 11 1972– Aug 5, 1973
Vegetation	2%	6	92	0	0	100
Bare Soil	0	0	100	0	0	100
Rock	0	0	82	4	0	86

TABLE 2. — Climatic Data for the Transplant Garden Site at 3600 m.

Temperature (°C):	25 Jun 1972–23 Jul 1972 (wet season)	mean maximum	13.9
		mean minimum	1.1
	17 Dec 1972–14 Jan 1973 (dry season)	mean maximum	20.0
		mean minimum	-3.6
Soil Moisture (% oven-dry weight):	24 Aug 1972		49.5
	2 Jan 1973		31.0
	26 Feb 1973		20.6
	wilting percentage		18.0
Mean Wind Speed (mph): 8 Jun 1972–14 Jan 1973			3.6

$P<0.005$). Mean height of these seven seedlings at the beginning of the study was 6.9 ± 1.01 cm; mean number of leaves per plant was 3.6 ± 0.72. At the end of the study mean height was 3.1 ± 1.10; mean number of leaves was 3.7 ± 1.19. The plants wilted back to ground level during the dry season, and began to grow again at the beginning of the next wet season.

Marked seedlings in the *Polylepis* forest at Laguna Negra were vandalized. However, observations suggest that dry season mortality for seedlings 5–10 cm tall was low in this site, compared to mortality in the transplant gardens. Although live seedlings were abundant, very few dead seedlings could be located at the end of the dry season.

Climatic data are summarized in Table 2. Soil moisture for the experimental plots was recorded on February 13, 1973, in the middle of the dry season. Soil moisture (percent dry weight) was 17.6% for the vegetated quadrats, 20.4% for the bare soil quadrats, and 31.4% for the rock-covered quadrats.

The lowest soil surface temperatures recorded during the 24-hour study were −3°C beneath the rock cover, and −6°C on bare soil. The highest temperatures recorded were 33°C beneath the rock and 36°C on bare soil.

DISCUSSION

These data suggest that the páramo climate during the dry season can prevent establishment of *Polylepis,* unless seedlings grow in sheltered microsites. Seedling death occurred first in the vegetated quadrats, and no other treatment showed wet season mortality. These facts suggest that interspecific competition may be a significant factor. However, mortality on bare soil treatments — in the absence of interspecific competition — was 100%, indicating that competition and climatic stress may interact to cause seedling mortality on vegetated sites.

Microclimatic data, although not extensive, do suggest that rock cover can moderate dry season temperature extremes, and can also result in higher dry season soil moisture levels.

In the early 1950's a *Polylepis* seedling was planted among rocks of an old stone wall at Mucubaji (Faustino Diaz, personal communication, August, 1973). The site is fully exposed to the prevailing winds, yet the tree is now approximately 2.5 m tall, and has flowered. This suggests that, given a suitable microenvironment for establishment and growth, *Polylepis* can survive to maturity in the open páramo. The relative scarcity of such microenvironments in the open páramo may be one factor contributing to the restriction of *Polylepis* to talus slopes in the upper portion of its range.

ACKNOWLEDGMENTS

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ADDITIONS TO THE FLORA OF SUNRISE MILL PARK, MONTGOMERY COUNTY, PENNSYLVANIA

Ann Newbold
Bechtelsville, Pennsylvania

The study of the flora of Sunrise Mill Park, authorized by the Perkiomen Valley Watershed Association through the Office of the Superintendent of the County Park System and reported in *Bartonia* 44:32–36, was continued in 1976 and '77. The Wild Flora Committee, chaired by Anna Felton, had the good fortune to be joined by two new workers, both members of the Philadelphia Botanical Club: Nancy Ryan, newcomer to plant identification, and Hans Wilkens, veteran taxonomist and local-flora expert of many years' standing.

The additional taxa discovered for the flora count amounted to 17 families, 57 genera, 183 species, 5 varieties, and one form. The latest totals for the 150 acre park are 101 families, 316 genera, and 614 species. Since each visit to the park uncovers new species, it seems clear that this is not the end.

The greatest gain was in Cyperaceae: *Carex aggregata, amphibola, annectens, blanda, bushii, caroliniana, communis, conjuncta, convoluta, davisii, digitalis, festucacea, frankii, granularis* var. *haleana, grayii* var. *hispidula, molesta, normalis, pensylvanica, retroflexa, rosea, scoparia, sparganioides, sprengelii, squarrosa, stipata, stricta, tribuloides, virescens, vulpinoidea, willdenowii; Cyperus strigosus;* and *Eleocharis erythropoda.*

The second largest gain was in Graminae: *Agrostis hyemalis, perennans; Bromus japonicus; Digitaria ischaemum; Eleusine indica; Elymus virginicus* var. *hirsutiglumis; Festuca elatior, obtusa; Holcus lanatus; Leersia oryzoides, virginica; Muhlenbergia frondosa, sobolifera, sylvatica; Panicum boscii, clandestinum, dichotomiflorum, dichotomum, gattingeri, lanuginosum* var. *fasciculatum, linearifolium; Poa annua, compressa; Setaria glauca, italica; Sphenopholis nitida; Sporobolus vaginiflorus.*

A heretofore undiscovered drainage pond provided *Potamogeton crispus, nodosus; Alisma subcordatum; Elodea canadensis, nuttallii; Lemna minor; Ceratophyllum demersum;* and *Ludwigia alternifolia.*

Perhaps the most interesting of the new finds was *Lilium canadense* f. *rubrum,* listed by E. T. Wherry (*Bartonia* 44:23) as endangered. The flower was photographed. Other outstanding finds were *Habenaria lacera; Myrica pensylvanica; Aralia racemosa; Gentiana andrewsii; Apocynum androsaemifolium; Asclepias purpurascens;* and *Gerardia tenuifolia.* In an area just bordering the park property, but unfortunately not within its boundaries, there was an exceptionally large colony of *Chimaphila umbellata,* not often found in this county. Only one fern was added — *Woodsia obtusa.*

The other plants found during 1976–77 at Sunrise Mill Park were as follows: *Selaginella apoda; Sagittaria australis; Commelina communis* var. *ludens; Juncus tenuis; Acorus calamus; Tradescantia virginiana; Allium canadense, tricoccum; Maianthemum canadense* var. *interius; Iris versicolor; Sisyrinchium angustifolium; Salix rigida; Carya glabra; Maclura pomifera; Parietaria pensylvanica; Comandra umbellata; Polygonum aviculare, erectum, lapathifolium, tenue; Chenopodium lanceolatum; Mollugo verticillata; Portulaca oleracea; Paronychia fastigiata; Silene stellata; Stellaria graminea, longifolia; Nuphar advena; Aquilegia canadensis; Cimicifuga racemosa; Ranunculus hispidus, recurvatus, sceleratus, septentrionalis; Menispermum canadense; Cardamine bulbosa, impatiens, parviflora; Rorippa sylvestris; Thlaspi arvense; Penthorum sedoides; Ribes rotundifolium; Crataegus crus-galli; Potentilla norvegica; Pyrus communis, malus; Rosa carolina; Rubus flagellaris, occidentalis* var. *pallidus; Amphicarpa bracteata* var. *comosa; Desmodium canadense; Lespedeza intermedia, procumbens, repens; Trifolium arvense, procumbens; Linum striatum; Polygala verticillata; Acalypha rhomboidea; Euphorbia preslii; Abutilon theophrasti; Hypericum gentianoides, mutilum; Viola fimbriatula, sagittata; Elaeagnus umbellata, Cuphea petiolata; Lythrum salicaria; Oenothera tetragona; Cicuta maculata; Pyrola elliptica; Rhododendron nudiflorum; Vaccinium vacillans; Anagallis arvensis; Lysimachia quadrifolia; Phlox maculata, subulata; Hydrophyllum virginianum; Myosotis verna; Lycopus americanus; Mentha arvensis, spicata; Monarda fistulosa; Scutellaria elliptica, integrifolia, lateriflora; Trichostema dichotomum; Solanum nigrum; Gratiola neglecta; Lindernia anagallidea, dubia; Mimulus alatus; Penstemon digitalis; Veronica anagallis-aquatica, arvensis; Catalpa speciosa; Orobanche uniflora; Cephalanthus occidentalis; Galium mollugo, pilosum, triflorum; Houstonia caerulea; Lonicera japonica* var. *chinensis; Triosteum aurantiacum; Lobelia spicata; Antennaria neglecta; Aster macrophyllus, prenanthoides; Bidens bipinnata, connata* var. *petiolata; Cirsium discolor; Eupatorium sessilifolium; Lactuca biennis, floridana* and *floridana* var. *villosa, scariola; Hieracium venosum; Senecio obovatus, pauperculus; Solidago arguta; Sonchus asper;* and *Xanthium strumarium.*

Sunrise Mill Park comprises 150 acres within the County of Montgomery which contains 314,200 acres. It lies within the Triassic Lowland area of the county and is limited to six of the 36 major soils listed in the County Soil Survey of 1967. There are 1,832 taxa recorded for Montgomery County; Sunrise Mill Park hosts 614 or one-third of these taxa. With the exception of Bowmansville silt loam, Bp, the creek bottom soil, and Readington silt loam, ReB2[1], found in the southwest corner of Neiffer and Swamp Creek Roads, all of the other soil types encountered have two characteristics in common, "Available moisture capacity low: Natural fertility low." At the end of the soil descriptions for the Brecknock channery silt loam, BtC and BtD, Klinesville very shaly silt loam, KsE3, and Reaville shaly silt loam, RsB3

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[1] In *Bartonia* 44:34, it was noted that there were two trees of *Gymnocladus dioica* in "habitat strikingly dissimilar" within the park. On examination of soil types where they grow, it becomes evident that the creek bottom Bowmansville is similar to the Zone 3-corner Readington. These two soils, and only these, have a reasonable fertility and a moderate-to-high available moisture capacity.

and C3, the Montgomery County Soil Survey reads, "This soil has severe limitations if used for residential, light industrial, commercial, or institutional development." Since agriculture is ruled out because of slope and low fertility, this site which contains wooded, open (pipe line) and stream bottom habitats has been left to natural species proliferation with only moderate interference from man. The "Stoneyland, Steep" StE, soil of Zone 1 is, according to the Survey, "suitable for recreational or esthetic purposes, watershed protection, or a wild life propagation area." Happily, this is precisely the use for which the County acquired it.

POLYGONUM PERFOLIATUM: A RECENT ASIATIC ADVENTIVE

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The prickly annual vine *Polygonum perfoliatum* L. has become established in southeastern Pennsylvania within this century. Five distinct populations have been discovered on the Swarthmore College campus within the last five years. The record of its introduction to North America from eastern Asia is unclear and it is still either localized or little noticed. Attention to it at this time may be useful in studying and dealing with the process of its invasion of this continent. This brief report presents what information we can uncover of the plant's history in North America, discusses the morphological and distributional characteristics that affect its potential as a weed, and provides a more detailed description than is currently available.

Little prior evidence of *P. perfoliatum* in North America is available. The first record is a specimen (*Suksdorf 1607*) now in the Gray Herbarium. The specimen was collected on ballast near Portland, Oregon, in the 1890's and, like most of the unusual oriental species collected in such sites by Suksdorf, the population from which it was taken was short-lived. It seems not to have been collected since that time in the Pacific Northwest.

The record of *P. perfoliatum* in eastern North America is no more extensive. A single specimen is in the Gray Herbarium (*Swartley*, in 1946), collected from an old orchard near Stewartstown, southern York County, Pennsylvania. It is apparently this specimen, which was distributed to the Gray Herbarium from the herbarium of the University of Pennsylvania, that brought M. L. Fernald's attention to the species. As a postscript to Section *Echinocaulon* (Fernald 1950, p. 588) he provides the following information: "*P. perfoliatum* L. (with leaf surrounding stem), a species of e. Asia, is becoming established in nurseries, etc. in Pa. and may become a troublesome weed. Its ocreae are expanded into leafy perfoliate blades, the true leaves deltoid and basally peltate. (Adv. from Asia)." Until the present, the matter stopped there. The U.S. National Herbarium, and the herbaria of the Academy of Natural Sciences of Philadelphia and of the New York Botanical Garden have no North American specimens of *P. perfoliatum*. It was not reported by Stone (1945) or Keller and Brown (1905), and the absence of specimens in the herbarium of the Academy of Natural Sciences suggests that it has not been seen growing in the heavily botanized Philadelphia area.

P. perfoliatum has thus far failed to become a "troublesome weed" but it clearly has the potential for doing so. Our first encounter with the species was on the

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floodplain of Crum Creek on the Swarthmore College campus in fall of 1972, the season after heavy floods deposited a thick layer of sandy silt on the floodplain, burying the well-established meadow forbs and grasses. Many weed species established abundantly the following growing season, presumably from seed deposited with the sediment. For one year, *P. perfoliatum* was a dominant in this weed community, along with *Humulus japonicus* Sieb. & Zucc., which has persisted. The *Polygonum,* by contrast, was much restricted in dominance in 1973 and since then has failed to establish in that location.

We did not positively identify *P. perfoliatum* until fall of 1976, by which time we had discovered several other, more persistent populations, at least some of which matured plants each year from 1972. All these populations were associated more or less closely with rhododendrons planted on Swarthmore College property by the A. H. Scott Horticultural Foundation. Four duplicate herbarium specimens were collected while the plants were in late bloom in mid-October, 1976, and are being distributed to GH, NY, US, and PH.

Joseph Oppe and David Melrose of the Scott Foundation and Gertrude Wister also first noticed *P. perfoliatum* at Swarthmore about 1972. The congruence in time of these first observations suggests that it has not been established here for too many years.

Our attempt to determine the time of arrival of *P. perfoliatum* on the Swarthmore campus led to two connected discoveries. First, Edgar T. Wherry informed us that a spiny *Polygonum* with blue berries has become a troublesome weed in the Stewartstown nursery of Joseph Gable and has spread from there to adjacent sites. This is clearly the origin of the Swartley specimen at the Gray Herbarium. Second, we were able to learn from John and Gertrude Wister that the Scott Foundation had received many rhododendron plants from Gable's nursery over the years from 1932 to 1967. Further, several of the largest *P. perfoliatum* populations at Swarthmore are centered around Gable rhododendrons. This suggests that the plant was established in Stewartstown before Swarthmore, and that it has been spread primarily attached to rhododendrons.

The arrival of the species in North America is more puzzling. Because its seeds are large and conspicuous and could not be confused with rhododendron seed, it would seem likely that it was brought to this continent as seed-bearing herbage attached to a rhododendron plant prior to the initiation of plant quarantine in 1919. However, according to John Wister, Joseph Gable did not begin his plant collecting until after World War I, or after plant quarantine began. Most of his rhododendron introductions were apparently from seed rather than plants, removing the source of *P. perfoliatum* yet another step.

The morphology of this plant adapts it well to being spread from one nursery to another, and it is likely that it will continue to increase in abundance at Swarthmore and, through exchanges of outdoor-grown horticultural material with other nurseries, to be spread broadly. There are several pieces of evidence that suggests this may happen. *P. perfoliatum* is a member of Section *Echinocaulon* of *Polygonum*, which includes the several species of "tearthumbs" characterized by retrorse prickles on the stems and petioles. Of these species, only *P. perfoliatum* is a scandent vine that grows at least 6 meters up into shrubs and understory trees. The vine is annual (in itself an unusual combination of life habits), and produces an abundance of seed. The achenes are spherical (the angles obsolete), and the persistent calyx thickens and becomes iridescent blue as the fruit matures, making the whole structure appear berry-like. Some fruits are retained within the bractlike ocreae long after the vine dies. The retrorse prickles cause the dead vines to adhere to the "host" plant. Even if an attempt is made to remove the vine from the "host", the fragile stems fracture, leaving terminal, seed-bearing inflorescences attached to the "host." As "host" plants are moved and transplanted, new populations of *P. perfoliatum* are likely to establish in disturbed soil under them. Figure 1 shows dead, seed-bearing stems that have overwintered on a rhododendron cultivar in the Crum Woods at Swarthmore. Viable seed may also be transported in rootballs.

Although it is also possible that habitat restriction will pervent *P. perfoliatum* from becoming a serious weed, it does not seem possible that it will prevent it altogether from spreading. In its native Japan and eastern Asia, *P. perfoliatum* grows in moist thickets and along rivers (Ohwi 1965; Steward 1958). It is much more shade tolerant than our two common tearthumbs (*P. sagittatum* and *P. arifolium*) but, like them, requires moist soil. Possibly this requirement will keep its populations small and localized, but the species has occupied, at least temporarily, a range of variously disturbed habitats on the Swarthmore College campus. Its colonizing potential seems well established.

It is not clear whether the absence of collections of *P. perfoliatum* in major East Coast herbaria, including the Academy of Natural Sciences, reflects its rarity — as a species that is establishing very slowly and in highly localized populations — or whether it reflects an oversight on the part of collectors. Every attempt should be made to determine the current distribution of the species in southeastern Pennsylvania, the species with which it is associated, and the range of environments in which it occurs. Nurseries supplying rhododendrons are particularly likely to be productive of new populations.

We hope that Philadelphia Botanical Club members will be alert for this species, and make multiple collections from any populations found. In an attempt to determine the effect of Gable's wide distribution of rhododendrons on *P. perfoliatum*, we are submitting a note, with illustration, to the Bulletin of the American Rhododendron Society, asking members for information. An early understanding of the distribution and behavior of this species could be important in controlling its spread in eastern North America.

To aid others in identification of this species, we present a line drawing (Fig. 2) and quote the diagnosis of Ohwi (1965, p. 408): "Scandent glabrous annual; stems [somewhat angled and] much elongate, branched, 1–2 [1–6] m long, retrorsely prick-

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Fig. 1. Dead remains of *Polygonum perfoliatum* L. in March in a rhododendron cultivar, Crum Woods, Swarthmore College. Note retrorse stem prickles.

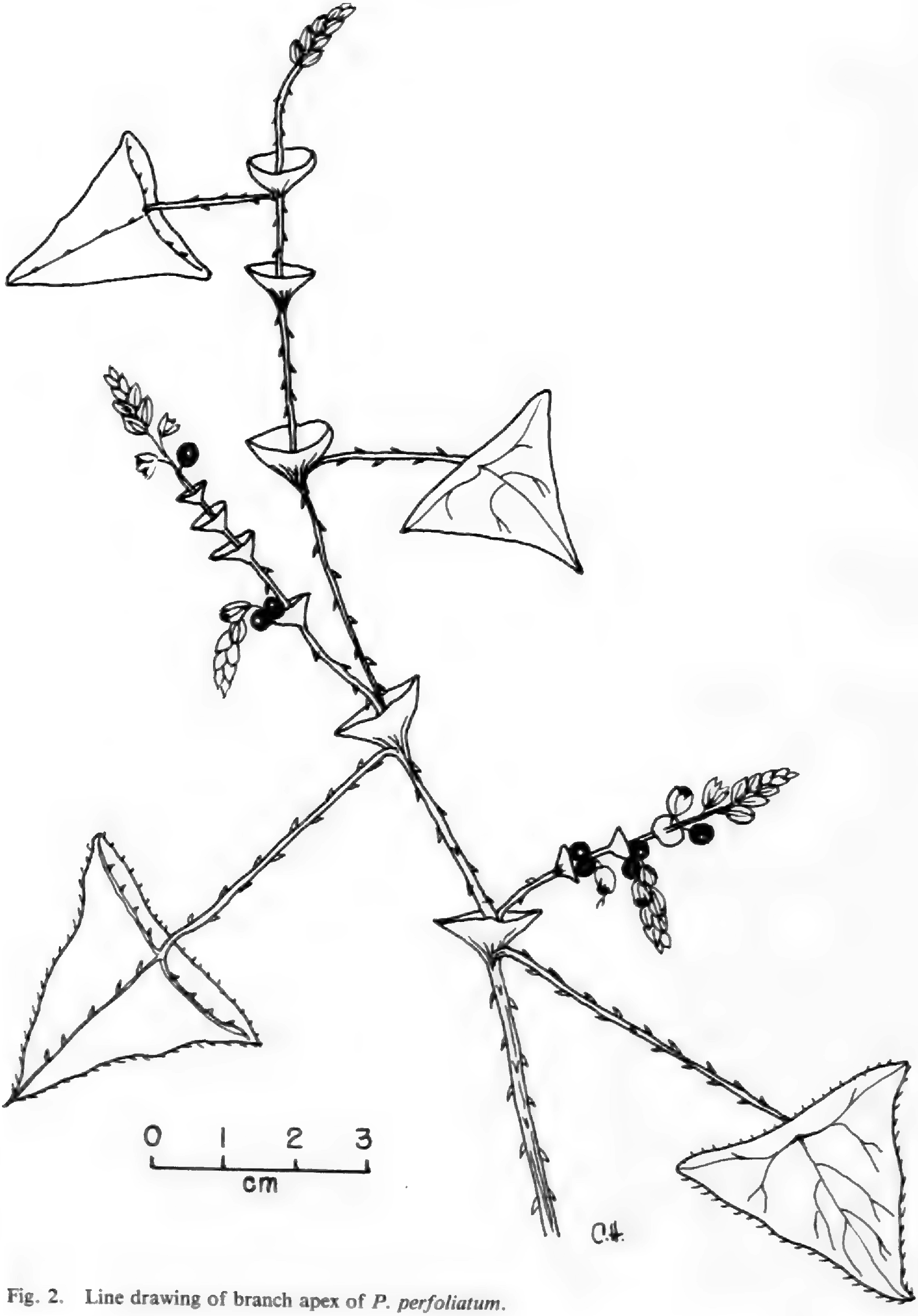

Fig. 2. Line drawing of branch apex of *P. perfoliatum*.

ly [on the angles]; leaves deltoid, [basally peltate,] thinly membranous, retrorsely prickly on the [three main] nerves beneath, glaucous or pale green, [paler beneath,] 3–6 cm long and as wide, acute to subacute, truncate to shallowly cordate, the margins sometimes minutely retrorsely scabrous, the petioles long, [divaricate, stiff and] retrorsely prickly; sheaths scarcely tubular, the dilated leaflike limb orbicular, perfoliate, green; spikes short, 1–2 [1–4] cm long, subtended by an orbicular leaflike bract, the pedicels short; perianth 3–4 mm long, pale greenish white, the segments broadly elliptic, becoming fleshy [about 1 mm thick] and blue in fruit; achenes inflated [and spherical], obsoletely trigonous, black, lustrous, about 3 mm long and as wide. Wet thickets and along rivers in lowlands; Hokkaido, Honshu, Kyushu; common. — Korea, China, Malay Peninsula, and India."

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SEEDS AND SHIPS AND HEALING HERBS, ENCOURAGERS AND KINGS[1]

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"If we begin with certainties," said Francis Bacon, "we shall end in doubts; but if we begin with doubts, and we are patient with them, we shall end in certainties." When were American seeds and plants first taken to Europe, either for use or for ornament? How did they travel? Some were coddled in the captain's cabin and watered with precious drinking water designed for the crew, some stood in what came to be called Ward's closely glazed cases — in fact, glass menageries, for they took across the Atlantic as well live turtles, opossums, salamanders, and so on — "curiosities" fit for the naturalist. Who patronized the collectors who searched the wild woods for these novelties? I invite you to consider some sides to the story, possibly, in Josselyn's word, overslipt, that you may continue your search individually in a growing garden of books on the history of plant hunting.

Three rules of caution: Read critically: in 1862 Cecilia Lucy Brightwell wrote on a topic of real concern at the moment to those who live along the Mississippi River: Abbe Domenech, she said, came upon a crevasse through which river waters rush and devastate the plain — "Thousands of negroes were at work up to the waist in mud, striving to stop up the crevasse with fascines, branches of trees, and a kind of hemp, made of a parasite plant, called barbe d'Espagnol, which hangs pendant from the trees in long tendrils . . . This plant destroys the trees to which it clings, by absorbing all their sap." Printed words never die: Franklinia was *not* last seen in 1790 as repeated in book after book but in 1803 and by John Lyon. And then there is the matter of what is *introduction* of a plant? And if it died out, do we credit the *re*introduction as the significant date? Definitions are not always quickly understood. Lately a student in my class, when asked what was meant by heterogamy, wrote "the gametes differ in more than just sex."

Seeds and plants transported from colonial North America to England did not all stop there. Surplus seeds, progeny, or cuttings were carried on to France, Holland, and Italy. One of the earliest documented contacts is that of the Flemish botanist Clusius who visited Sir Francis Drake in 1581. Drake had put in to land in Chile, Peru, Mexico, and California in 1578–79, and thus the first knowledge of any Pacific coast plants is derived from this visit of Clusius with Drake. The year following his visit with Drake, Clusius published at Christopher Plantin's press in Antwerp a 42 page duodecimo commentary on Drake's discoveries illustrated by fourteen drawings, none of North American plants (Sabin 13800). The best drawing is of a plant grown from seed via Italy that Clusius called *Jasminum indicum vel Mexicanum*, that is, Indian or Mexican jasmine. It is four o'clock and surely came

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[1] Presented at Philadelphia Botanical Club, April 28, 1977, being a revision of talk at Colonial Williamsburg Foundation, April 9, 1973.

from Peru and was later called the marvel of Peru, that is, genus *Mirabilis*. The shrub "Dama de Noche," fragrant at night, *Cestrum nocturnum*, may be identified from the description and remarkably good drawing labelled *Arbor tristis*. The writings of Clusius and of the Spanish physician Monardes publicized Drake's plant discoveries. Drake's botanical cargoes have not been inspected carefully, in fact he is barely mentioned in the histories of botany. Sassafras was one of his enthusiasms though it may have been known earlier. Though Drake sailed into San Francisco Bay before Thomas Hariot and John White made their landfall on Roanoke, we have no information on the plants noticed in California, but for Hariot's visit we have tantalizingly more. By my latest count thirty North American plants were known in Europe before 1600. Four of these originated in New France; the oldest American tree is the arbor vitae, *Thuja occidentalis*, mentioned by Belon in 1558. The other three plants of Canadian origin were the milkweed, *Asclepias syriaca*, the columbine, *Aquilegia canadensis*, and the pitcher plant, *Sarracenia purpurea*. The other twenty-six of these North American plants came from Virginia and/or "Florida," and Hariot in 1588 or Gerard in 1599 reported most of them. Thomas Hariot returned with Drake from Roanoke Island in 1586, when Drake came to the aid of Ralph Lane's beleagured colonists, and carried seeds and vestiges of native plants back to England with him. In a reciprocal way Old World garden favorites were introduced into the colonies and weeds arrived in shipments of grains and vegetable seeds. We know that by 1620 such a European garden favorite as "snowball" (*Viburnum opulus* cultivar) was growing in Virginia. Few of these two-way introductions were for decorative garden use — "their own excuse for being" — and *Yucca* from Virginia which ultimately proved one of these, curiously soon attracted attention because of the confusion that involved it with the tropical root crop "yuca" that is, cassava or manioc. Of course the generic name *Yucca* bears witness to this historic mistaken identity. The martagon of Canada, *Lilium canadense*, certainly an ornament for any garden, was, it must be remembered, a food plant, the bulbs being eaten by the Indians who found them starchy and slightly sweetish. Though the record is incomplete, Gerard grew such introductions from the Roanoke colony as sunflower, Jerusalem artichoke, red mulberry, spiderwort (that was later to immortalize Tradescant), and *Asclepias* reported by Hariot, and the last drawn by John White.

These introductions almost always had socio-economic connections. *Yucca* of Hariot, that is, silk-grass, and red mulberry, for example, attracted notice for their textile uses; sumac as a dye-stuff; tulip tree and *Taxodium* as timber and construction for ships and buildings; sassafras as an "aromaticall drugg," for the great pox, and so on.

The fate of American introductions after reaching England has been given scant attention. The story of how and when they reached England has been related in part by Bragg, Stetson, Warner, Hedrick, and others, but their continuing journeys on to the Continent or back and forth across Europe has been scarcely noticed. Knowledge of these novelties penetrated by two avenues: the fraternity of botanical gardens, both institutional and private, and royalty, or those acting in their behalf.

The transit of plants and knowledge about them from the English gardens of Holborn and South Lambeth where Gerard and Tradescant, for example, grew their novelties from America, were but way stations on the way to Paris, Blois, Montpellier, Leiden, Padua, and Rome. The routes of penetration may be traced in botanical literature and more tediously through letters preserved in Paris, in Leiden, and elsewhere.

Jean Robin, the royal botanist in Paris, and his son Vespasien, were understandably secretive about their sources, and at this point in the search, we may only surmise that they secured their seeds and information from French explorers, perhaps from the Ribault and Laudonniere expeditions (1562–65), and from apothecaries and clergymen from "Florida" and New France, many of whom are surely unrecorded. It is often difficult to trace origins even among the plantsmen themselves: Rene Morin and his younger brother Pierre were evidently independently engaged in rival introduction and plant sales. Cornut knew Rene Morin personally. Too, Alpino was growing American introductions in Padua before 1627, and Ferrari in Rome before 1633 tells us how swiftly the knowledge of these plants spread across Europe. Bobart the elder at Oxford Physick Garden reintroduced the tulip tree and sent it to Holland where Hermann publicized its merit. Robert Morison, Professor of Botany at Oxford, who had been primarily responsible for sending John Banister to collect in Virginia for him, was also a correspondent of Hermann's and, from his years spent at Blois, was in touch with French gardens. Morison's fatal accident in 1683 in London prevented his reporting on Banister's plants. Bishop Compton, an enthusiastic plantsman, reintroduced the Virginia black walnut, a lusty competitor of the Persian, that is, the "English" walnut, through Banister who had sought out worthy and undescribed plants in the James River country of Virginia, and Compton forwarded the nuts to Hermann.

The Reverend John Banister, M.A. Oxford 1674, went as a clergyman to Virginia, that being the only way at the time a naturalist could support himself, having been recommended to Compton by Morison. For about fourteen years Banister lived and studied along the James River and toward the Appalachians, and over to the Roanoke River, on the banks of which in 1692 he was accidentally shot as he botanized. Seeing how important it was to illustrate the fascinating new forms he found, he had taught himself to draw. So enthusiastic over his finds, and so eager for specimens, seeds, descriptions, and drawings, were his British correspondents that he projected a "Natural History of Virginia," but, Alas! with England staggering under the financial burden of years of civil strife, and the ambition of the more prosperous Virginians to acquire the niceties of English life, their patronage proved inadequate. In 1690 Banister acquired land and slaves so that he could devote his major energies to his "Natural History." Just before his death he had taken part in plans to establish the College of William and Mary, and had been named a Trustee. Robert Beverley made extensive use of Banister's natural history notes and especially his "Account of the Natives," publishing part verbatim in his classic *History and Present State of Virginia* (1705).

Leonard Plukenet reproduced 64 of Banister's 89 known plant drawings along with Banister's Latin descriptions of about 340 plants in his *Phytographia* (1691–1705). Linnaeus cited John Ray's publication (1688) of Banister's 1679 "Catalogus plantarum" and his later collections from Ray's supplement (1704). Linnaeus also cites Plukenet's *Phytographia*, and Morison's *Historia universalis plantarum*, with Banister's plants reported in Vol. 3, completed in 1696, after Morison's death. Linnaeus cited at least some of Banister's specimens and plants which he saw growing in the botanical gardens at Oxford and Chelsea. Thus, Banister was the basis, at least in part, for 122 plants in the *Species plantarum* (1753), a fact not generally appreciated.

Our knowledge of plant hunters, as they have been called lately, has increased notably. The role of ships and ship captains that carried them away is a topic of recent interest. There is botany in naval stores and ships: the *Susan Constant, Godspeed,* and *Discovery,* all which dropped anchor at Jamestown in May 1607, were made of pine and so, called pinnace. In the *Memorials of John Bartram and Humphry Marshall,* 48 ship captains are mentioned. To some, not all, of these old salts horticulture owes a large debt for the solicitous care they showed in the safe delivery of plants entrusted to them. They were "men of the most humanity of any of the Fraternity." Seeds and bulbs arrived successfully but rhizomes often had rotted in transit. John Custis protested to Robert Cary in 1727 that some plants put on deck exposed to salt spray should have been put in the hold. Departure season was critical: Custis wrote to Peter Collinson in 1734 that "our ships never [go] from hence in a proper season" leaving in gentle summer only to arrive in winter. "Ships went to sea, and ships came from the sea, And the slow years sailed by and ceased to be."

The search for healing herbs went out with the first ships. Nicholas Monardes, the Seville physician who collected reports from the Spanish and Portuguese travellers returning from the New World, used the name "Sassafrass Arbor" for that tree in 1569. His information came from a Frenchman who likely had survived the expedition of Ribault and Laudonniere to northern Florida and Carolina. In 1588 Hariot took the Indian name "Winauk, a kind of wood of most pleasant and sweete smel." When Martyn wrote the last edition of Miller's *Gardeners' Dictionary* he said that some persons found the fragrance to affect the head first, "which inconvenience ceases on continuing its use a little time. It is made an ingredient in several diet drinks, both empyrical and such as are used in regular practice." He adds, bedsteads made of sassafras wood will never be infested with bedbugs.

Alexander Garden, a Scot, trained in medicine at Edinburgh, arrived in Charles Town in April, 1752. He was 22. About 8,000 persons lived there then, perhaps one half slaves. Within ten days Garden had sent a small parcel of pinkroot back to Edinburgh and in January, 1753, he sent a Latin description of the plant to Dr. Alston, the King's Botanist. This pinkroot was named by Linnaeus *Spigelia marylandica* and was of immense interest because the Caribbean species, *Spigelia anthelmia,* or Demerara pinkroot, was considered the "most efficacious medicine for worms yet known." The plants were pulled up by the roots, in a green state, and the seeds stripped off, them stems carefully cleaned, dried in the sun, and packed in bundles. Garden's enthusiasm for pinkroot persisted and in 1768 he sent the plant to Cadwallader Colden in New York state.

Banister knew Virginia ipecacuana or Indian physic and sent a drawing of the plant to Bishop Compton in 1689. William Byrd the Second sent a box of ipecac to Sir Hans Sloane in 1710. Byrd wrote Sloane that he cut a portion into bits, as the apothecaries sell it, and adds, "I woud beg the favour of you to dispose of this for me after the best manner you can, and send me word whether it sells best whole in the root, ore else cut into pieces. . . . I hope youll forgive me for makeing a merchant of you; but for your trouble am willing to allow the merchant rate of 2½ percent upon the neat proceed. If you can make a good hand of it, I will engage to send you a great Quantity." James Petiver included it in his list of 161 "divers rare plants observed this summer, A. D. 1713, in several curious gardens about London, and particularly the Society of Apothecaries Physick Garden at Chelsea." Catesby sent it too. Peter Collinson was delighted to see it in 1736.

The "truly honest, ingenious, and modest Mr. Mark Catesby" is known to many of you. Professors Frick and Stearns wrote a gratifying biography of Catesby, published in 1961. Catesby, you will recall, made two visits to America, the first to Virginia, and a second to the Carolinas, arriving in Charles Town May 3, 1722. On his second visit Catesby was supported by a dozen patrons, — he called them encouragers. Let us consider a few of these men. The encourager who solicited aid for Catesby, wrote letters to his friends and as Prof. Stearns remarked, led the search for patrons, was William Sherard. In the words of the Oxford botanist Bobart, Sherard was a "botanist of the first order." His planned encyclopedic survey of the world's flora would have been a major work of systematic botany. It rests in the Bodleian Library today as 16 volumes of unfinished manuscript. Sherard died in 1728 at the age of 69, leaving his library, herbarium, and manuscripts including unpublished Banister manuscripts, to Oxford and establishing a chair of botany there. When Linnaeus visited Oxford eight years later — one of the two botanical gardens that he visited in England — it was one of the preeminent collections of Europe. There are many things that might be said of Sherard, aiding as he did many other botanists to ready their works for publication. One of these naturalists he befriended was Catesby whose *Natural History* Sherard did not live to see published. Catesby's plant specimens are in the Oxford "Sherardian" Herbarium today. Another of Catesby's encouragers was the Duke of Chandos, who, I believe, either by himself or through his efforts provided the French text for Catesby's *Natural History*. After Sherard's death Peter Collinson aided Catesby, as he also did John Bartram, organizing 60 subscribers for Bartram over a span of thirty years beginning in 1736.

One almost unnoticed encourager was Samuel Vaughan, who was responsible for the publication of Humphry Marshall's *Arbustum Americanum*. Samuel Vaughan, a wealthy planter from Jamaica, moved to Philadelphia in 1782 because of his friendship for that "good old man" Benjamin Franklin. Vaughan had a plan for including a specimen of every tree and shrub representative of the various sections of the young republic in landscaping the State House grounds, but the plan was abandoned. It was Vaughan who paid for *Arbustum* advertisements in the Philadelphia newspapers and who paid Joseph Crukshank for printing one thousand copies. In the history of publishing, the *Arbustum* was the first American imprint on trees and shrubs, 1785. Another almost unnoticed encourager was Thomas Mifflin, member of the Continental Congress and governor of Pennsylvania, to whom William Bartram dedicated his *Travels* in 1791. Mifflin's part in Bartram's *Travels* has eluded all the Bartram scholars, including the late Francis Harper. The governor does not appear in the scattered letters written by Bartram to his friends. Mifflin died at the age of 56, penniless, and was buried by the state.

"Book openeth book," said Dibdin, and I have believed my most valued service to the student is to turn some pages for him. Samuel Johnson, I am aware, said that "no man ever read a book of science from pure inclination." But to follow with Wilfrid Blunt's *Linnaeus*, the fate of the Linnaean collections after his death: How in the absence of the King of Sweden, they might have passed to Empress Catherine II, among others, but instead went by purchase to England; or, Father Plumier who was sent to the West Indies by Louis XIV under the prod of Sloane's discoveries in Jamaica; Elizabeth I whose Raleigh sent Hariot and John White to seek knowledge of the land they called Virginia; George III, guided by Joseph Banks, widened the search for novelties. King Charles III of Spain, with unusual questioning curiosity, launched a vast royal expedition to Peru, a story told footfall by footfall in Steele's *Flowers for the King*. But, then, let Francis Bacon speak again: the "images of men's wits and knowledge remain in books, exempted from the wrong of time and capable of perpetual renovation. . . .they generate still, and cast their seeds in the minds of others, provoking and causing infinite actions and opinions in succeeding ages."

A Note on Sources

In this essay I have suggested a few uncultivated but deserving topics in this large garden of history. Overviews of the garden will be seen in the pages devoted to "early history" (26–48) in the *Short History of Botany in the United States* (Hafner, N.Y., 1969) and in the introductory essay in *Hortus Botanicus: The Botanic Garden & the Book* (Newberry Library for Morton Arboretum, Lisle, Ill., 1972). "Columbian discoveries and the growth of botanical ideas with special reference to the sixteenth century" in *First Images of America,* edited by Fredi Chiapelli (Univ. Calif. Press, Berkeley, 1976) and Jonathan Sauer's companion essay with its extensive references will initiate many studies. My short résumé entitled "Traffic in seeds and plants between continental North America, England, and the Continent during the 16th and 17th centuries" (*XII^e Congress Intern. d'Hist. Sci.* (Paris, 1969) Actes 8:47–49, 1971) is a précis to the subject. The little seventeenth century works of Pierre Morin on first inspection seem too trifling to be worthwhile but when several editions are assembled and compared the results, as with Philip Miller's *Gardener's Dictionary*, prove rewarding for their record of the introduction and movements of cultivated plants across Europe.

GROWTH PATTERNS AND RELATIVE DISTRIBUTION OF *CHAMAECYPARIS THYOIDES* AND *ACER RUBRUM* IN LEBANON STATE FOREST, NEW JERSEY

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Because of the economic importance of Atlantic white cedar, many data have been collected concerning the comparative ecology of this species and the several kinds of associated hardwoods, especially red maple. These data are not fully consistent, either within the broader studies or among them (e.g., Little 1950, Korstian and Brush 1931). Little's (1950) conclusions depend, in part, on his selection of particular plots for emphasis. There has developed, nevertheless, a set of generally accepted suppositions about establishment of white cedar and red maple that continue to influence management practices intended to maximize growth of cedar at the expense of maple. These ideas include the following: (1) white cedar is more shade tolerant than pitch pine (*Pinus rigida)* or gray birch (*Betula populifolia*), but less tolerant than other hardwoods such as red maple, sweetbay (*Magnolia virginiana*), black gum (*Nyssa sylvatica*), sassafras (*Sassafras albidum*) or holly (*Ilex opaca*); (2) after logging or fire, red maple will produce all-aged stands and so tend to permanently replace white cedar; and therefore (3) white cedar is subclimax to hardwoods, particularly to red maple. These ideas have been expounded by Little (1950, 1964), who, in addition to extensive field work, has studied shade tolerance experimentally in greenhouse culture. His experiments support (1) above, but seem to have been performed under sufficiently unnatural conditions that we cannot be sure of their pertinence to most field situations.

Through the fall of 1976, we investigated several mixed and pure stands of white cedar and red maple with varying fire and logging histories. Our data contradict to some degree all of the ideas listed above. We believe that general conclusions are difficult to make because the partially overlapping amplitudes of these two species (and of pines as well) insure that patterns of interaction will vary with particular local circumstances, as well as with different ages of trees. Nevertheless, study of five sites scattered through Lebanon State Forest provided data that all point to the same conclusions. We found that, under field conditions, maples fail to establish under any closed canopy but that cedars can establish, albeit slowly, under a dense

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[1] This study was a project of the Plant Ecology class at Swarthmore College, Fall 1976, taught by J. C. Hickman. Other investigators who participated at every stage of planning and data collection were Stephen D. Belsky, Martha Burdick, John W. Chesnut, Jerry G. Coleman, Peter C. Frederick, Susan B. Katz, Irene C. Magran, Margaret E. McWethy, Jeffrey L. Pennington, Daniella J. Schutzengel, David E. Titus, Margaret L. Willits, Elizabeth L. Wirtz, Sandra L. Wolfe, and Amy J. Yale.

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canopy of maple. Further, after logging and slash burning, cedars establish from seed more abundantly, and in a greater diversity of microsites, than maples.

METHODS AND RESULTS

Field Sites. — All data were collected from naturally growing stands of trees in three different areas of Lebanon State Forest: Shinn's Branch (39°53′37–48″ N, 74°33′20–30″ W); Cooper's Branch (39°53′18–30″ N, 74°32′10–25″ W); and McDonald's Branch (39°53′0–12″ N, 74°30′10–30″ W).

The Shinn's Branch area is separable into three sites with differing histories. The northwest corner was mature cedar swamp until it was logged in several phases from 9–15 years ago. The eastern and central portion is currently mature cedar swamp (trees up to 130 years old) from which about 10% of the cedars were thinned several decades ago. The southwest corner, across Shinn's Branch from the mature cedar swamp, was also mature cedar swamp with dense understory maples until it burned about 40 years ago. It now has a pure canopy of red maple root sprouts that reach about 5 m in height. The New Jersey Bureau of Forestry has no record of fire at this spot, but it is indicated by the uniform-aged 34–40 year old maple root sprouts and adjacent pitch pines, by reduced annual growth increments 35–40 years ago in the few large cedars that survived close to the stream, and by buried cedar logs and stumps.

The McDonald's Branch site is a younger cedar swamp: mean age of mature cedars is about 60 years. The wetter portion, upstream of Butterworth Road, is younger, with dense pole-saplings, and apparently has been burned in part within the last 30 years. Although the Bureau of Forestry also has no record of this fire, we found trunk charring on living trees, charred stumps, and pieces of charcoal in the sphagnum mat.

The studied portion of Cooper's Branch was logged in 1958. There is abundant regeneration of cedar and a sparse population of larger vigorous maple and cedar trees. The cedar trees survived the logging as saplings, but the maples are primarily root sprouts.

Soils. — Soil samples were taken from several points at all sites. At each site, pH was determined with pHydrion papers. Water content and organic matter, both expressed as percent dry weight, were determined by drying and ashing weighed samples. Pooled data from cedar swamps, hardwood swamps, and drier hardwood areas are given in Table 1. In the cedar and hardwood swamps, pH is similar, but

TABLE 1. — Soil Characteristics for Three Habitat Types in the New Jersey Pine Barrens.

	pH	H_2O (as % dry wt)	Organic Matter (as % dry wt)
Cedar Swamps (n = 9)	4 ± 0.5	960 ± 304	86 ± 5
Hardwood Swamps (n = 3)	4 ± 0.5	564 ± 225	88 ± 3
Drier Hardwoods (n = 3)	5 ± 0.5	50 ± 20	1.5 ± 1

increases under hardwoods growing in drier soils. The highly organic soils of both types of swamp hold an enormous amount of water, but both organic and water contents of soils in adjacent drier sites are considerably lower.

Light. — Total incoming radiant energy was measured (in langleys) in the cedar and hardwood swamps on Shinn's Branch with a Yellow Springs Instruments Model 68 Pyranometer. Readings were taken at solar noon on clear days at 0 and 2 m heights at 30–40 points in each site before leaf fall and shortly thereafter (mid- and late October). Before leaf fall, incoming light at both sites was highly variable, and means were nearly identical. After leaf fall, high variance was maintained, but cedar swamp means at 0 and 2 m heights were 0.092 and 0.094 ly, whereas hardwood swamp means were 0.203 and 0.240 ly. By the nonparametric Mann-Whitney U-Test, the hardwood swamp then had significantly more light than the cedar swamp ($p < 0.001$).

Seedling Distribution, Density, and Age. — In all sites except the Shinn's and Cooper's Branch logged areas, in which maneuvering was difficult, 2 m by 10 m quadrats were established to determine community structure. The most useful data were those collected on seedlings and saplings of cedars and maples. The combined cedar swamp quadrats yielded, with low variance, means of 3150 cedar seedlings per hectare and 2000 maple seedlings/ha. No sapling of either species older than three years was found, indicating that while germination conditions were adequate, establishment conditions were unfavorable. By contrast, the hardwood swamp had 76,000 cedar seedlings/ha and 10,000 maple seedlings/ha under a canopy of 34–40 year old maples. The maple seedlings did not exceed three years of age, but cedar saplings had a continuous age distribution up to 15 years. They were continuing to grow at a slow rate.

In the Shinn's and Cooper's Branch logged areas, maple seedlings were judged by careful observation without quadrats to be much less abundant than cedar seedlings, to span all ages from the time of logging, and to occupy only the more open, sunny microsites within each logged area. At Cooper's Branch, in the 18 years since logging, growth of both trees and underbrush (primarily *Clethra, Vaccinium,* and *Gaylussacia* had produced dense shade in most areas. Young maples were entirely absent from these shaded microsites, although cedar seedlings and saplings were growing vigorously in them. Most maple regeneration in the Cooper's Branch site has been from root sprouting, which has produced scattered nine-meter trees.

Growth Rates of Establishing Cedars and Maples. — In all the areas where either maples or cedars were successfully establishing, samples were collected of 40–60 young trees of the entire range of sizes. Sampling was not formally random, but an attempt was made to weight the sample toward abundant size classes while encompassing the whole range of sizes. Samples were taken from both the sunniest and shaddiest microsites at each station. We noted in the field at the Shinn's Branch logged area that maple seedlings were restricted to sunny and lightly shaded microsites whereas cedar seedlings spanned a considerably broader range of light conditions. At the Cooper's Branch logged area no samples were found in shady sites. Age distributions of the samples from the logged areas were similar. Too few

TABLE 2. — Site Characteristics, Tree Composition, and Sapling Growth Rates in Three Swamps in the New Jersey Pine Barrens.

			Shinn's Branch cedar	Cooper's Branch cedar	Shinn's Branch hardwood
Years since logged (L) or burned (B)			15 (L)	18 (L)	40? (B)
Organic soil depth (cm)			75	200	60
Cedar—	Saplings—	growth rate[a] in sun	7.1	12.2	—
		growth rate[a] in shade	5.4	6.7	3.1
	Trees—	mean age	49	20	82
		growth rate	no data	17[a]	8.9[b]
Red Maple—	Saplings—	growth rate[a] in sun	6.2	12.3	—
		growth rate[a] in shade	5.1	—	—
	Trees—	mean age	35 (14*)	28 (21*)	31*
		growth rate	no data	32[a] (33*[a])	15*[a] 0.6*[b]

*root sprouts

[a] cm height per year

[b] cm^2 basal area per year

maple seedlings grew in the hardwood swamp to constitute a reasonable sample, and their age distribution (all less than three years old) indicated failure to establish.

Seedings and saplings were sectioned at the base, and age was determined by counting annual growth rings. Each plant was aged by two investigators, and additional counts were made if the first two strongly disagreed. Sapling height was recorded, and growth rates were calculated as cm of height growth per year.

Data on growth rates of seedlings, disturbance type and date, organic soil depth (determined at 5–50 points in each site with a soil augur), and ages and average growth rates of mature trees are given in Table 2 for the three sites in which seedling establishment was found. Growth rates of the eight distinct seedling populations were compared using Student's *t*-tests. A matrix of the results is presented as Table 3. Both young maples (although rare) and young cedars had very high growth rates in the Cooper's Branch logged area. At the Shinn's Branch logged area both cedars and maples showed a higher growth rate in the sun than in the shade, but differential in both growth rate and light intensity was greater for the cedars. At this site cedars and maples growing in sunny areas showed no significant difference in growth rates. Growth rates of cedars under the maple canopy of the hardwood swamp were extremely low. Sapling growth rates for both species combined is highly correlated with depth of the organic layer of the soil (coefficient of determination = $r^2 = 0.96$ for the three sites).

Growth of maple root sprouts in the marginal, fire-susceptible Shinn's Branch hardwood swamp was much less than in the central, fire-protected and cedar-dominated Cooper's Branch population. Excavation of Shinn's Branch root burls indicated multiple sproutings, but, because the centers were decomposed, exact ages of rootstocks could not be determined.

TABLE 3. — Pairwise Comparison of Sapling Growth Rates from Three Localities and Eight Populations. [S: = Shinn's Branch logged cedar swamp; C: = Cooper's Branch logged cedar swamp; H: = Shinn's Branch hardwood swamp; :M = maple; :C = cedar; :S = sunniest microsites; :Sh = shadiest microsites. NS = not significant; ${}_{+}^{-}$ = row member of pair had greater growth rate than column member at 0.05 significance level; ${}_{--}^{++}$ = column member had greater growth rate than row member at 0.01 significance level (Student's *t*-test).]

	S:MSh	S:CS	S:CSh	C:MS	C:CS	C:CSh	H:CSh
S:MS	${}_{+}^{-}$	NS	NS	${}_{--}^{++}$	${}_{--}^{++}$	NS	${}_{++}^{--}$
S:MSh		NS	NS	${}_{--}^{++}$	${}_{--}^{++}$	${}_{-}^{+}$	${}_{+}^{-}$
S:CS			${}_{+}^{-}$	${}_{--}^{++}$	${}_{-}^{+}$	NS	${}_{++}^{--}$
S:CSh				${}_{--}^{++}$	${}_{--}^{++}$	${}_{-}^{+}$	${}_{++}^{--}$
C:MS					NS	${}_{++}^{--}$	${}_{++}^{--}$
C:CS						${}_{++}^{--}$	${}_{++}^{--}$
C:CSh							${}_{++}^{--}$

Neither Shinn's nor McDonald's Branch cedar swamps had successful reproduction of either cedars or maples, so are not included in Tables 2 and 3. However, some data concerning organic soil depth and ages and growth rates of mature trees adds perspective to a comparison of cedars and maples. In the Shinn's Branch stand organic soil depth was 175 cm or more. Cedars ranged in age from 70–130 years (mean = 92) and had a mean growth rate of 4.6 cm^2 basal area per year. The scattered maples ranged from 36–60 years old (mean = 51) with an average growth rate of 0.6 cm^2/yr. In the McDonald's Branch stand, with an organic soil layer of 100 cm, the largest cedars averaged 61 years old and showed a mean growth rate of 6.8 cm^2/yr. Maples averaged 51 years old, and grew 0.5 cm^2/yr. Data from only a few trees suggest that basal area growth rate of canopy cedars has been constant at Shinn's Branch, but has increased with age at McDonald's Branch, perhaps due to thinning of competitors by fire.

DISCUSSION AND CONCLUSIONS

The data can be summarized by the following points: (1) Neither cedars nor maples are successfully reproducing under any of the mature cedar stands studied, although at Shinn's Branch, maples appear to have established sparsely under an approximately 40-year-old cedar canopy. (2) At Shinn's Branch, cedars established over a period of at least 60 years. (3) Cedar is able to establish successfully in shadier environments than maple. Thus, at least during the establishment stage, cedar must be considered more shade tolerant than maple. (4) Hardwood swamps are environments of higher light intensity than cedar swamps, if only because of their seasonally leafless state. Correspondingly, they support a much greater regeneration density than cedar swamps, and supply more light for cedar regeneration than for maple regeneration because cedars are evergreen and can take advantage of higher light levels after leaf fall and before leaf expansion in the spring.

(5) In the sites studied, depth of the water-holding organic soil layer is positively and strongly correlated with sapling growth rate.

We must conclude that it is incorrect to postulate that cedar is in any general way subclimax to maple (e.g., Little 1950, p. 44). The only site we found in which maple is currently dominant over cedar is a former marginal cedar swamp that has the thinnest organic soil layer of all the swamps measured in this study. It burned about 40 years ago, killing most of the mature cedars. The current maple canopy is entirely from root sprouting. Our observations support the view that maple root sprouts show vigorous early growth, but cannot sustain high growth rates upon multiple sprouting and may become increasingly susceptible to elimination by disease (Little 1950, McCormick 1970). Under this maple canopy only cedars are regenerating. Their growth rate is low, but they have survived for as long as 15 years and have a continuous age distribution. Upon slow disintegration or death of the maple root sprouts, we suspect that cedars will become dominant again.

Many mature cedar swamps in the Pine Barrens are surrounded by a "halo" of red maple that blends into younger pitch pine forest. This is at least in part the result of recurrent fires burning the edges of cedar swamps, allowing the dominance of root-sprouting maples. If this is correct, fire is necessary for the maintenance of maples as long-term dominants in sites that would otherwise revert to cedars.

Because all our evidence suggests that cedar is more shade tolerant at establishment than maple, its main hardwood competitor, we do not believe that white cedar stands are in danger of domination by maple. Our observations support the data of Little (1950) that sweetbay is, in fact, the only hardwood that can maintain a continuous age distribution under cedar. It is generally a subcanopy tree and we have never seen it become dominant.

Natural distribution patterns suggest that maple's tolerance of dry soil is greater than that of cedar. Because swamps with thin organic soil are more susceptible to drought than those with a thick organic layer, attention to potential problems of increased maple dominance through fire or logging disturbance might well be centered on cedar swamps where organic soil depths are less than 70 cm, or on swamps that, for other reasons such as road-building, are partially separated from their water supplies. Water-table depth has received much observational and experimental attention as a factor controlling cedar and maple distribution, but water retention capacity through the accumulation of a deep organic soil has been largely ignored. Because this is the primary factor differentiating the Shinn's Branch and Cooper's Branch logged areas that have strikingly different growth rates of regenerating trees, we believe this factor deserves more attention.

We have not seen data that would distinguish fire-related causes from soil-related causes of maple dominance at the margins of cedar swamps. If soil properties are as important as we suspect they are, maple could be considered the climax species in marginal "halos", but not in sites where economically valuable cedars can grow.

Finally, we would like to emphasize that we are not convinced that our data are extensive enough to allow broad conclusions. Because of the breadth of tolerance of all the major tree species in the Pine Barrens, and because of the diversity and seasonal changes of environments encountered, complex questions concerning the comparative ecology of these trees will not likely have simple answers. We were able, however, to provide evidence that generally accepted relationships between cedars and red maples do not hold.

ACKNOWLEDGMENTS

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SCIENTIFIC CONTRIBUTIONS OF AMOS EATON'S SON HEZEKIAH HULBERT EATON[1]

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Hezekiah Hulbert Eaton was one of the early pioneer naturalists of the states of New York and Kentucky in the early 1820's and 1830's. Living only to the age of 23, he was able during his short life to leave a significant mark in the field of natural history. This paper brings together information from several published and unpublished sources emphasizing his professional life with particular reference to his contributions to botany — publications, herbarium, collecting localities, and type collections. Biographical information has been summarized from Short (1832), Nason (1887), McAllister (1941), and Payne and Anderson (1962).

PROFESSIONAL LIFE OTHER THAN BOTANY

Hezekiah Hulbert Eaton was born 23 July 1809, the fifth of ten sons of Amos Eaton (1776–1842) and the fourth son of the latter's second wife, Sally Cady, at Catskill, Greene County, New York. At age 23 he died of pulmonary consumption on 16 August 1832 in Lexington, Kentucky. In his early years, H. H. Eaton attended a common school at Catskill and in Chatham, where he was engaged in acquiring the rudiments of a common English education until about 1818, when his father moved to Albany to deliver a course of lectures on chemistry and geology to the members of the legislature. Here at the age of 9, young Eaton took part in his father's chemical experiments, collected rocks, and in the following year began assisting his elder brothers in the collection of plants for the illustration of the lectures of their father. It was Amos Eaton's hope that Hezekiah would become a manufacturing chemist and druggist, but with the interest he was showing working with his father, these desires were about to change. In April of 1823, Amos Eaton went to Amherst College in Massachusetts, where Hezekiah became his assistant in chemistry, mineralogy, and botany. In the summer of that same year he served in the same capacity to his father in a course on some of the branches of natural history at Middlebury College in Vermont. In the autumn of that year he accompanied his father on a geological tour of three thousand miles over the western parts of the state of New York and some parts of Massachusetts. This activity afforded him a rare opportunity to extend and enlarge his acquirements in geology and mineralogy, and

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[1] The research presented here has resulted from several extended periods at the Academy of Natural Sciences, Philadephia, sponsored by the systematic and evolutionary biology program of the University of Michigan in1965, a National Science Foundation grant to the Academy in 1973, and by the Academy in 1977. The paper was read in part at the Historical Section of the Botanical Society of America, American Institute of Biological Sciences meeting held at Tulane University, New Orleans, Louisiana, June 1976.

in the winter he again assisted his father in a course of lectures on chemistry, natural philosophy, zoology, and botany at the Medical College of Vermont.

In the fall of 1824 the Rensselaer School was established in Troy, New York, and Amos Eaton was appointed as a senior professor in the fields of chemistry and experimental philosophy, and lecturer on geology, land surveying, and the laws regulating town officers and jurors (McAllister, 1941, p. 369). At the Rensselaer School, Amos Eaton became one of the most prominent and influential figures in the history of botany in our country in the first half of the nineteenth century. The object of the school was to furnish instruction in the application of science to the common purposes of life. All parts of the plan were strictly practical. In every exercise, the pupil was made to take the place of the teacher, he becoming the lecturer and performing for himself the experiments necessary to illustrate and prove the truths of chemistry and natural philosophy (Short, 1832). Hezekiah entered the school at its opening, and two years later at age 17 in April 1826 took the Rensselaer degree of Bachelor of Arts. He was in the first graduating class, consisting of ten students, each of whom delivered a lecture. Hezekiah's was on "Hydrodynamics."

Upon leaving the Rensselaer School, H. H. Eaton lectured on chemistry in Canandaigua at the Female Academy, in Black Rock, and in Rochester, and by the winter of 1828 he was as far east as Boston delivering a course on chemistry before the Mechanics Institute. Upon returning to Troy from Boston, Hezekiah was elected in 1829 to a Junior Professorship in the Rensselaer School, succeeding Dr. Lewis Caleb Beck (1798–1853), a mineralogist, botanist, chemist, zoologist, and the first Junior Professor, who had resigned in 1828 to take a position in the Medical College of Vermont. Having now become a colleague with his father, the young professor attempted to improve himself in extemporaneous lecturing, general literature, practical mathematics, and especially in all the natural sciences. He was considered a very eloquent teacher, resembling his father in that respect. Hezekiah did not, however, remain long in this position, for in the autumn of 1829, at the invitation of the Rev. Benjamin O. Peers (1800–1842) of Lexington, Kentucky, he was invited to aid in the establishment of an experimental school. Rev. Peers had entered Transylvania University in 1817, was tutor in Latin and Greek by 1819, and was graduated in 1821. He also studied theology at Princeton and at the Episcopalian Seminary (Payne and Anderson, 1962). Believing that his special vocation in the holy ministry was as an educator of youth, he examined the systems of common school education in New England and the Middle States under an appointment from the Governor of Kentucky in 1829. This trust he executed faithfully and upon his return exerted a powerful influence in molding the popular will in favor of a common school system in Kentucky (Collins and Collins, 1874, p. 442). In this respect, Peers wanted to try a similar type of instruction that was offered at the Rensselaer School, and so persuaded young Eaton to come (Wright, 1955, p. 17).

On October 21, H. H. Eaton wrote in a letter[2] of his invitation to teach in

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[2] A list of all letters cited appears in an arrangement separate from the references cited at the end of the paper.

Kentucky to his friend, Mr. George Clinton, volunteer assistant to Amos Eaton and son of the late Governor DeWitt Clinton of New York:

> I have lately received an application to go to Lexington, Kentucky, to aid in the establishment of an experimental school; and I shall start in about three or four weeks for that place. I shall remain there one year; and at the expiration of that period shall return, either to remain, or get additional apparatus, specimens, &c— It is one of my greatest objects in going to Kentucky, to examine the natural productions of that district; . . .

The main purpose of the letter was to borrow from Mr. Clinton books on botany and zoology, on the condition that they would be safely returned after a year with a complete "suit of Plants, Shells, Minerals &c. as I can get in Kentucky, at the expiration of that year." Mr. Clinton loaned him some books as indicated by Hezekiah's gratification and generosity expressed to him in a letter of 24 October.

The school was opened in the fall of 1829, and Mr. Eaton taught the natural sciences and mathematics. In 1830 the school took on the name Eclectic Institute and Mr. Henry A. Griswold (–1873) of Lexington, later to become a botanical companion of Dr. Charles W. Short (1794–1863), was also associated with the school. Eaton remained with the Eclectic Institute until his death. In the summer of 1832 Eaton was listed for the Department of Natural Sciences for the session beginning on 2 July. Peers continued to teach moral and mental philosophy, Griswold had mathematics, and three other faculty members had been added (Anonymous, 1832b). The school, however, was short lived, as it was discontinued in the winter of 1832–33.

Short (1832) believed that Eaton's contributions to the Eclectic Institute were of great importance and highly successful. Because of Eaton's acquisition of useful knowledge as a child, he was in an excellent position to teach the boys of Peers' school according to the methods of the Rensselaer School. At Rensselaer, the efforts were employed only with matured minds, while at the Eclectic Institute, Eaton was the first to make trial of it with young minds.

Eaton had planned to return to Troy after one year's stay in Lexington, for one of his main objectives was to examine the natural productions of the area about Lexington. To that objective he prosecuted with great industry and earnestness the study of the natural history of the immediate neighborhood, and of the surrounding country, so far as opportunities were offered for exploring it. During these excursions, Dr. Charles W. Short was his frequent companion. One of the longest of these excursions was taken in the fall of 1830 involving a trip to the Big Bone Lick and a study of the autumnal flora and the bivalves of the Ohio River below Cincinnati, the latter being published (Short and Eaton, 1831) with its results described later in this paper.

Two events extended Eaton's stay in Lexington, Kentucky. On 26 March 1831, he was selected to assist Lunsford P. Yandell (1804–1878) who was elected on 16 March as Professor of Chemistry in the Medical Department of Transylvania University. Yandell, although a good scholar, had never devoted special attention to chemistry. Therefore to strengthen the chemistry offering, Eaton, being available, and with prominent achievements in this discipline, attracted the attention of friends and members of the institution, and accordingly was selected and was to receive one-third of the net proceeds of the tickets sold for that chair. He accepted the appointment on 2 April 1831 and both he and Yandell took the oaths of office on 2 November. Before taking office, Eaton visited the eastern cities for the purpose of procuring apparatus and reagents, as well as to examine the construction and fixtures of the best laboratories (Short, 1832). By his industry and practical knowledge, he greatly improved the means of instruction in the Chemical Department with a complete reorganization of the laboratory and the procurement of much new apparatus during his short term of service (Peter, 1905; Payne and Anderson, 1962). Robert Peter (1805–1894), a former student of the Rensselaer School who operated a drug store and lectured in chemistry and the natural sciences in Pittsburgh, succeeded Eaton in both of the positions he held (Wright, 1955, pp. 24–25). The second event was Eaton's marriage on 30 November 1831 to Mary R. Harper of Lexington. His decision to remain in Lexington was further strengthened by his desire to continue a work he had begun on "The Birds of Kentucky," intended as a manual for the student, of which a large portion was already printed, but which never was completed.

At the time of his death, Hezekiah H. Eaton was eulogized by two of his scientific contemporaries and close friends of Kentucky. Yandell (1832, p. 457) wrote:

> . . .Mr. Eaton was an *uncommon* man. In his attainments, which were far beyond his years, *accuracy* was the predominant [p. 458] quality. He had no *opinions* — at least he contended for none. His aim was *positive* knowledge, which alone he valued. And of that, his stock, especially in the Natural Sciences, was abundant. In his acquaintance with those branches, and in his industry and ambition to become further versed in them, we believe no man of his age in the United States surpassed him; and we are confident but few equalled him. In all his pursuits, his end was practical usefulness. And he was as amiable in disposition, and as modest in deportment, and he was accomplished in intellect. Added to the other excellencies of his character, the clearness and simplicity with which he communicated knowledge to his pupils, fitted him peculiarly for the business of instruction.

The most extensive and detailed memoir was prepared by Charles W. Short (1832). Two brief quotations are noteworthy: . . . [p. 480] Mr. Eaton's character as a man of science, corresponded to his education. Of his ripe judgement and accuracy of observation, he gave ample proofs in the few papers published by him on matters of natural history. . .[p. 481] Though removed when his prospects were the most cheering and our hopes the most confident, he lived long enough to prove how rich, and various, and useful, may be the acquisitions of years so rarely devoted to science.

CONTRIBUTIONS TO BOTANY

While becoming established in Kentucky, Eaton opened on 25 July 1831, a correspondence on an exchange of plants and information with two botanists, Charles Pickering (1805–1878) of the Academy of Natural Sciences of Philadelphia, and Dr. John Torrey (1796–1873) of New York City. In Pickering's reply of 24 November, he acknowledged the box of plants that Eaton had sent. Among the plants, Pickering noted that several . . .were exceedingly interesting, and as it is a favorite object with me to get together a complete collection of our native plants for reference, I will, with your permission, present them in your name to the Acad. N. Sc. to be added to Mr. Nuttall's collection, which you know is in the possession of the Academy. By the bye, your specimens are very superior to Nuttall's, in general, and any specimens of those plants which are peculiar to your section of the country would be very acceptible. . . . Pickering continued the letter with comments on specific plants that

Eaton sent. Commenting upon the selection of epithets for some new species that Eaton was proposing, Pickering said . . . though I do not object to local names within certain

> limits, Lexingtoniensis is rather too local; Kentuckiensis to be sure is not much better in euphony. I prefer those names which express some peculiarity of structure or habit.

Eaton's letter to Torrey of 25 July 1831 was mainly concerned with four parcels of plants he sent to him with the wish that Torrey would write him about them, particularly some of the difficult ones. It is not known if Torrey responded. He was usually about a year behind in mailing replies.

H. H. Eaton's published contributions to botany were limited, but of significance in the early organization of the eastern North American flora of the 1830's. While at the Rensselaer School in 1828 and working closely with his father, young Eaton assisted in the preparation of the fifth edition of Eaton's *Manual of Botany* (A. Eaton, 1829). In the closing remarks of the Preface, Amos Eaton stated that Dr. William Aiken and Hezekiah H. Eaton . . . prepared the species, after the genus

> Carex [p. 161]. I assisted no farther than to supervise the work. I decided in doubtful cases, compared their translations with the original authors, examined the proof-sheets, and gave all the new specific names. But they selected, arranged, compared, and transcribed the whole. They compared descriptions with plants in their extensive collections, and suggested numerous valuable improvements.

H. H. Eaton did provide (p. 3) one description from a dried specimen, a moss, *Hypnum cooleyanum*, first found by Dr. Dennis Cooley (1787–1860) in Deerfield, Massachusetts. Amos Eaton noted in the sixth edition (A. Eaton, 1833) that his son together with his colleague, Dr. Short, "corrected many errors in the descriptions of plants" from Kentucky.

Aside from the assistance he gave his father with the *Manuals,* H. H. Eaton published two papers in *The Transylvania Journal of Medicine and the Associate Sciences* (Short and Eaton, 1831; Eaton, 1832). This journal, founded in 1828 and edited by Charles W. Short and John Esten Cooke through volume four, was published by the Medical Department of Transylvania University. It was easily available as a publication outlet for Eaton. The first paper dealt with western botany and conchology, and was co-authored with Dr. Short. It consisted of an enumeration of 50 plants and 36 bivalves noted along the northern side of the Ohio river a mile or two above and below the mouth of Muddy Creek, a small stream which empties into the Ohio River about 15 miles below Cincinnati, and the eastern border of the Great Miami River at the village of Cleves, all in Hamilton County, Ohio. Other nearby mentioned localities were North Bend, Big Bone Lick, Big Bone Creek, and Eagle Creek. Travelling by stage and on foot, the excursion to the Ohio River was made from Lexington, a distance of about eighty miles north of Lexington, in the early September of 1830. The plant list was a fair representation of the late autumnal flora in flower on the mudflats of a major river, and therefore represents one of the first, if not the first, list of this type of flora west of the Allegheny Mountains. Notes on habitats, substrates, and abundance were generally given. Their paper received favorable notice as "interesting" and deserving of being made available to the natural history public, but was "corked up . . . in a medical journal, although of the greatest respectability" (Anonymous, 1832a).

In the second paper Eaton (1832) reported on 17 taxa of plants of the vicinity of Troy, New York, that he had discovered to be either imperfectly or erroneously described or new to science. Following the Linnaean classification of arrangement, he gave detailed descriptions of each species or variety, comparisons with related or confused species, habitat and locality information, and time of flowering. Two species and two varieties were described as new to science and are discussed in detail in Appendix I.

HERBARIUM

As noted by Amos Eaton (1829, p. 1), his son's herbarium was "extensive," although H. H. Eaton himself wrote in a letter of 17 March 1831 to Samuel P. Hildreth (1783–1863), pioneer physician and naturalist of Marietta, Ohio, that his herbarium was "not large, about 2000 species," and that he was anxious to increase it. H. H. Eaton began making an herbarium at the age of 9 while helping his father who was lecturing in Albany in 1818. Hezekiah's earliest known collections date from June 1818, Castleton, Vermont. He continued to add to his herbarium until the spring of 1832. As noted in a letter of 4 August 1832, written 12 days before his death and in the presence of his good friend, Prof. Charles W. Short, Eaton told him of the condition of his herbarium:

> Dear Friend,
>
> My plants, &c. are all moved into Mr. Bell's room under the Library. I should be very much pleased if you, at your leisure hours, when you feel so disposed, would look through the different bundles, books, &c.
>
> Many of the plants are not labelled which you are familiar with; others from the East (if labelled long ago) may be wrongly named — or not named at all, if Mr. Peter would look over such plants with you — he might name them for me.
>
> I am anxious that you should know what plants I have.
>
> The plants are in the large case, some in the new books I believe.
>
> You will see I began to arrange them according to Torrey's Lindley.
>
> Yours truly,
>
> H. H. Eaton

After Eaton's death, Mrs. Eaton sought Dr. Short's help in the disposition of the herbarium. In a letter to Dr. Short of 20 August 1832, she wrote: . . . I know of no other person to whom I can apply for advice, as to the *value* and *disposal of the Plants*; and your many acts of kindness will not withhold it.

> So few persons, (in this western world at least) take that interest in the study of *Botany* that would induce them to purchase so large a collection; indeed I suppose *Mr. Peers* was the only one in town who would give anything like the value of them.

Later, in an undated letter, Mrs. Eaton replied to Short, "The sum you offer for the case of plants is much more than I expected to get for them." At the bottom of the letter Short noted, "Paid to Mrs. Eaton fifty dollars for the case of Plants Nov. 13th 1838."

H. H. Eaton's herbarium, having become a part of the 30,000 specimens in the vast herbarium of Charles Wilkins Short, was presented in 1864 by his family to the Academy of Natural Sciences of Philadelphia (Pennell, 1929). Examination of many of Eaton's specimens reveals both the status of his herbarium at the time Short received it and how Short treated it. Many of Eaton's original labels are with the specimens, and, in addition, Short had labels printed with the notation, "Herb^{m}. H. H. Eaton," and on these labels he added the name of the plant. Some of these names were evidently added in 1850 because that year is handwritten in ink on some of the specimens.

Unfortunately, not all of Eaton's collection stayed in Short's herbarium before it went to the Academy. Writing to Asa Gray, 31 May 1858, Short pointed out some favors that a nephew of H. H. Eaton and Gray's pupil, Daniel Cady Eaton (1834–1895), had done for Short. Consequently, in return for these favors, Short said, I am now putting up for Mr. E. a set of plants for his Herbarium, some of which were prepared by

> his lamented Uncle (H. Hulbert Eaton), when a little school boy at the Rensselaer Institute at Troy, under the tutelege of his Father the venerable Amos Eaton. This collection, much enlarged after he removed to Kentucky, became mine by purchase after the death of the former of it; and the portion I return to the nephew will I hope be an interesting relic and memorial of an Uncle, who had he lived would have been an ornament to the Science. . . ."

Daniel Cady Eaton's herbarium containing approximately 60,000 specimens was left after his death to Yale University in 1896 (Day, 1901, p. 287). No attempt has been made to locate any of H. H. Eaton's specimens in his nephew's herbarium, if they should have survived.

From the data obtained in a sampling of 170 specimens seen in the remaining portion of H. H. Eaton's herbarium at the Academy of Natural Sciences, a descriptive list of 24 localities in seven states where Eaton obtained plants is presented in Appendix II. A chronology correlated with these collecting localities is developed in Appendix III. Contributions to Eaton's herbarium came from others interested in botany, including his brother Lt. Amos Beebe Eaton, Prof. Fay Edgerton, and John L. Riddell. The localities cited for 1823 represent places along the route of the Erie Canal where Eaton was with his father who was examining the canal during the summer and fall of that year (McAllister, 1941, p. 49). However, most of the plants examined were obtained in 1829 from the vicinity of Troy, New York. The second most represented locality is Lexington, Kentucky, where he spent the last two years of his life.

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APPENDIX I.

TAXA DESCRIBED BY AND/OR FROM SPECIMENS COLLECTED BY H. H. EATON

Epilobium coloratum Muhl. var. *tenuifolium* H. H. Eaton, Transylv. Jour. Med. & the Assoc. Sci. 5:105. 1832. "Grows in wet meadows about Troy, New York." Specimen: not located.

Rosa parviflora Ehrhart var. *inermis* H. H. Eaton, Transylv. Jour. Med. & the Assoc. Sci. 5:105–106. 1832. "Grows on the banks of the Hudson and Mohawk rivers in New York." Specimen: "Rosa parviflora? June 11th 1829, Troy, N[ew] Y[ork] H. H. Eaton." Ex Herb. C. W. Short (PH). Possible LECTOTYPE.

This is the only specimen located among the genus *Rosa* that might possibly serve as a type. Eaton's original label is no longer present. The label is one added by Dr. Short in his handwriting, dated 1850. If this sample was Eaton's original specimen of this taxon, then Short evidently omitted the varietal epithet when he labeled this plant.

Erigeron spathulatum H. H. Eaton, Transylv. Jour. Med. & the Assoc. Sci. 5:106–107. 1832. Probably = *E. strigosus* Muhl., but not mentioned or cited *in* A. Cronquist. 1947. Brittonia 6:121–300. "Grows in dry fields and woods in all the Northern States." Specimen: "Erigeron *spathulatum June 1822 Troy N[ew] Y[ork]." Herb^{m}. H. H. Eaton. Ex. Herb. C. W. Short (PH). HOLOTYPE.

Eaton's original label is no longer present. The label is one added by Dr. Short in his handwriting, but undated.

Neottia lucida H. H. Eaton, Transylv. Jour. Med. & the Assoc. Sci. 5:107–108. 1832. = *Spiranthes lucida* (H. H. Eaton) Ames, *fide* D. S. Correll. 1950. Native Orchids of North America North of Mexico, p. 208. "Grows in Troy and other parts of New York." Specimen: "Neottia *lanceolata. Dampish meadows, June 5, 1829, Troy, N[ew] Y[ork]." Herb^{m}. H. H. Eaton. Ex Herb. C. W. Short (PH). HOLOTYPE.

Eaton's original label is present. He had written the epithet *lanceolata,* but a *Neottia lanceolata* Willd. previously had been described.

Nuphar variegatum Engelmann ex Durand *in* Clinton, Regents Univ. State of New York on the Condition of the State Cabinet of Natural History. . . , p. 73. 1866. = *N. lutem* (L.) Sibth. & Sm. subsp. *variegatum* (Durand *in* Clinton) Beal, *fide* E. O. Beal. 1956. Jour. Elisha Mitchell Sci. Soc. 72:330–332. Specimen: "Nuphar———New York. 1828" Herb^{m}. H. H. Eaton. Ex Herb. C. W. Short (PH). HOLOTYPE.

Eaton's original label is no longer present. The label is one added by Dr. Short in his handwriting, but undated.

The confusion that has surrounded the authorship and type specimen of this taxon is discussed in detail by Voss (Taxon 14:159–160. 1965). The lectotype selected by Beal (Jour. Elisha Mitchell Sci. Soc. 72:330–332. 1956) is incorrect, now that the specimen used by Clinton for the description has been located, as was also pointed out by Voss in his paper.

APPENDIX II

H. H. EATON'S COLLECTING LOCALITIES

CONNECTICUT. New Haven: City at the head of New Haven Bay, 4 miles from its entrance into Long Island Sound. New Haven County. (Specimens from Prof. Fay Edgerton[3].) 4 specimens.

KENTUCKY. Danville: Town situated 36 miles south-southwest of Lexington. Boyle County. 1 specimen.

Dick's River (Dix River): Rises in Rockcastle County and enters the Kentucky River 25 miles southeast of Frankfort. Fayette County. 1 specimen.

Elkhorn Creek: Rises by two branches in Fayette County and enters the Kentucky River about 10 miles north of Frankfort. 1 specimen.

Fayette County: In northeast central Kentucky. 1 specimen.

Gaines: Boone County. (This locality has not been located.) 1 specimen.

Jessamine County: In central Kentucky. 1 specimen.

Lexington: Town on the Town Fork of the Elkhorn Creek, 25 miles southeast of Frankfort. Fayette County. 1 specimen.

MARYLAND. 3 specimens.

Baltimore: City on an estuary of the Patapsco River, 14 miles from Chesapeake Bay. 2 specimens.

Ellicott's Mills: Village and township on both sides of the Patapsco River, 12 miles west by south of Baltimore. Howard and Baltimore Counties. 2 specimens.

MINNESOTA. Upper Mississippi: Near the headwaters of the Mississippi River. (Specimens from Lt. Amos Beebe Eaton[4].) 16 specimens.

NEW JERSEY. Middleton: not located. (This locality may have been Middletown: Village and township on the Atlantic Ocean, about 13 miles northeast of Freehold. Monmouth County). In June 1829, when collecting was attributed to this locality, Eaton was in Troy. One sheet is labeled with the locality "Mid Pt., New Jersey," collected 27 June 1829. 2 specimens.

NEW YORK. Albany: City on the west bank of the Hudson River, 142 miles north of New York City. Albany County. 4 specimens.

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[3] Fay Edgerton (–1832), a famed teacher of science and disciple of Amos Eaton, was appointed adjunct professor to Amos Eaton in 1828 at the Rensselaer School (Ethel M. McAllister. 1941. Amos Eaton: Scientist and Educator, p. 411). Later he taught at Charles Bartlett's Utica Gymnasium in Utica, New York (A. Hunter Dupree. 1959. Asa Gray 1810–1888, p. 31).

[4] Amos Beebe Eaton (1806–1877), the fourth son of Amos Eaton and the second son with his second wife Sally (Cady) Eaton, was a graduate of the West Point Military Academy. He collected plants on his travels into the Great Lakes region, particularly the areas now the states of Michigan, Minnesota, and Wisconsin. Later Eaton became Brigadier General in charge of the Commissary Department under the presidency of Abraham Lincoln (Ethel M. McAllister. 1941. Amos Eaton: Scientist and Educator, pp. 30, 40–45, 66; Willian Albert Setchell. 1900. Fern Bull. 8:49).

Lansingburg: Former post-village on the east bank of the Hudson River and since 1901 forming a part of Troy. Rensselaer County. 4 specimens.

Niagara Falls: The outlet of Lake Erie into the Niagara River, 22 miles north-northwest of Buffalo. Niagara County. 2 specimens.

Oxford: Village on the Chenango River, 8 miles south-southwest of Norwich. Chenango County. (Specimens from John L. Riddell[5].) 5 specimens.

Preston: Village 5 miles west of Norwich. Chenango County. (Specimen from John L. Riddell[5].) 1 specimen.

Rome: Town on the Mohawk River and on the Erie Canal, 15 miles northwest of Utica. Oneida County. 1 specimen.

Trenton Falls: Village on West Canada Creek, 15 miles north by east of Utica. Oneida County. 1 specimen.

Troy: Town on the east bank of the Hudson River at the mouth of the Poesten Kill, 6 miles north of Albany. Rensselaer County. 72 specimens.

Watervliet: Township on the west side of the Hudson River opposite Troy. Albany County.

PENNSYLVANIA. Beaver: Village on the north bank of the Ohio River at the mouth of Beaver River, 28 miles northwest of Pittsburgh. Beaver County. 2 specimens.

VERMONT. Castleton: Village on the Castleton River, 11 miles west of Rutland. Rutland County. 4 specimens.

Chimney Point: Village in Shoreham Township on the shore of Lake Champlain, 50 miles southwest of Montpelier. Addison County. 1 specimen.

Middlebury: Town on Otter Creek and on the Rutland River, 35 miles south of Burlington. Addison County. 2 specimens.

Poultney: Village on the Delaware and Hudson Rivers, 18 miles west-southwest of Rutland. Rutland County. 1 specimen.

VIRGINIA. Allegheny Mountains: Broad range of mountains in Pennsylvania, Maryland, and Virginia. 8 specimens.

Fairfax County: In the northeast part of Virginia bordering on Maryland and the District of Columbia. One of the specimens with this locality is attributed to have been collected on 11 June 1829 when Eaton was in Troy. These specimens may have been contributed to Eaton's Herbarium by another botanist whose identity is unknown. 3 specimens.

Wheeling: Town on the east bank of the Ohio River at the mouth of Wheeling Creek, 45 miles southwest of Pittsburgh. Ohio County, now West Virginia. 2 specimens.

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[5] John Leonard Riddell (1807–1865), a graduate of the Rensselaer School, spent his early childhood at Preston, New York. He took his M.D. degree in the Medical Department of the Cincinnati College under Dr. Daniel Drake. Riddell was the author of the *Synopsis of the Flora of the Western States* (1834–1835), the first major flora covering the area west of the Allegheny Mountains to the Platte River in the Missouri Territory. In 1836 he was appointed Professor of Chemistry in the Medical College of Louisiana at New Orleans, a position he retained until his death (L. H. Bailey, Jr. 1883. Bot. Gaz. 8:269–271).

WISCONSIN. Fox River: Rises in Marquette County and flows into the south end of Green Bay. (Specimens from Lt. Amos Beebe Eaton[4].) 3 specimens.

Total number of specimens studied: 170.

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APPENDIX III

CHRONOLOGY CORRELATED WITH COLLECTING LOCALITIES

1818	June	Castleton
1822	June	Troy
1823	May	West of Rome; Trenton Falls
	August	Niagara Falls
1824	April, July	Troy
1825	May–August	Troy
	(Without month)	Lansingburg
	June	Castleton; Middlebury; Poultney
	July	Chimney Point
	September	Castleton
1826–1827		No Collections
1828	May	Albany
	May, July	Troy
1829	April–August	Troy
	June	Albany
	August, September	Lansingburg
	August	Watervliet
1830	March, April	Lexington
	September	Gaines, Boone County
	(Without month)	Fayette County; Kentucky River
1831	April	Lexington
	June	Maryland; Between Washington and Baltimore; Baltimore; Ellicott's Mills; Allegheny Mountains, Virginia
	August	Beaver; Wheeling; Danville
1832	March, April	Lexington
	April	Elkhorn Creek

THE GEOGRAPHICAL DISTRIBUTION OF THE SALT MARSH CORDGRASS (*SPARTINA ALTERNIFLORA* LOISEL.) IN MARYLAND

William S. Sipple

Maryland Department of Natural Resources

According to Fernald (1950), the North American distribution of the salt marsh cordgrass (*Spartina alterniflora* Loisel.) is from Newfoundland to Texas on the Atlantic and Gulf coasts. Mobberly (1956) gives a similar distribution. In Maryland, however, its geographical distribution has never been accurately determined although it is recognized in many publications (e.g., Shreve, et al., 1910; Norton and Brown, 1946; Tatnall, 1946; Mercer, 1969; Higman, 1972). Thompson (1974), in his review of the plants occurring in the Maryland portion of the Chesapeake Bay, gives the most recent and apparently the most accurate description of the distribution of this species. He states that *S. alterniflora* ". . . occurs in marshes from A. A. Co. south on the Western Shore and from southern Kent Co. south on the Eastern Shore." Figure 1 is a distribution map based on recent collections of *S. alterniflora* in Maryland. Considering this species' value to wildlife, estuarine food webs, and inorganic nutrient cycles and considering that as a species widespread in Maryland's tidal wetlands and intertidal zones it can serve as a baseline species for measuring future changes in tidal wetland and/or water quality, this map hopefully will prove useful.

The data for the distribution map were collected between 1971 and 1976 from a total of 566 stations (Fig. 2).

As Figure 1 indicates, *S. alterniflora* has a wide geographical distribution in Maryland. It was found in all tidewater counties except Prince Georges and Harford: however, it undoubtedly occurs in lower Prince Georges County along the Patuxent River because it was found on the opposite bank in Calvert County as far upstream as Ferry Landing, and it may occur in Harford County, a large part of which had no sampling stations due to restricted access on federal lands around Aberdeen. The species was not found in Baltimore City although there was one sampling station there. A total of 364 (64%) out of 566 sampling stations contained *S. alterniflora*.

The geographical distribution of *S. alterniflora* can be related to published salinity distributions. By comparing Figure 1 to the salinity maps of Lippson (1973) for the Chesapeake Bay and some of its tributaries, it is apparent that *S. alterniflora* occurs geographically over a wide range of salinities (spring range of less than 1 ppt to about 16 ppt; autumn range of less than 3 ppt to about 20 ppt) including the highest levels shown for the Maryland portion of the Chesapeake Bay. *S. alterniflora*

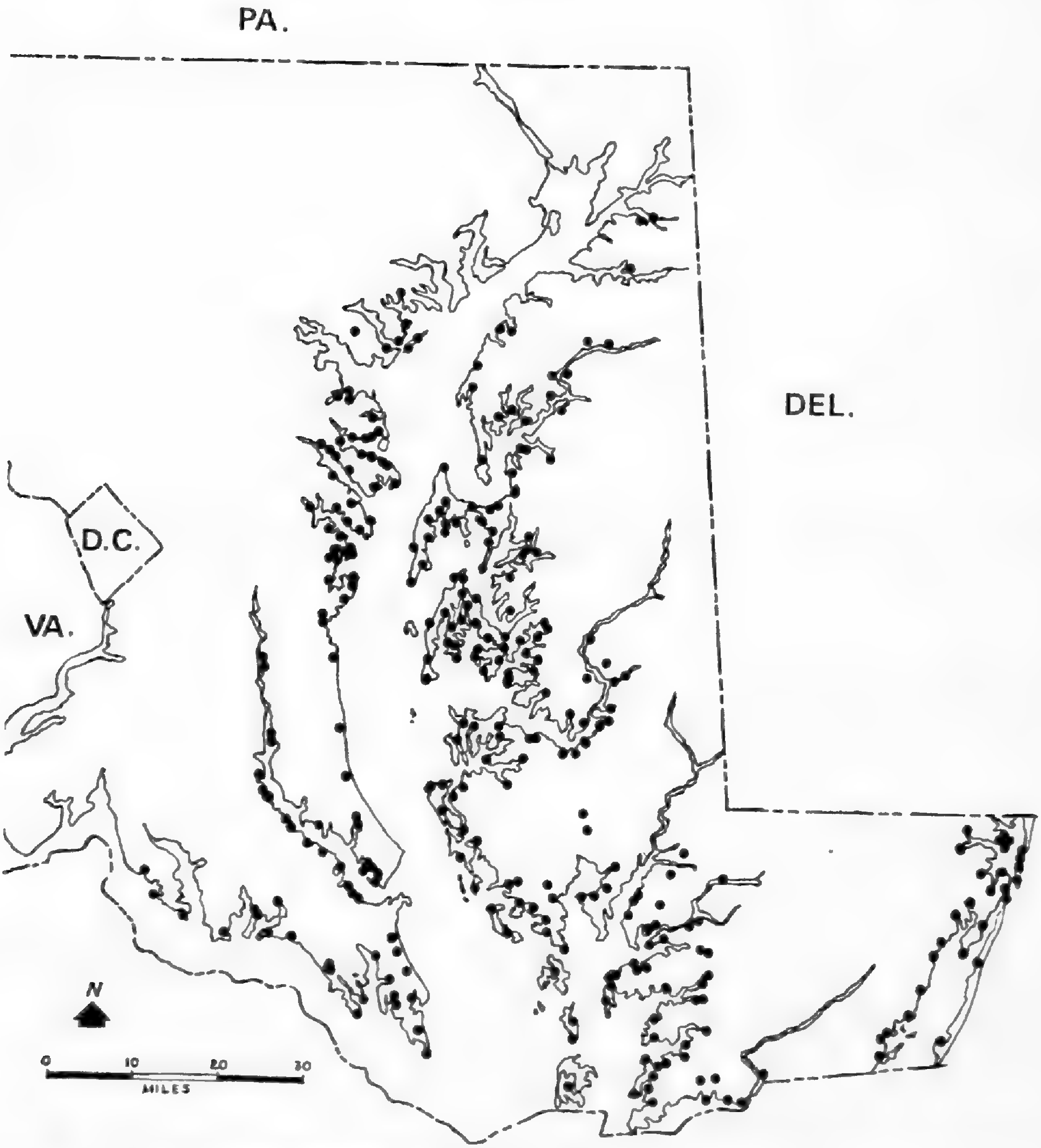

FIG. 1 — Map of tidewater Maryland showing the distribution of sampling stations containing *Spartina alterniflora*. One dot may represent more than one station.

occurs in areas of very low salinity as well: its distribution ends in upstream sections of the major Chesapeake Bay tributaries (the Potomac, Patuxent, South, Severn, Magothy, and Patapsco on the Western Shore; the Pocomoke, Wicomico, Nanticoke, Choptank, Chester, Sassafras, and Elk on the Eastern Shore) and in the upper Chesapeake Bay itself. These are localities between points shown by the Webb and Heidel (1970) to have predicted minimum extents of water having a specific conductance of 5000 micromhos (about 3 ppt) and points shown to have maximum extents of water having a specific conductance of 1000 micromhos (about .6 ppt).

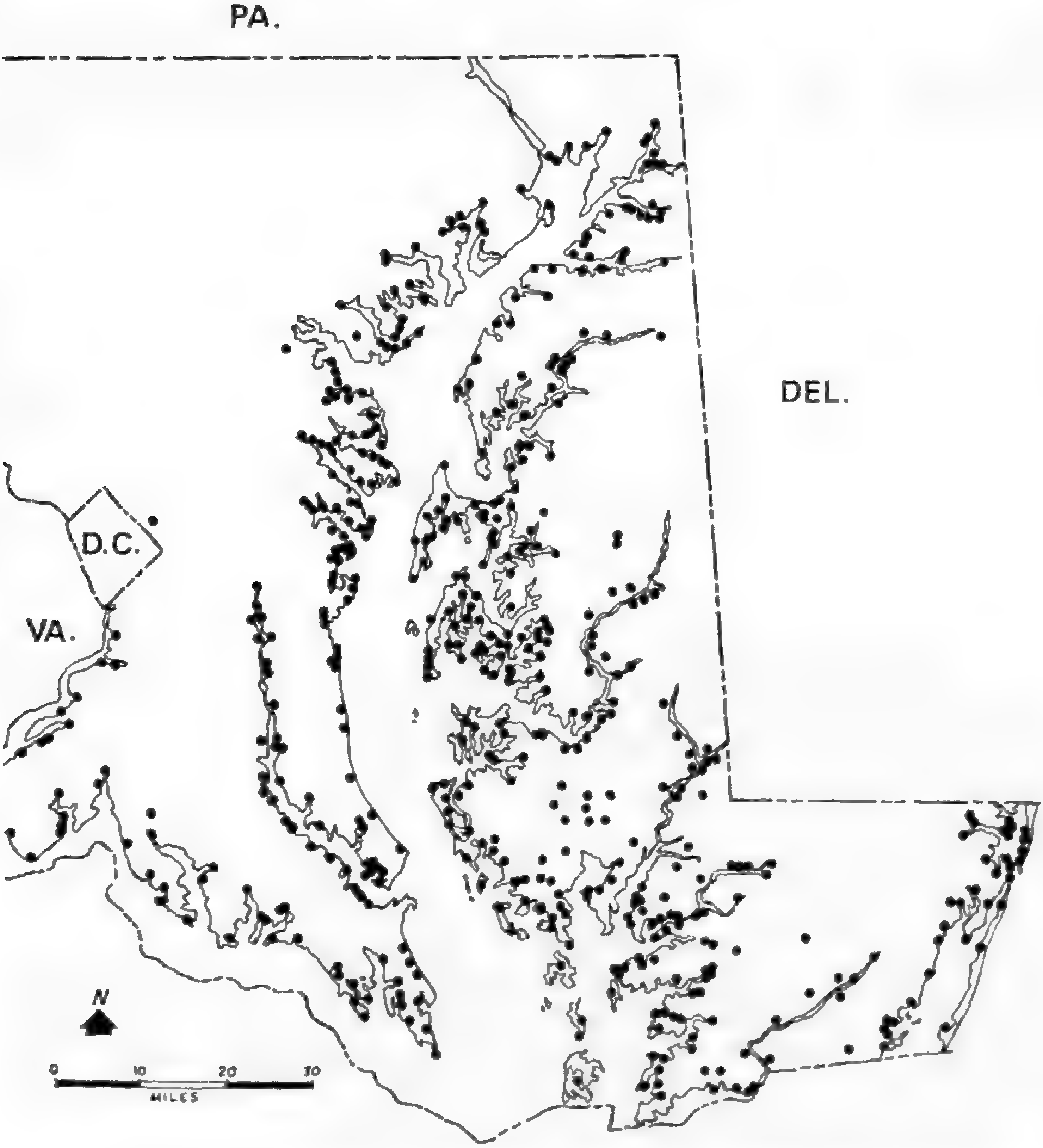

FIG. 2 — Map of tidewater Maryland showing the distribution of sampling stations for marsh, swamp, strand, and submerged aquatic vascular plant species. One dot may represent more than one station.

Barbour (1970), in a review of the literature dealing with the range of salt tolerance of angiosperms, has shown that the tolerance of low salinities by *S. alterniflora* and other halophytes is to be expected. He concluded that there was no laboratory-based evidence that definitely demonstrated that any angiosperm was an obligate halophyte (which by his definition was a plant with optimal growth at moderate to high salinities and incapable of growth at low salinities). Even from field evidence Barbour found that few species appeared to be restricted to salinities above 5 ppt. When compared to the existing published salinity data cited above, Figure 1 lends support to Barbour's conclusion — at least for *S. alterniflora* in Maryland.

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NEWS AND NOTES

Field Trips. — The 1976 field trips were designed to monitor the vascular plants of southern New Jersey and southeastern Pennsylvania. Among the objectives were the documentation through collection, photography and listing of the vegetation and geology of selected sites, and the searching out of rare and unusual species. Much research was done by James Mears and Wayne Ferren in selecting the sites and plants to be located, and in contacting several persons for their cooperation and support. Many interesting discoveries were made.

May 1, 1976: Pine Plains, Burlington Co., N.J. The Philadelphia Botanical Club started out this year's monitoring project with a trip to the Pine Plains (east and west), photographing and listing the limited flora of the area. No specimens were collected. The flora was typical of the Pine Plains area, with old established populations, not collected for many years, still seemingly the same. Among the plants located and listed were those which we were intentionally searching out: *Arctostaphylos uva-ursi, Comptonia peregrina, Epigaea repens, Hudsonia ericoides, H. tomentosa, Leiophyllum buxifolium, Pyxidanthera barbulata, Quercus ilicifolia,* and *Quercus marilandica.* Trip Organizer: Wayne R. Ferren, Jr.

May 15, 1976: Wood Chromite Mine, Serpentine Barren, Lancaster Co., Pa. A new site for our local herbarium, in terms of previously collected specimens. Located some 4 miles southwest of Nottingham, Pa. on Route 1 South, it is near the area of the classic Nottingham Barrens site, and in the vicinity of Octoraro Creek. Overgrown dump areas on serpentine slopes and piles were collected and listed. *Acer negunda, Chionanthes virginicus, Juglans nigra, Juniperus virginiana, Pinus rigida, Quercus marilandica, Q. velutina,* and *Vaccinium stamineum* were found in the wooded areas. *Cerastium arvense* v. *villosum, C. arvense* v. *villosissimum* (see Edgar T. Wherry. 1976. Rare plants of southeastern Pennsylvania. Bartonia 44:22-26), *Senecio smallii,* and *Solidago caesia* were collected in an open area of the serpentine dump. *Quercus bicolor* was found and collected along a stream bank. A side trip was taken to the classic site of Goat Hill, located to the east of the Wood Chromite mine. Collections of *Arenaria stricta* and *Asclepias viridiflora* were made on open serpentine in the bottom of an old quarry, some 1.4 km northeast of Goat Hill. Trip Organizer: Robin Hart.

May 23, 1976: Preston Run Serpentine Barren, Chester-Delaware Co., Pa. This area was selected because it was a soon-to-be-bulldozed site. Collections were made. The following is a list of the plants sighted: *Acer rubrum, Achillea millefolium, Agrostis hyemalis, Ambrosia artemisiifolia, A. trifida, Andropogon virginicus, A. virginicus* v. *abbreviatus, Antennaria plantaginifolia, Anthoxanthum odoratum, Asclepias syriaca, A. tuberosa, Aster lateriflorus, Barbarea vulgaris, Boehmeria cylindrica, Botrychium virginianum, Cardamine hirsuta, Carya ovata, Celastrus orbiculatus, Cerastium arvense, C. nutans, Cicuta maculata, Claytonia virginica, Comandra umbellata, Cornus florida, Crataegus* sp., *Desmodium* sp., *Eleocharis* sp. *Erigeron philadelphicus, Eupatorium fistulosum, E. maculatum, E.*

rugosum, Fraxinus pennsylvanica v. *lanceolata, Galium aparine, Geranium maculatum, Geum canadense, Glechoma hederacea, Heuchera americana, Hieracium flagellare, H. pratense, Hypericum punctatum, Impatiens capensis, Juncus effusus, Krigia virginica, Lactuca biennis, Lamium purpureum, Lespedeza* sp., *Lilium canadense, Linaria vulgaris* f. *canadensis, Lindera benzoin, Lonicera japonica, Lychnis alba, Lysimachia ciliata, L. quadrifolia, Malus* sp., *Nyssa sylvatica, Onoclea sensibilis, Ornithogalum umbellatum, Osmorhiza longistylis, Oxalis stricta, Panicum clandestinum, Parthenocissus quinquefolia, Phytolacca americana, Poa pratensis, Podophyllum peltatum, Polygonatum biflorum, P. pubescens, Polygonum scandens, Populus grandidentata, P. tremuloides, Potentilla canadensis, Prunus serotina, Pteridium aquilinum, Quercus alba, Q. prinoides, Q. velutina, Rhododendron nudiflorum, Rhus glabra, R. radicans, Rosa multiflora, Rubus flagellaris, R. occidentalis, R. phoenicolasius, Rudbeckia hirta, R. laciniata, Rumex acetosella, R. obtusifolius, Sambucus canadensis, Sanguinaria canadensis, Sassafras albidum, Scrophularia marilandica, Senecio smallii, Silene antirrhina, Sisyrinchium angustifolium, S. mucronatum, Smilacina racemosa, Smilax glauca, S. rotundifolia, Solidago bicolor, S. caesia, S. graminifolia, S. rigida, S. rugosa, S. speciosa, Specularia perfoliata, Stellaria longifolia, S. media, Symplocarpus foetidus, Thalictrum polygamum, Urtica dioica, Vaccinium stamineum, Verbascum thapsus, Verbena urticifolia, Viburnum dentatum, V. prunifolium, Viola pubsecens, Vitis vulpina.* Trip Organizer: Robin Hart.

June 26, 1976: Cumberland Furnace, Cumberland Co., N.J. Varied habitats in a concentrated area made this one of the most interesting field trips. We crossed open fields where *Asclepias tuberosa* and *Opuntia compressa* were in bloom to get to the Cumberland Furnace site, a loam covered bog iron, slag and brick area. *Asplenium platyneuron* and *Magnolia virginiana* were among the bordering flora. Here, where most of the collecting was done, *Arisaema triphyllum* v. *pusillum, Belamcanda chinensis, Chionanthus virginicus, Liriodendron tulipifera, Myrica pensylvanica, Quercus michauxii,* and *Vaccinium atrococcum* were found. In the adjoining alluvial woods, *Acer rubrum* and *Habenaria lacera* were located. Across the road from Cumberland Furnace, *Utricularia inflata* and *Nymphaea odorata* were collected from Cumberland Lake, south end. Those who chose to make a longer day of it walked along railroad tracks which lead to the Manumuskin River. Here, along the marshy shoreline and the channel area, we sighted *Carex lurida* and *C. squarrosa, Elatine americana, Eleocharis olivacea, Lobelia cardinalis,* and *Nuphar advena.* Trip Organizer: Wayne R. Ferren, Jr.

August 29, 1976: Silver Lake-Mill Creek, Bristol, Bucks Co., Pa. This area of Bucks County is classic for its coastal plain species. The interesting "finds" on this trip were *Liquidambar styraciflua, Quercus phellos,* (both listed as rare in Wherry. "Rare Plants of Southeastern Pennsylvania," p. 24.) and *Jussiaea repens.* Until a Bayard Long specimen was found in the Academy's backlog of unmounted plants — volunteers take note! — *Jussiaea repens* was thought to be a new discovery for the county. A fine collection of about forty-two plant specimens was made.

BARTONIA

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GERMINATION BEHAVIOR OF *IMPATIENS CAPENSIS* MEERB. (BALSAMINACEAE)

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Impatiens capensis Meerb. (*I. biflora* Walt) (Balsaminaceae), the spotted touch-me-not or jewelweed, occurs in moist habitats such as brooksides (Gleason, 1963). In New Jersey it is a common annual on flood plains (Wistendahl, 1958; Robichaud and Buell, 1973) and freshwater tidal marshes (McCormick and Ashbaugh, 1972; McCormick, 1970; Whigham, 1974). Although *I. capensis* usually occurs in the open in moist areas, I have observed it in the spring to be an important component of the herbaceous layer under both *Pinus strobus* (plantation) and mixed forest in the area described by Horn (1975).

Cleistogamous flowers may occur early in the season and the showy ones later, but in certain habitats populations produce only cleistogamous flowers (Leck, personal observation). Although Fernald (1950) states that the larger showy flowers seldom ripen seed, pollinators frequent these flowers. Bumblebees, honeybees, and ruby throated hummingbirds have been observed at *I. capensis* flowers, and Heinrich (1976) has found that jewelweed is one of the greatest nectar producers in Maine. Ornduff (1967) reports *I. capensis* is involved in natural hybridization with *I. escalcarata* indicating that sexual reproduction is occurring in some habitats. Presumably, over the period of seed production in central New Jersey ranging from late May to mid October, seeds are produced both by selfing and crossing.

Germination in the field occurs after seeds are exposed to low winter temperatures. In New Jersey seedlings have been found as early as 14 March (1977). Germination seems to occur uniformly and rapidly once conditions are favorable.

Studies were initiated to determine germination requirements of *I. capensis* seeds and to establish conditions for maintaining viability. Germination records for *I. capensis (biflora)* by Barton (1939) and Jouret (1976) indicated the effective pretreatment for germination to be low temperatures for two to five months. Jouret's data show the adverse effects of dry storage. A considerable literature exists implicating gibberellins in the chilling requirement leading to germination (e.g. Baskin and Baskin, 1974 and 1975; Stokes, 1965; Villiers and Waring, 1965; West et al, 1970). Low temperature, moisture, and the effect of exogenous GA_3 were therefore studied. Field observations of *I. capensis* germination on a stream bottom suggested that oxygen requirements are minimal. Accordingly, germination of *I. capensis* in various oxygen regimes was examined. The role of the seed coat in the long afterripening requirement was also studied. Field storage was compared with laboratory storage. Germination of samples of seed collected at various times during the summer was used to investigate the possibility of differences in the degree of dormancy produced under various environmental conditions.

MATERIALS AND METHODS

Seeds were harvested on the flood plain of the Little Shabagunk Creek near the Rider College campus in Lawrenceville, and from the woodland of the Charles H. Rogers Refuge and adjacent Institute for Advanced Study woods in Princeton.

Seeds of *Impatiens capensis* were collected from capsules which dehisced readily upon touching. Seeds were cleaned after harvest and stored in glass containers unless used immediately. Tests were made only with those which appeared viable.

Storage conditions. **1971** — Seeds, both dry and moistened for about 24 hours and then dried, were stored either at room temperature or at 5°C for five months after harvest in September. Germination at various temperatures was followed for one month. **1972** — Seeds were stored dry or first moistened for about 24 hours, dried, and then stored for four months at either 5°C or 15°C in unwrapped Petri dishes. Seeds were then moistened and observed for two months. **1973** — Seeds harvested in June and September were immediately placed into test conditions and kept continuously wet in Petri dishes with 15 ml of distilled water at either 5°, 10°, 20°, or room temperature. In addition, some September seeds were stored dry in the laboratory, and some placed in nylon mesh bags at the soil surface at a field site under existing *I. capensis* plants. The latter were removed from the field to the laboratory after varying periods of time ranging from two to six months. Germination observations were made until the end of March. **1975** — Seeds, harvested 18 June, 8 July, and 16 September at the Princeton site, were moistened on filter paper in Petri dishes and placed either at 5°C, 10°C or 15°-10°C until germination was observed. The seeds at 15°-10°C were transferred to 5°C in early January. Seeds harvested in October were placed immediately into various oxygen diffusion regimes at 5° or 10°C. Tests were run until March. **1976** — Seeds collected in late September and early October were sealed and stored at 5°C (It should be noted that these seeds were harvested during a rainy period, and were wet). Some seeds were inbibed immediately in 10 ml of distilled water for the GA_3 and scarification studies. Seeds were also placed in the field on the soil surface, at 5 or 10 cm. Tests were run until late April or early May.

Germination tests. — Usually tests were run in 9 cm plastic Petri dishes in which 33 seeds were placed on 2 pieces of Whatman No. 1 filter paper. Tests were run in triplicate. Petri dishes were wrapped in aluminum foil to prevent evaporation and to provide darkness, and germination was recorded every two days for a month or, in some cases, tests were followed for as long as seven or eight months and germination observed on a weekly basis. Jars or beakers were also kept in the dark. Observations were made at room temperature with room light for a brief period of time during which germinated seeds were removed. The criterion for germination was emergence of the radicle. Results are reported as percentages, the means ± SE.

Temperature. — Temperature regimes were obtained using a variably air conditioned laboratory for room temperature, refrigerator (5°C), and Harrington germinators for 10°, 15°, 15°-10°, 20°-10°, and 20°C. Whenever alternating temperatures were used, each was held for 12 hours. For stratification seeds (1971) were moistened and stored in the dark at 5°C for two weeks and then transferred to 15°C.

GA_3 treatment. — The effect of the addition of exogenous gibberellic acid was determined by addition of 5 ml GA_3 (final concentration 0.1 mM) at 1, 2, 4, and 8 weeks to seeds (1976) that had been moistened immediately after harvest with 10 ml distilled water and stored at 5° or 10°C. Germination was observed at 5° or 10°C until April 1977.

Scarification. — Seeds (1976) were nicked with a razor blade either immediately after harvest in September or after four months storage at 5°C. Germination was observed at 5°, 10°, or 20°-10°C in 10 ml distilled water until April 1977.

Oxygen requirements. — To determine the necessity of oxygen for the afterripening process, immediately after harvest seeds (1975) were placed into the following aquatic regimes at 5° and 10°C where: (1) oxygen diffusion was impeded using a cm layer of olive oil (Kordan, 1972) over 100 ml of water in a 200 ml narrow beaker (oil-water interface) (to prevent seeds from floating at the interface, they were placed in a nylon mesh bag weighted with a marble); (2) no gas exchange was allowed, in 250 ml canning jars with vacuum lids which were filled with water and no bubbles permitted to remain upon sealing; (3) normal gas exchange with air in beakers with 100 ml water (air-water interface). Germination was observed for five months. Viability of nongerminated seed was determined using 0.1% tetrazolium chloride for 24 hours. The oxygen requirement of seeds (1976) which had afterripened for four months at 5°C was determined by placing the afterripened seeds either into jars (air-tight) or open beakers (air-water interface) and following germination at 5° and 10°C. After a month, two of the three air-tight samples were opened and the volume of water reduced to 100 ml and germination observed for an additional month. Oxygen determinations were made with a Yellow Springs Instruments oxygen meter (Model 52).

Field storage. — Seeds (1973) were collected and immediately placed into small bags made from 400 cm^2 nylon netting in lots of 100 seeds. The bags, tied to plastic stakes, were placed on the ground under existing *I. capensis* plants. They were then removed to the laboratory at various times and seeds placed on moistened filter paper at 5°C. In 1976 seeds were stored at three soil depths (surface, 5 cm, and 10 cm) in an effort to ascertain whether seeds afterripened and germinated even when buried.

RESULTS

Storage and temperature. — Seeds (1971) which had been moistened, dried and stored at 5°C for five months germinated at the three germination temperatures. After a month, germination was 89 ± 4% at 5°C, 81 ± 8% at 15°-10°C, and 49 ± 11% at 15°C. Figure 1 illustrates the rates of germination of these seeds. Alternating temperatures (15°-10°C) hastened germination, but final germination at 5°C was equally great. Transfer to 15°C of seeds stratified at 5°C for two weeks produced very rapid and more complete germination. Seeds stored dry at 5°C for five

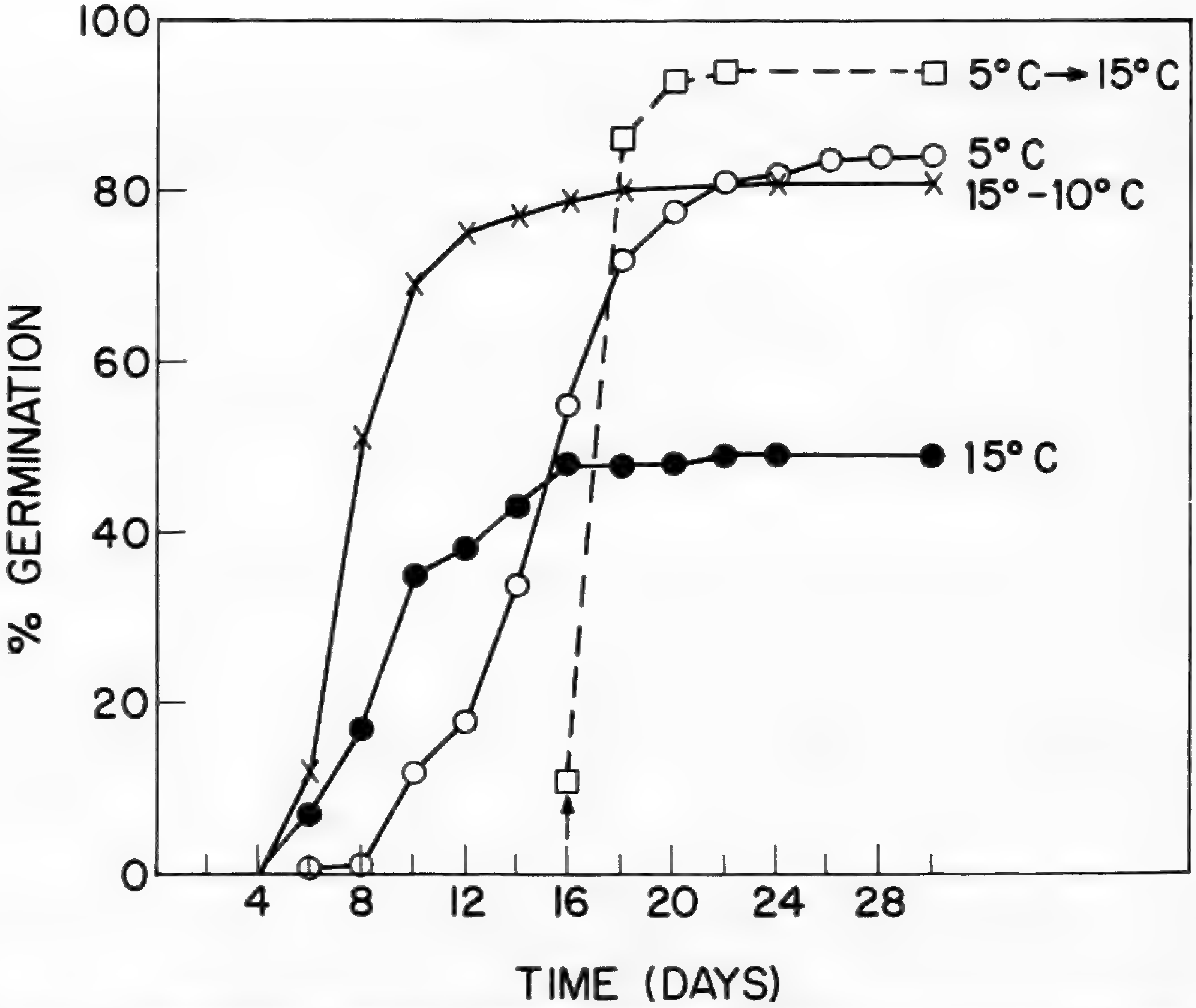

Fig. 1. Germination of *I. capensis* at various temperatures. The arrow indicates transfer of the sample to 15°C. Seeds harvested September 1971 had been imbibed, dried and stored at 5°C for 5 months.

months did not germinate, nor did those stored at room temperature whether wetted or dry.

At neither 5°C nor 15°C was there germination of the seeds (1972) stored four months at 5°C in unwrapped Petri dishes. However, seeds (1973) kept continuously moist after harvest at the test temperatures germinated, with the June sample having 79 ± 2% at 5°C and 30 ± 5% at 10°C and the September sample 93 ± 3% at 5°C and 27 ± 5% at 10°C. Reduced germination at 10°C, as compared with 5°C, also occurred regardless of the time of GA_3 treatment (Figs. 2 and 3) or time of seed harvest (Fig. 5).

GA_3 treatment. — Figures 2 and 3 compare the responses of *I. capensis* seed (1976) to 0.1 mM GA_3 added to imbibed seeds at 5° and 10°C at 1, 2, 4, and 8 weeks after harvest. Although at 5°C (Fig. 2) the control had earlier germination, 27 January versus 11 February for 50% germination, final germination was higher with GA_3 treatment at 1, 2, and 4 weeks. Addition of GA_3 at 8 weeks delayed germination, but final germination was similar to the untreated control.

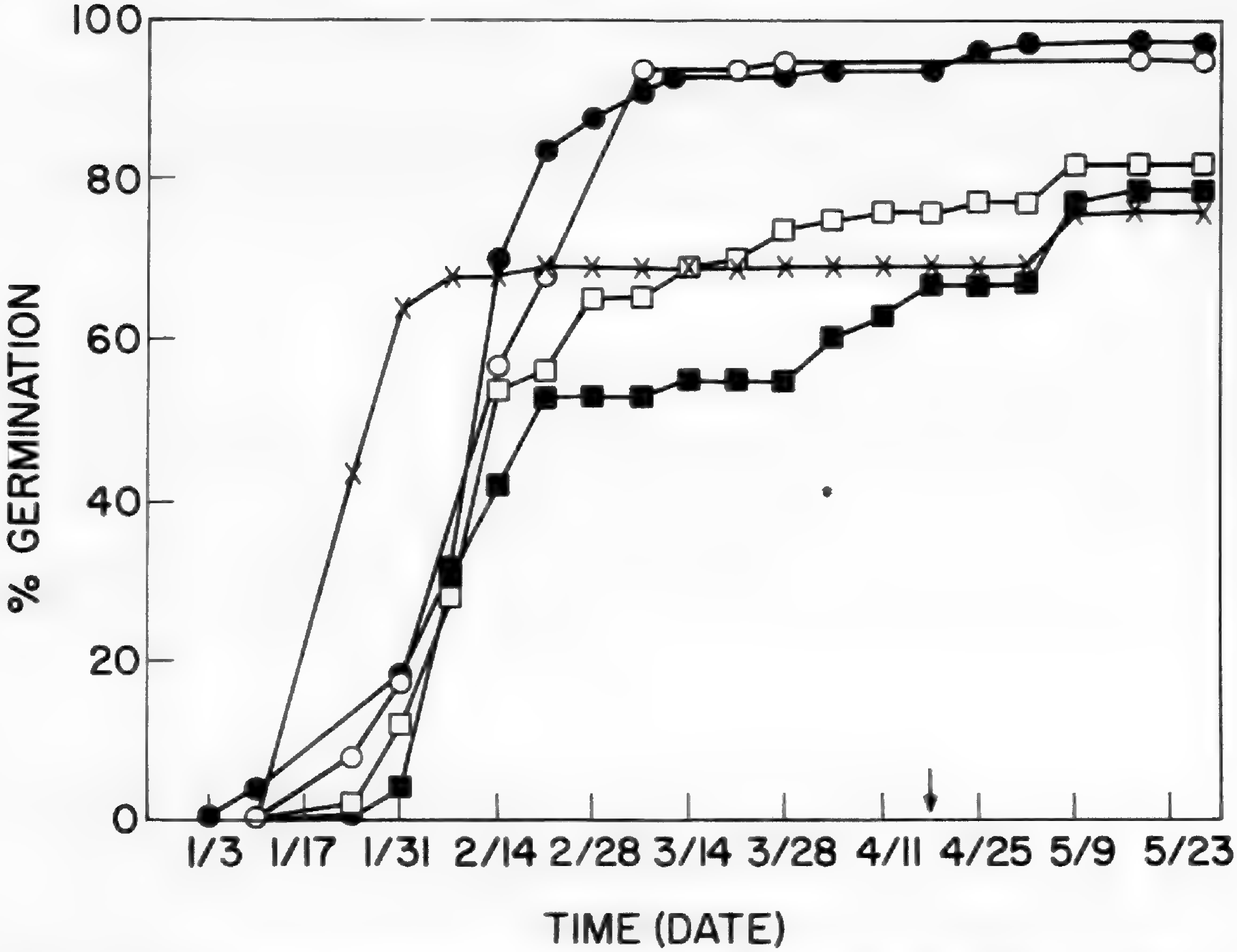

Fig. 2. Effect of gibberellin (GA_3) treatment at various times after harvest on *I. capensis* germination at 5°C. The arrow indicates transfer from water to filter paper. Harvest time was October 1976. Control, x-x; 1 wk + GA_3, open circles; 2 wk + GA_3, closed circles; 4 wk + GA_3, open squares; 8 wk + GA_3, closed squares.

GA_3 treatment for seeds at 10°C (Fig. 3) resulted in much improved germination compared with the control although less than that at 5°C. The earlier the time of treatment, the better the germination. Removal to filter paper with improved aeration caused no improvement at 10°C and only a little at 5°C.

Scarification. — Nicking had no significant effect on germination of seeds imbibed immediately after harvest (Table 1). Germination of the seeds afterripened at 5°C for four months was slightly improved by scarification especially at the higher germination temperatures, 10° and 20°-10°C. Earlier germination did not result from the improved gas exchange since the rate of germination, as indicated by the number of days to 50% germination, is similar to that of the controls.

Oxygen requirement. — Data (Table 2) strongly support the necessity for adequate oxygen and low temperatures for germination to occur and for viability to be maintained. That the 5°C air-water interface germination was only 63% may be due to relatively low oxygen levels in 4.5 cm of water as compared with Petri dish controls on moistened filter paper. Tetrazolium viability testing of nongerminated

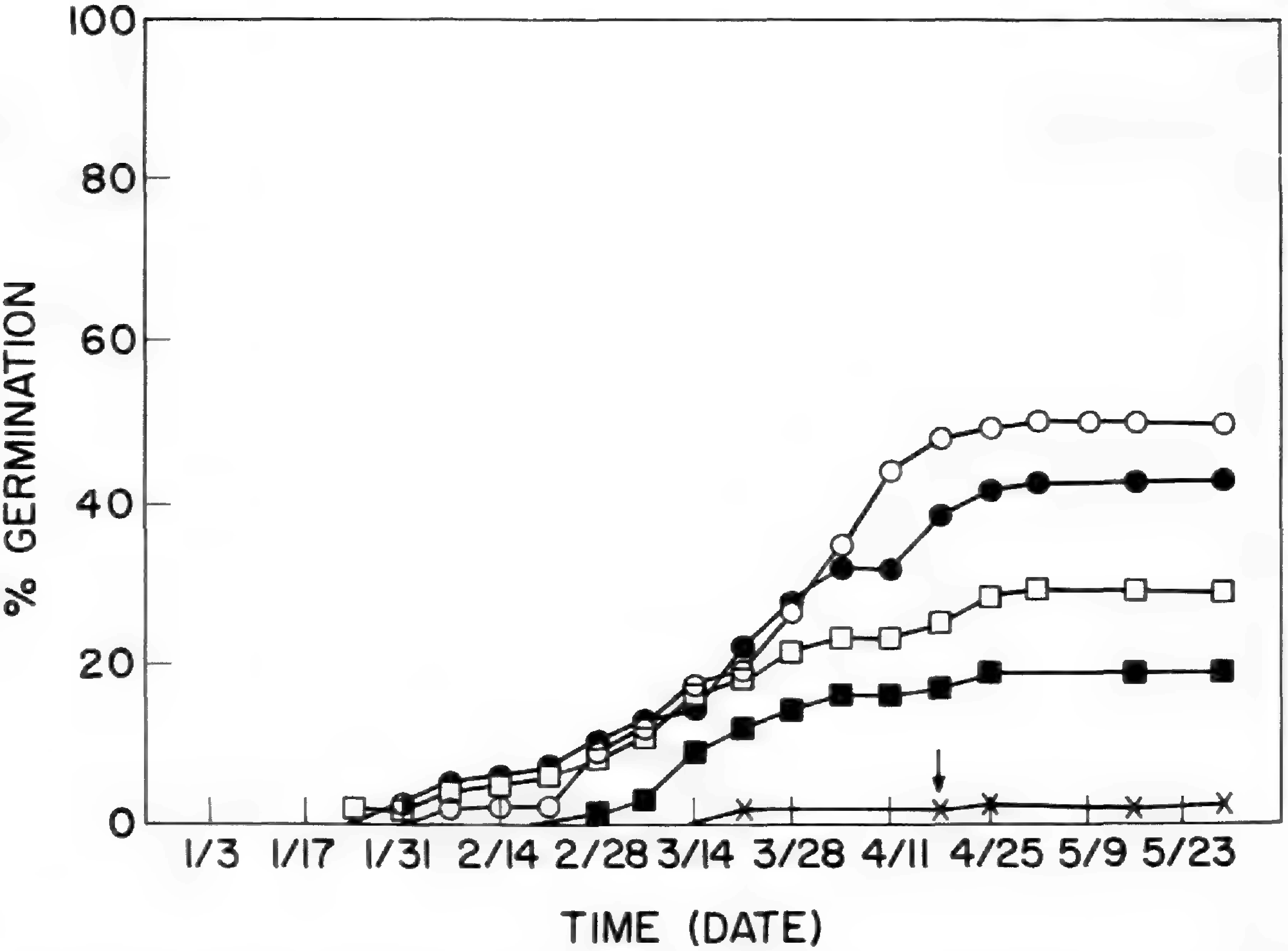

Fig. 3. Effect of gibberellin (GA_3) treatment at various times after harvest on germination of *I. capensis* at 10°C. The arrow indicates transfer from water to filter paper. Harvest time was October 1976. Control 0%; 1 wk + GA_3, open circles; 2 wk + GA_3, closed circles; 4 wk + GA_3, open squares; 8 wk + GA_3, closed squares.

Table 1. — Germination percentages (mean ± SE) of *I. capensis* seeds scarified immediately after harvest in September 1976 and those afterripened at 5°C for 4 months. The number of days after scarification required to reach 50% germination is indicated. (The test was terminated in April 1977).

Germination Temperature	CONTROL % Germination	CONTROL Days to 50% Germination	SCARIFIED % Germination	SCARIFIED Days to 50% Germination
5°C	69 ± 8	106	77 ± 7	106
10°C	0		2 ± 1	
5°C*	90 ± 5	11	87 ± 2	13
10°C*	70 ± 3	8	88 ± 6	7
20-10°C*	62 ± 4	8	77 ± 1	8

*Afterripened at 5°C for 4 months.

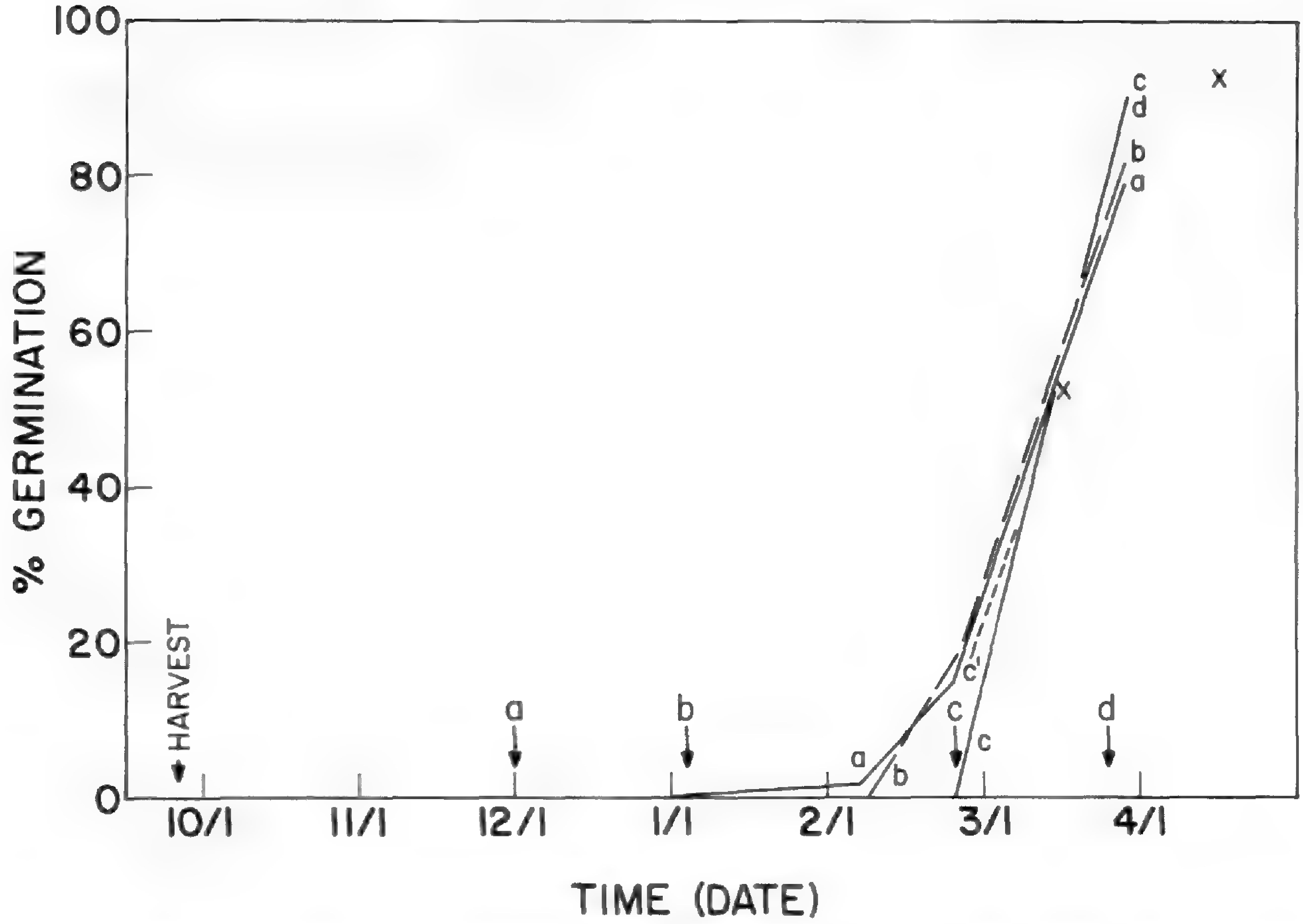

Fig. 4. Effect of varying periods of field storage on germination of *I. capensis*. Seeds were harvested on 25 September 1973. Arrows indicate the times at which samples were transferred to 5°C. C indicates the number of seeds in which rupture of the seed coat had occurred, but the radicle was not yet visible. x's indicate germination of the control at 5°C.

seeds (Table 2) showed that only those samples with unrestricted gas exchange with the atmosphere produced unquestionably positive tests; those stored with a layer of oil gave no response, and those in sealed jars showed but a trace of color indicative of hydrogenase activity.

Germination of afterripened seeds also requires oxygen (Table 2). Few seeds germinated in the air-tight containers. A week after the jars were opened, germination at 5°C increased from 10% to 27% and at 10°C from 6% to 13%. After a month, germination in these opened jars was 63% and 36% at 5° and 10°C respectively, as compared with 9% in unopened jars.

On day 16 germination of the 5°C sample was 55%, while that of the "stratified" sample was only 10% (Fig. 1). This low germination could have been due to inadequate aeration because the "stratified" sample was not examined for germination during the stratification period. Light was not eliminated as a factor. Germination of the "stratified" sample was rapid after opening and transfer to 15°C.

Field storage. — Figure 4 illustrates that after field storage (1973) for varying lengths of time, natural afterripening and afterripening at 5°C (for samples removed from the field) were not completed and dormancy not terminated until early February. The timing of this is remarkable since samples collected 30 November, 2

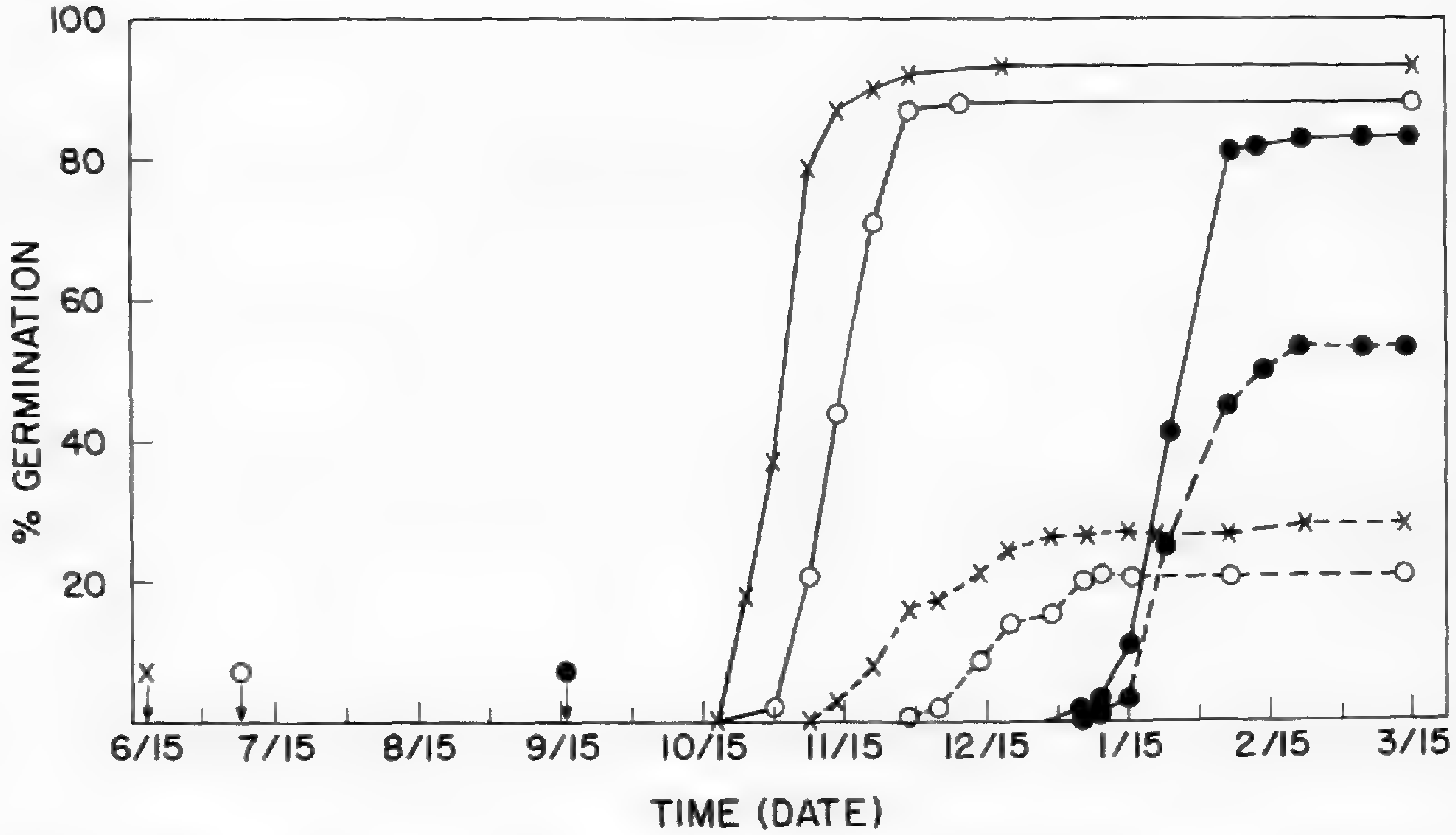

Fig. 5. Comparison of germination of *I. capensis* samples harvested at the three dates (June, July and September 1975) indicated by the arrows. The moistened seeds were placed at 5°C (—) or 10°C (— —) immediately after collection.

January, and 26 February have the same germination curve (some of the 26 February sample had ruptured seed coats, but ambient temperatures out-of-doors prevented radicle emergence). Final germination was similar, with the two samples longest at 5°C having slightly lower germination.

All field samples (1976) placed on the soil surface and 5 and 10 cm below the surface germinated equally well. After 161 days (4 Oct. - 14 March) germination was 90% at the surface, 90± 3% at 5 cm, and 95± 2% at 10 cm. Many of the seedlings were 2 cm long, even those at 10 cm.

Collection time. — Seeds collected at three times during summer 1975 and stored wet at 5°C had a germination pattern (Fig. 5) similar to those with field storage (Fig. 4). Germination at 10°C was reduced and delayed for 18 June and 8 July as compared with seeds harvested on 16 September.

After 5 January, when samples at 5°C or 10°C had germinated, 15°-10°C samples (none of which had germinated) were transferred to 5°C. Although germination times were not recorded, the following germination percentages were obtained: 18 June 78%, 8 July 71%, and 16 September 68%.

In addition, some yearly variation in germinability was noted. Based on comparable data, seeds collected in 1976 appeared to be more dormant than 1973 or 1975 seeds. This is especially obvious with the 10°C data which showed a high of 3% for 1976 seeds as compared with 20% or more for 1973 and 1975 seeds.

DISCUSSION

As observed by Barton (1939) and Jouret (1976), *I. capensis* seeds are dormant at

TABLE 2. — Effect of oxygen availability on germination (% ± SE) of *I. capensis* seeds (1975) after 6 months at 5°C or 10°C and of seeds (1976) afterripened at 5°C for 4 months and then germinated at 5°C or 10°C for 3 or (4) months. Tetrazolium viability of nongerminated seeds and the oxygen concentrations at the termination of the experiment are also given. The initial oxygen concentration was 7.2-7.6 p.p.m.

Germination Temperature and Aquatic Environment	% Germination	Tetrazolium Viability (% of nongerminated seed)	Oxygen (p.p.m.)
	Nonafterripened Seeds		
5°C Petri dish control	86 ± 4	—	—
5°C air-water interface	63 ± 8	96 ± 4 (dark pink)	8.6 ± 0.2
5°C oil-water interface	0	0	1.3 ± 0.1
5°C air tight	0	67 ± 7 (faint pink)	0.7 ± 0
10°C Petri dish control	53 ± 7	—	—
10°C air-water interface	44 ± 11	100 (medium pink)	9.3 ± 0.1
10°C oil-water interface	0	0	1.3 ± 0.2
10°C air tight	0	63 ± 9 (very faint pink)	0.7 ± 0
	Afterripened Seeds		
5°C Petri dish control	90 ± 5	—	—
5°C air-water interface	67 ± 10	—	5.9 ± 0.1
5°C air tight	10 ± 3	—	1.4 ± 0.1
(5°C air tight)	(9)	—	(0.8)
(5°C air tight 3 months and open 1 month)	(63 ± 10)	—	—
10°C Petri dish control	75 ± 3	—	—
10°C air-water interface	78 ± 3	—	7.0 ± 0.2
10°C air tight	6 ± 0	—	0.8 ± 0
(10°C air tight)	(9)	—	(0.8)
(10°C air tight 3 months and open 1 month)	(36 ± 0)	—	—

maturity. For the seeds observed here, about four months at 5°C is required before germination begins (Figs. 4 and 5). As with a large number (some 64%) of short-lived species (Harrington, 1972), *I. capensis* will not tolerate dessication and requires low temperature storage. The adverse effects of drying reported here are greater than those reported by Jouret (1976). If storage conditions are not favorable (Table 2; Fig. 5), germination does not occur, germinability is substantially reduced, or, as indicated by the tetrazolium test, vigor is reduced. To maintain viability and assure that afterripening occurs, *I. capensis* seeds need to be kept moist at low temperature with adequate air exchange.

The amount of moisture required for afterripening is not known but seeds which dropped below initial weights during storage did not germinate (unpublished data). Under natural conditions water uptake may be discontinuous, but since imbibition is rapid, adequate levels are maintained in seeds on the soil surface during the afterripening period. Perhaps, as suggested by Stokes (1965), the level of moisture is not critical, provided it is above some minimum value yet does not interfere with access of air. Short periods of drying soon after harvest (unpublished data) do not appear to be as harmful as prolonged drying such as occurred during storage of seeds imbibed briefly and then stored dry (1971 and 1972).

The length of time at low temperature required for germination appeared to be a constant feature of seeds from a given site. The 50% germination at 5°C of seeds (1973) stored in the field for varying periods of time took place in approximately 165 days for all samples (Fig. 4). Those maintained at 5°C continuously (1975; Fig. 5) reached 50% germination in 136 ± 1.7 days regardless of the date of harvest.

Temperature markedly influenced the ability of seeds to afterripen (Figs. 2-3, 5), and the ability of afterripened seed to complete germination processes (Table 2). The most suitable temperature was 5°C, the same as obtained by Barton (1939) and Jouret (1976). The range of afterripening and germination temperatures overlap; neither process is benefited by higher temperatures (> 10°C; Table 2). Although seeds germinate well at low temperature, once afterripening has occurred they are responsive to alternating temperature (Fig. 1), as would occur in springtime in a sunny location. At high temperature (Fig. 1 and 5; Table 2) germination is reduced. Nikolaeva (1969) reports that for *I. parviflora* even an insignificant increase in temperature at the end of the stratification period, just before the completion of the breaking of dormancy, inhibits germination and results in secondary dormancy. This, it is suggested, explains the incomplete germination of *I. parviflora* under natural conditions and the large seed reserve in the soil. In the area of study in New Jersey, *I. capensis* appears to germinate nearly completely in the field since germination of 90-95% occurred in field samples stored at various depths.

Changes in gibberellin levels are frequently associated with the chilling requirement and exogenous gibberelins may be used to replace the chilling requirement (Baskin and Baskin, 1974, 1975; Stokes, 1965; Villiers and Waring, 1965; West et al, 1970). At above optimal temperature (10°C), the exogenous GA_3 replaced, at least partially, the cold requirement (Fig. 3) with early treatment having greater effect. The more than two week delay in achieving 50% germination at 5°C, but improved germination caused by exogenous GA_3 treatment (Fig. 2) suggests not only that the timing of treatment is critical, but that the GA_3 affects different germination processes to different degrees. Perhaps concentrations greater than 0.1 mM would be necessary to promote germination to a greater degree (Chen and Park, 1973). Additional studies would be necessary to determine whether, as suggested by Waring, van Staden, and Webb (1973), dormancy-breaking treatment affects primarily gibberellin levels or cytokinin levels. Waller (personal communication) has obtained improved germination of afterripened seeds with kinetin and kinetin plus GA_3.

Germination of afterripened *I. capensis* seed (Table 2) appears to require adequate oxygen. At low temperature, little oxygen may be required to meet the respiratory needs of the embryo and the metabolic processes which permit germination to take place (Côme and Tissaoui, 1973). It may seem that 10°C is not substantially different from 5°C, but the oxygen available to the embryo may be lessened by the increased rate at which oxygen is removed by oxidation of phenolic components in the seed coats (Côme and Tissaoui, 1973). However, the intact seed coat did not impose dormancy by interfering with oxygen availability (Table 1); scarification did not significantly enhance germination nor was the time of initial germination for scarified seed decreased. With afterripened seed there was a slight acceleration in the rate of germination of scarified seed, presumably because of improved aeration for the germination process.

It is not known whether or not *I. capensis* seeds which are buried in soil and receive inadequate aeration remain dormant until a time when they are brought to the surface as is suggested by Nikolaeya (1969) for *I. parviflora*. Such activity may occur frequently in areas which are periodically flooded or which are subject to tidal flux and debris moved about. In the freshwater tidal marsh, *I. capensis* is frequently found where lodging of floating materials occurs in the spring, a microsite where there would be adequate aeration (personal observation). The data indicate that *I. capensis* seeds do not remain viable or vigorous for long under anaerobic conditions (Table 2). Flood plain field germination at 10 cm was 95 ± 2%, but little *I. capensis* germination was observed in marsh soils from 4 to 6 and 8 to 10 cm (unpublished data) which are probably anaerobic most of the time. This lack of *I. capensis* in the soil profile may be due to a rapid loss of viability under anaerobic conditions, or, as Coombe (1956) suggests for *I. parviflora* which also germinates and becomes established when seeds are buried at considerable depth, due to the fact that a great majority of a year's seeds germinate the following spring and few seeds remain.

The year to year variation in the degree of dormancy has been noted for other species (e.g. Allessio, 1969; Barton, 1965; Koller, 1972; Von Abrams and Hand, 1956). Many environmental factors may be involved in the development of germination characteristics (Barton, 1965; Koller, 1972), and accordingly, it is not surprising that yearly variation also occurs in *I. capensis* germination.

Since flower production and seed set extend from May to October, it is also not surprising to observe differences in seeds collected throughout the season (Fig. 5). Seasonal differences have also been reported for *Hieracium aurantiacum* (Stergios, 1976), *Scabiosa colombaria* (Rorison, 1973) and *I. balsamina* (Kroeger, 1941), in all of which, however, there was a tendancy for inferior germination capacity to be demonstrated by the seed harvested later in the season. Even though the 5°C data (Fig. 5) seem to agree with these observations, laboratory and field germination data from *I. capensis* seeds collected later (mid October) frequently exceeded 83% and was often better than 95%.

The high spring germination results in dense stands of seedlings very early in the growing season (flood plain seedlings numbered 1200 m^{-2} on 27 April with about 20% surviving at the end of summer on 7 September). This may be of considerable advantage in competition with other species, and there may be advantage in being able to grow, flower, and set seed, especially in non-ideal habitats, where the moisture and light regimes only permit growth early in the season. Such is probably the case with populations where soil moisture falls during the summer and flowers are cleistogamous (Waller, personal communication). Production of cleistogamous flowers under such conditions is also reported by Skenes (1938) for *I. noli-tangere*.

Because of several characteristics of reproduction and germination, *I. capensis* appears to be an opportunistic species. Although dense populations of seedlings may be observed, effective means of dispersal exist since seeds may be scattered when the fruits dehisce or they may float for long periods of time. Seeds may be produced by cleistogamous or chasmogamous flowers depending upon environmental conditions over a long period (from May to October). Germination is not confined to strictly moist habitats such as stream banks, marshes, and flood plains, but also occurs in forest areas, albeit early in the spring when soil moisture is high. Requirements to maintain viability (aeration, moisture, and moderate temperature), to afterripen (aeration, moisture, and low temperature), to allow early spring germination (aeration and low temperature) are easily met on the soil surface in the habitats where *I. capensis* is common. A single stratification period afterripens seed and there is no need for prolonged dormancy. While seeds of many annuals are long lived, those of aquatics are often short lived (Harrington, 1972). With *I. capensis* dispersal in time as well as space may be the alternative to seed longevity (Harper and White, 1974).

SUMMARY

Germination of *Impatiens capensis* seeds in the laboratory occurred readily after about four months at 5°C. Adequate aeration was required for the afterripening and germination processes. Dessication during storage was harmful. At 10°C the chilling requirement was not completely met, and germination was substantially reduced (0 to 10% compared with 85 to 95%). Treatment with GA_3 (0.1 mM) at 10°C did not completely replace the need for chilling, and at 5°C did not result in earlier germination. During field storage a single cold season produced high spring germination (90 to 95%). Burial at 10 cm did not reduce germination. Seeds collected at three times during the fruiting season (June, July and September) had similar low temperature requirements, but at 10°C dormancy seemed more pronounced in seeds collected earlier in the season. Aeration, low temperature, and moisture requirements for afterripening are easily met in nature and seeds germinate early the spring after they were produced.

Acknowledgements

I wish to thank the students who at various times helped collect seed, and Don Waller of Princeton University for his helpful suggestions and discussions. I also wish to acknowledge the efforts of Jean Allessio who was successful in eliciting *I. capensis* germination in her refrigerator long before I was successful in the laboratory.

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BOTANICAL EXCERPTS FROM THREE LETTERS OF REV. CHRISTIAN FREDERICK DENKE TO THE BOTANIST SCHWEINITZ

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Little is known of the botanical interests and accomplishments of the nineteenth century Moravians in eastern United States, perhaps with the exception of the Rev. Lewis David von Schweinitz (1780-1834) of Bethlehem, Pennsylvania, who was outstanding as a botanist. His work with the fungi and flowering plants is continually discussed and documented (Bynum, 1975; Johnson, 1835; Pennell, 1935; Rogers, 1977; Stuckey, 1978, in press). Rev. Schweinitz corresponded with over 100 individuals both on the domestic and foreign scene, including several missionaries of the Moravian Church who were interested in studying plants (Barnhart, 1921, 1926, 1935; Stuckey, 1967). Among these latter correspondents in the United States were Christian Frederick Denke (1775-1838), Eugene Alexander Frueauff (1806-1879), Anna Rosina Gambold (1762-1821), Samuel Renatus Hübner (1795-1849), Christian Gottlieb Hüffel (1762-1842), Samuel Gottlieb Kramsch (1756-1824), Daniel Steinhauer (1785-1852), Henry Steinhauer (1782-1818), and William Henry Van Vleck (1790-1853). This paper represents primarily a translation from the German language of three letters that Rev. Denke wrote to Schweinitz which included the subject of botany. These letters (Denke, 1826, 1833) are preserved in the manuscript collection at the Academy of Natural Sciences, Philadelphia, and were made available to the second author who undertook the translation. The biographical text is by the first author.

BIOGRAPHICAL SKETCH

Born 8 September 1775 at Bethlehem, Christian Frederick Denke was a Moravian clergyman who was a missionary for 18 years to the Chippewa Indians at Fairfield, near the present town of Thamesville, on the Thames River in western Ontario, Canada. Denke was educated at Nazareth Hall, where both he and Schweinitz were students of Samuel Kramsch, who encouraged botanical investigation. In 1787 and 1788, Mr. Kramsch prepared a local flora of the area to which Denke is believed to have added a supplement and index in 1797 (Pennell, 1935). Denke taught Latin and botany at Nazareth Hall from 1796 to 1800. As summarized from Gray and Gray (1956, pp. 183-268), Denke was ordained in 1800 as a deacon, and was selected by the Church to begin the mission to the Chippewas. He began studying with the missionary expert, Rev. David Zeisberger, at Goshen, Ohio, and during the winter

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months of 1800-1801 became acquainted with all phases of frontier life among the Indians.

Rev. Denke was the first Protestant missionary to enter the villages of the most common Indian tribe in that part of Canada north of Lake Erie. His early attempts failed to establish missions northwest of Fairfield at Point au Chenes, now Algonac, Michigan, on the north shore of Lake St. Clair, and at the present town of Florence on the Sydenham River in Ontario. Beginning in 1803, Denke concentrated his efforts on the mission at Fairfield. After a short interlude in 1807 at the mission on the Pettquotting River, the present Huron River, in northern Ohio, he returned to Fairfield in 1809 and continued his missionary work until he fled the town prior to its destruction in October 1813 by Major General William Henry Harrison during the "War of 1812." Denke returned in the spring of 1815 to rebuild the mission a few miles upriver at a town called New Fairfield, where he remained until November, 1818 (Gray and Gray, 1956, pp. 183-268).

Rev. Denke was a linguist of considerable distinction. He wrote and spoke well in English and in German, but he also had developed a knowledge of the languages of the Indian tribes with which he worked. Accordingly, he was able in 1818 to translate the Epistles of St. John into the language of the Delaware Indians for the then newly-formed American Bible Society. Denke's work represented the first phase of the Society's pioneering Bible translation program (Anonymous, 1971).

Referring to Denke's diary describing the botany of the region, Gray and Gray (1956, p. 184) believed Denke "might have become one of America's outstanding botanists," had he not chosen the missionary field. In the diary of 25 June 1801, as quoted by Gray and Gray, Denke wrote that about five miles from Fairfield, "high grasses grew on a 'great plain or prairie,' and the floundering horses had to be led through the swamps." He noted trees of:

> beech, birch, linden, water and white ash, elm of various sort, oak especially water and swamp oak, walnut, wild cherries, aspen, Lombardy poplars and varieties of it. One also finds white and black oak, chestnut, and extraordinarily thick and high Tulip trees. There are no stones. On the hunt the Tschipues, who still own their land often set long stretches of bush on fire, for that reason quite generally then there is no underbrush, but wild grape vines of considerable thickness are common, but sugar trees are rare. I saw flowers everywhere in abundance, many varieties unknown to me and new. Ferns grew everywhere and in the work of clearing or cultivating the land are a great annoyance because of their thick bundles of roots . . . I also noticed hazel bushes (corylus rostrata) in which the husk of the nut has a beaklike point. It is common mostly in southern neighbourhoods.

Rev. Denke returned to Bethlehem before settling in North Carolina, where he was pastor at Hope, now Wachovia, from 1820-1822 and at Friedberg from 1822-1831. After retirement in 1831, he spent the remainder of his life at Salem, North Carolina, where he died 12 January 1838 (Barnhart, 1921, 1926).

Because of his long interest in botany, Denke collected plants in the various localities where he lived, and sent specimens and exchanged letters with his botanical friends, Dr. Benjamin Smith Barton (1766-1815) of Philadelphia, Rev. Henry Gotthilf Muhlenberg (1753-1815) of Lancaster, Pennsyvania, and Rev. Schweinitz of Salem, North Carolina, and later of Bethlehem. In Schweinitz's Herbarium Catalog (Schweinitz, undated), Rev. Denke is listed as a correspondent who sent specimens to Schweinitz from Canada and North Carolina. For a short period of time, 1820-1821, both Schweinitz and Denke lived in North Carolina. Their enthusiam for botanical work evidently was high, for in October 1820, Schweinitz wrote to his botanical friend Dr. John Torrey of New York City saying that he and Denke were planning two botanical excursions into the southern mountains during the next year. Schweinitz noted that it "promises great activity & I hope thro' his [Denke's] means chiefly to be enabled to procure for you . . . everything that we can get at" (Shear and Stevens, 1921, p. 131). In a letter to Torrey, Schweinitz noted that he had some years earlier received a "bag of mosses" from his friend Denke and reaffirmed their intention to collect plants for Torrey from their neighborhood in North Carolina (Shear and Stevens, 1921, pp. 133, 135). According to Schallert (1935), Denke must have been an enthusiastic botanist because of the large number of plants he collected, some of which were well preserved in the herbarium of Salem College, Salem, North Carolina.

The portions of the three letters reproduced here, written in the latter part of Denke's life, provide some reflection on his botanical interests. At the time, Schweinitz was living in Bethlehem and had completed his monographs on the genera *Viola* and *Carex*. He was at work arranging and preparing his Herbarium Catalog. Denke, too, spoke of bringing his own herbarium into order and of wanting to make a catalog of it. He mentioned the localities and described the habitats of certain species that he obtained or could not obtain. These findings were related to Schweinitz's (1821) unpublished manuscript, *Flora Salemitana*, the local flora of the area about Salem. His planned botanical expeditions to places some distance away seem not to have been carried out. Denke desired to study the grasses and cryptogams and asked for reference books that would help him in this effort. His major reference book was Nuttall's *Genera of North American Plants* . . . (1818), and he was aware of the botanical studies being conducted by John Torrey in New York. Apparently he had acquired Elliott's *Sketch of the Botany of South-Carolina and Georgia* (1816-1824) and Persoon's *Synopsis Plantarum* . . . (1805-1807), but these books were not useful to him in learning the fundamentals of identifying sedges, grasses, and cryptogams. Denke was impressed with Schweinitz's monograph of *Carex*, but it only helped for this one genus of the sedges. He also wanted specimens of the different genera of grasses which would provide him a more rapid means of identification and comparison. His concentrated efforts on many projects, including the building of a new church over several years, and his ill health seem to have prevented him from further progress in botanical science, an interest which he must have also dearly loved.

The Letters

Friedberg, 4 April 1826

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My very dearest friend,

• • •

Last year I did little from a botanical point of view; this year I hope this will improve; however, I am quite sickly — This winter, I brought my herbarium nearly into order — soon, towards my recovery, I will make two trips to the Yadkin [River]. I cannot find the *Ophiorhiza mitreola,*[2] on the plantation of Philipots or Peddycourts. Didn't you regard this as *Cynoglossum offic*[*inale*]? I found the *Smilax pubera,* with its scarlet-red corymb berries this winter in this vicinity at the South Fork. I have also become interested in the grasses. Where have you found *Equisetum arvense*? I have sent several of your requests [for specimens] last year, but by far not all. If I get the opportunity, I will send you more of them. Can you help me find a good book on grasses?

I already have nearly all of what you noted in Flora Salem[itana], with the exception of that which is a great distance away, and grasses. — I have not yet been able to identify some Syngenesia which I obtained through some wagon drivers — brothers from Friedberg — from the Sandhills, Fayette and Chowan. I think that one is *Eupatorium coronopifolium,* and a second is certainly *Inula gossypina* Nuttall. I have found *Rudbeckia triloba* in a meadow of the South Fork, ½ mile from here. On the Muddycreek heights is *Batschia Gmelini,* without a doubt. I disagree with your *Myosotis arvensis* and *Lycopsis virginica.* See Nuttall's Additions /*Myosotis verna, Lycopsis virginica* Pursh/. It is near here, as it says, in sandy woods and waysides, and corresponds to that figured in Flora Salem[itana] and that of Prof. Boner. It is probably one and the same — here on the sand hills, and there in his meadow — as well as here in Fischer's meadow and on the South Fork — in the final analysis it is probably Nuttall: *Myosotis verna.* I have studied several from each location in fresh condition. I count more *Lysimachia* than you, as well as *Gallia.* I have *Gelsemium nitidum* from the Saline gardens. I left *Viola* as by Nuttall. I have several new *Gentiana* from the Sandhills — their determination is difficult — one is certainly *angustifolia* Nuttall. One I think is *Catesbaei* Nuttall and another *linearis* — according to you in Flora Salem[itana]. I have all plus an additional specimen from the South Fork. *G*[*entiana*] *Pneumonanthe* or something similar has also been brought to me. There is a specimen of your *Asclepias cinerea* found on Stafford's flatrock — and is everywhere on flatrock substrate — on the Pinerocks and even adjacent to them where the soil is quite dry — it is, after I observed it in loco natali [natural habitat] and in its fluidity, not Nuttall's. Rather, it seems to me to be only a starved variety of *verticillata,* because *verticillata* also has this "alternating pubescent line." I saw and sent one once, I think, from near Pettquotting in Ohio, which was *cinerea,* and which was strikingly different from yours, in that the leaves are much longer and even smaller than in *verticillata.* Your *Antirrhinum canadense* is not to be found anymore on Stafford's flatrock — where and on which side was it? Near or on the flat, or in the brush nearby?

Now I must hurry to a close. Heartfelt greetings to your wife from mine and especially from myself; assuring [her] that we are thinking of her in great friendship as often as we come to Salem; . . Since June of last year, we have lived in a new house, where I even have a room for myself in the second story — the church is unfortunately not yet finished — our vegetables were frozen.

Again, Vale [goodbye] — after I recuperate I will come to the mother city [Bethlehem] and greet all on the eve of the Bethlehem sabbath.

As ever, remaining,
Denke

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[2] The names of the plants are according to Nuttall's *Genera* (1818).

Friedberg, 3 October 1826

My dear old friend,

I would have liked to have conversed with you for a good long time, but I was unable to — I would have liked to have sent you something botanical, but circumstances were such that on the occasion it was not possible!! It must therefore wait. Your letter, accompanying the magnificent monograph with regard to the described *Carex,* I eagerly received, from the point of view of my students, with heartfelt thanks. As soon as the winter idleness arrives, I will study the numerous preserved Carices which I have collected this year.

On several occasions, and once in the company of Huebner,[3] I searched through all Flatrocks to be found for *G.* [*Gentiana*] and *Antirrhinum canadense* — but found no trace of them — has it passed away? You write "on Stafford's rock in great plenty on the flat on the eastern part" — is it possible that no vestige remains? I searched at Philipots, Peddycourts, and old Hoye's where the Dunker graveyard is — between middle, south Fork and Muddy Creek — for *Ophiorhiza* but unfortunately found none — establish the exact location on Philipots — approximately where the old house was — or where? — or near *Lycopsis virginica* — about which you write — which is it now? It must be *Myosotis arvensis* or *verna* Nuttall — the first on the meadow, the latter near me on the trail on Blackjack Ridge towards the east. I would gladly see a real specimen of it.

The plates published with the monograph are magnificant; why not all? Why only some plates? I would have liked to have had all.

Enclosed are my several undetermined [specimens], some of which I received from wagon drivers from distant places; included among which are a beautiful *Gentiana* and a Synge[nesia]: which, until I am convinced of something better, I consider a *Eupatorium coronopifol[ia]* Pers: the corolla leaves or ligules alone are longer than elsewhere in the genus *Eupatorium:* and its pappus is truly plumose.

In the past summer, during the botanist's collecting time, I did little, because other duties required my attention, and because the terrible heat held me back. What I did collect still lies in the chaos of the daily collections. I saw a beautiful spec: *Hibiscus,* perhaps *Manihot Spalmatus* Persoons — from Georgia, here in a garden; I will find out if I can send you some seeds. What Nuttall (11.45) writes about *Antirrhinum canadense* still weighs upon my mind: ["]chiefly near the margins of sandy swamps and ponds["] — do not search on the barren and dry rocks.

I hear that Torrey wanted to publish a Flora Americ[ana]: septentr[ionalis]; is this true? If so, it would be a desired, and very sorely needed work. Is Elliot[t] continuing with his Flora? As I told you before you went to Europe — I wished to have Persoon's Synopsis of the Cryptogams, because I am completely lost in the Filices.

Are you familiar with a *Smilax* with red berries? In order to gain familarity in graminology (grasses), and to make progress in getting to know them, I would like a few examples of the different genera: because in this manner, it works the best, surest, and fastest. I am very far behind in them.

Soon now winter will arrive, and with it the idle period, in which to identify the plants collected this year, which I already happily await. The building of the church has still not been completed, and it causes me much worry and distress; I will be happy when it is completed. At present it is once again being worked on. In closing, I greet you and your love [wife] from us . . . and wish you all everything good especially with regard to the difficult and uncomfortable incident that affected you, which one hears about. I also must, oh, unfortunately!, struggle with the growing conflict over the dreadful lewdness. A true misery.

Embracing you in love I remain always,
Denke

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[3] This reference is to Rev. Samuel R. Hübner, who was pastor to the Moravian community of Gnadenhutten in Tuscarawas County, Ohio.

Salem, 13 June 1833

My dear old friend,

With this, through the emblem of death, you receive, I hope correctly and confidently as well as unharmed, the small, incomplete, pieced-together, imperfect Missio Prima [first missive in a long while]. We continue with the correspondence. As promised, I could hesitate no longer, and in haste still let you have something. In the meantime, be satisfied with it. If I should have more idle time in Pilgrim's rest than I have had up to now, which in any case does not appear likely, because I am not yet finished with the building, I could set the confused and chaotic fascicles of my herbarium in order — arrange and regulate and systematically incorporate everything, and make a catalog of it — which I often anticipate with delight in the spirit of my imagination — as such, the sorting would be an easy task, as would be the assignment of the duplicates to their compartments, the names to the unidentified specimens, and the consilium abeunde [throwing out] to the remaining ones. We reserve a place for the sendings and their numbers and as such cannot fall into confusion. I beg for your observations on the plan as Muhlenberg, of blessed memory, earlier had it. The numbers correlate and are written down in my herbarium and can be checked at any time. Certain scattered *Pomeae, Solidagineae, Astereae,* etc. and as in the grasses namely in *Carex* — require some [additional] information. To this hour I do not know whether you received, got, read, and pondered my last [letter]; yet I assume so. On the contrary, you wanted to send something to me, therefore do not forget *Hydrastis canadensis* and *Pyrola rotundifolia* . . .

This year probably nothing will come of my [planned?] distant botanical expeditions, even if I had the means, because I do not have sufficient time and presently my daily organizing is indispensable. You know well how busy I am.

I still intend to subscribe to the Landsetter[?] Botanical Journal — what do you think of this? Sensemann has been sent an order and a letter; if it is not worth the effort and costs, as you have been able to know up to now, since I can only consult newspapers sent over the distance, consult him before he goes to Philadelphia regarding the time and the costs.

I ask again, if you can direct me to or name a good, new, and proper work on Cryptogams, particularly the Filices. I am so wanting in this regard, that I do not know a single one without Nuttall's Genera. Persoon has nothing in his Synopsis — Elliot[t] as well has nothing — How can I learn them, or how can I become comfortable with this dark class?

For a time I have been quite ill. Often my chronic ill health weighs upon me too heavily; it seems to me that it is the natural result of the deprivations and hardships of the missionary work. Praise God, it happened in the service of my Lord, praise his name, and not through my own wantonness. . . . I, in my craziness, daily take on new projects. At present the ornamental fence in front of the house is being painted. As you know, the house was built 25 feet back to accommodate a garden in front of it. My lot is a corner lot, because the continuation of the street from the Drostey/Administration/ runs behind the 5 lots up to Shallowford — They are the most beautiful lots in Salem — 95 foot front and 300 deep — so we still have a culinary garden — and pasture for cow and horse. . . .

Now it is time to close; you are already tired due to my scrawl — affectionate greetings from my Polly and myself to your wife Schweinitz and you. Remaining,

Your friend, embracing you in the
spirit of my imagination

Denke

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ACKNOWLEDGEMENTS

Our thanks is expressed to the Academy of Natural Sciences, Ms. Susan Klimley, Librarian, for making these letters of Rev. Denke available for translation and study. We are also greatly indebted to Prof. Wolfgang Fleischhauer of the German Department of The Ohio State University, who gave freely of his time in assisting with the translations.

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DISTRIBUTIONAL HISTORY OF *POTAMOGETON CRISPUS* (CURLY PONDWEED) IN NORTH AMERICA[1]

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Potamogeton crispus L., curly pondweed, curly-leaved pondweed, crisp pondweed, or curly muckweed of the Potamogetonaceae (Zosteraceae and Zannichelliaceae of some authors), is a perennial, herbaceous, submersed rooted aquatic vascular plant native to Eurasia. Worldwide the species also occurs in Africa and Australia. *P. crispus* has been known from North America since about the middle of the nineteenth century. During the twentieth century it has spread over the North American continent, where it is now known in portions of southern Canada and in all except six states of the conterminous United States. The species is an aggressive "weed" with features favoring rapid asexual reproduction, vegetative spread, effective colonization, and considerable tolerance to not only clear, but also turbid and polluted waters. The species invades calcareous, brackish, and fresh water streams, rivers, canals, ditches, ponds, and reservoirs. In recent years curly pondweed has become a serious pest in some reservoir and stream waters used for fish and wildlife, recreation, navigation, and human consumption (Cypert, 1967; Falter et al., 1974; Harman, 1974; Simes, 1961; data associated with herbarium species). This paper brings together data from the literature and herbarium specimens to document the distributional history of *P. crispus,* a non-indigenous[2] thoroughly naturalized species, in North America. Since 1900, portions of this history have been analyzed and summarized by Groh (1944), Hanna (1932), Hull (1913), and Tehon (1929).

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[1] Presented in part at the contributed papers section of the American Society of Plant Taxonomists, Plant Sciences Conference, Blacksburg, Virginia, June 1978.

[2] Most authors of floras and manuals in the United States have considered *P. crispus* as a non-indigenous species in North America. Examination of the early literature reveals that there was some question about its status. In a letter that Asa Gray wrote to Edward Tatnall following his receipt of the first specimen of *P. crispus* that Gray saw from North America, he noted it "as a native of this country" (Harshberger, 1899, p. 225). In his published paper of this first record, Gray (1860) offered some concern as to whether *P. crispus* was native or foreign, and in the fourth edition of his Manual, Gray (1863) wrote, "probably indigenous." In the fifth and sixth editions of the Manual, the authors (Gray, 1867; Gray, Watson, and Coulter, 1889) continued to retain its status as a native. This status was changed to non-indigenous in the seventh edition (Robinson and Fernald, 1908). Recalling these earlier years when *P. crispus* was considered as possibly native, Taylor (1909) raised some doubt about its being from the "Old World," but later Taylor (1915) himself noted "Obviously introduced from the Old World." Hanna (1932) wrote that *P. crispus* "may actually be indigenous to parts of North America." He was referring to plants from the Rocky Mountains for which no documentation has been located supporting his statement (*see* table 1). Even in recent years, some doubt as to its foreign status is implied, such as the statement "Generally assumed to be an introduction from Europe" (Voss, 1972).

LIFE HISTORY AND DESCRIPTION OF THE PLANT

The life history of *P. crispus* in North America has been little understood because of the variance it displays from the life histories of the native pondweeds and the often erroneous fragments of information, particularly concerning dormant stages, perennating organs, and sexual stages, that are published in the manuals and floras. Extensive accurate life history information has been published by several individuals (Arber, 1920; Clos, 1856; Cypert, 1967; Deane, 1915; Glück, 1906, 1924; Gupta, 1934; Hagström, 1915; Hunt and Lutz, 1959; Moore, 1915; Muenscher, 1936; Oosting, 1932; Sculthorpe, 1967; Sinha and Srivastava, 1973; Stuckey, Wehrmeister, and Bartolotta, 1978; Waisel, 1971). In the fall of 1976, John R. Wehrmeister began a detailed study of the life history of *P. crispus* based on field observations, herbarium specimens, and experimental growth conditions in the laboratory. His results and evaluation of the literature were subsequently assembled (Wehrmeister, 1978). The brief description and life history of the plant which follows is summarized from his work.

Plants of *P. crispus* grow submersed as colonies from slender rhizomes. The leaves are sessile, serrulate-margined, linear to oblong, and two-ranked. In the northern portion of its North American range, two types of leaves are formed depending on the season of the year. In spring, distinctive features of the leaves are the dark green to red brown appearance, crisp brittle texture, undulate margins, and a prominent dark red midrib. In winter, the leaves are blue-green in appearance, limp and flexuous, flat-margined, and with a less prominent reddish-brown midrib. The leaves of the winter foliage are usually narrower than those of the spring foliage. The plant exists in a dormant state in the form of vegetative "dormant apices" from mid-through late-summer when water temperatures are the warmest. Formation of these dormant structures at the stem apices occurs in late spring, and their germination is initiated in late summer or early fall when water temperatures are generally cooler. During the winter the plants remain vegetative in a photosynthetically active state even under a thick cover of ice and snow (Stuckey, Wehrmeister, and Bartolotta, 1978). Flower formation and fruit production is apparently more common in North American plants than the literature has suggested. Hunt and Lutz (1959) reported excellent fruit (seed) production on plants growing under managed low-water level conditions in diked marshes of western Lake Erie. Flowering occurs on an emersed inflorescence generally from April to June. Fruiting subsequently follows, but germination of the one-seeded fruits, if it occurs in the natural environment, is still unknown. The species is illustrated in Fig. 1.

DISTRIBUTION PREVIOUS TO 1900

The first notation of *P. crispus* in North America is in Pursh's *Flora Americae Septentrionalis* (1814), which stated that plants were seen in the living condition and that the species occurred in rivers and ponds from Canada to Virginia. The basis for Pursh's record is apparently a specimen he collected on 2 August 1807 and identified as "*Potamogeton crispum* P[ursh]." The specimen has since been determin-

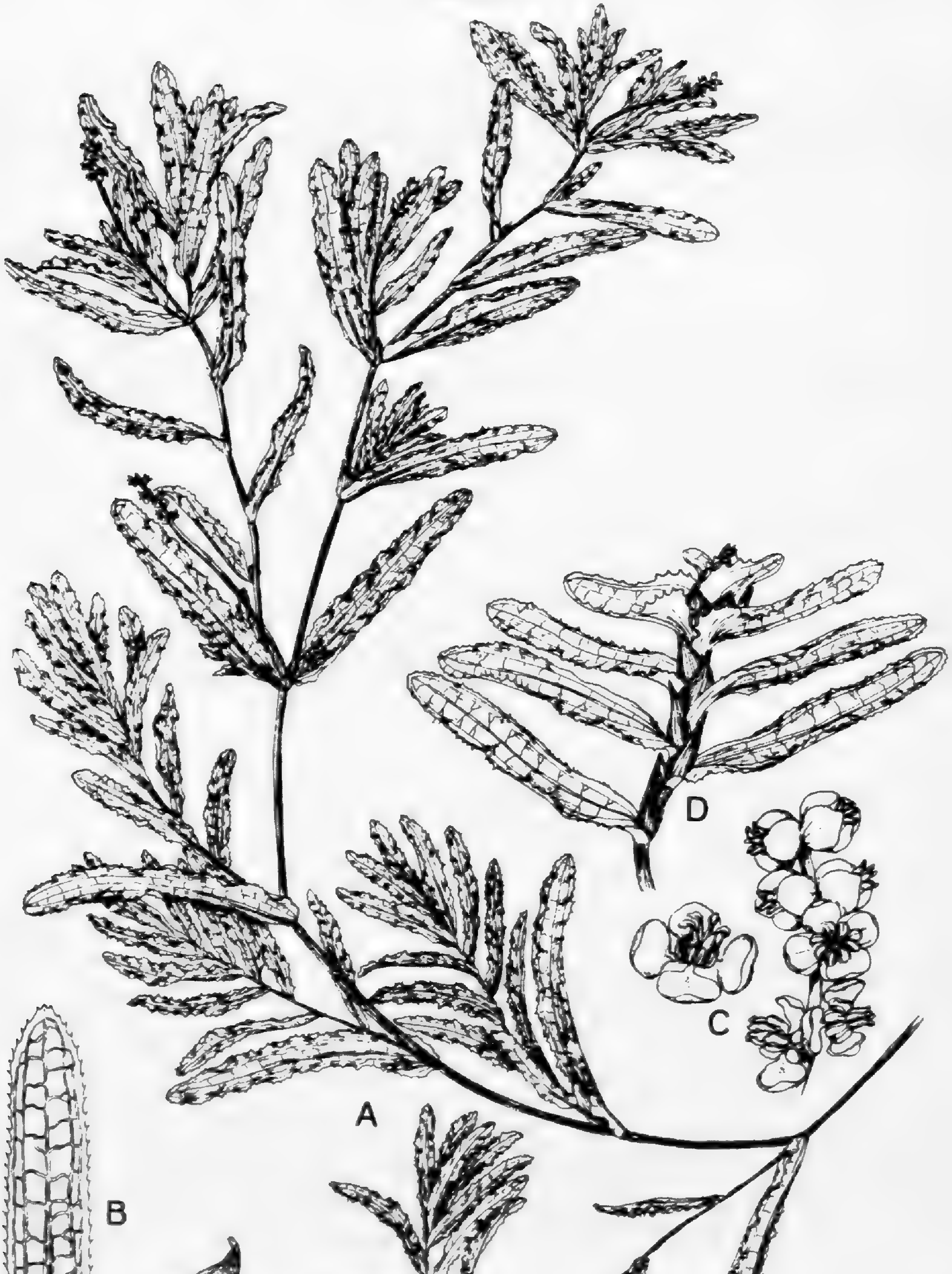

Fig. 1. *Potamogeton crispus.* A, Habit; B, leaf venation; C, flowers; D, developing dormant apex; E, achene. Reprinted from Reed and Hughes (1970).

ed as *P. richardsonii* (A. Benn.) Rydb. by McVaugh (1936). Later, Torrey (1824) reported *P. crispus* from Lake George, New York, in his *Flora of the Northern and Middle Sections of the United States,* but later omitted the record in his *Flora of the State of New-York* (Torrey, 1843). Tuckerman (1849) did not report *P. crispus* in his observations on the American species of *Potamogeton,* and Gray (1860) could not verify Pursh's account and omitted Torrey's record believing that the latter had made an error in identification. In later years, Burnham (1917) came to a similar conclusion concerning the record from Lake George. Accordingly, and in addition to not having seen the plant in North America, Gray (1848, 1856, 1858) did not report curly pondweed in the first, second, and third editions of his *Manual of Botany of the Northern United States.* In the second and third editions, however, Gray noted that Mr. Tuckerman had informed him of an herbarium specimen purported to have been gathered in Delaware and deposited in a European herbarium. This record may be the one noted by Bennett (1901) in the British Museum from Delaware collected by R. Egglesfeld Griffith about 1840 or earlier. Bennett (1893, 1901) further reported that the oldest North American specimen of *P. crispus* that he had seen was in England in Mr. Cosmo Melvill's herbarium with the data "Philadelphia, 1841-2," obtained by "Gavin Watson & Kilvington." As reported by Gray (1860), the first herbarium specimens he obtained were in 1859 from Mr. Edward Tatnall, a botanist and horticulturist, who collected specimens in the vicinity of Wilmington, Delaware. The oldest herbarium specimen I have seen is from Wilmington, Delaware, obtained by Edward Tatnall in 1860 (GH). In the addenda to the fourth edition of the *Manual*, Gray (1863) noted that *P. crispus* was abundant in streams at Wilmington, Delaware, and in the Lehigh River and at Lancaster, Pennsylvania. Herbarium specimens from the early 1860's have been seen from these sites, as well as farther inland in central Pennsylvania, from the Juniata River (Aug. 1864, *Porter s.n.,* GH). Its first appearance in eastern Massachusetts and western New York dates about 20 years later. In Massachusetts *P. crispus* was obtained at Spy Pond, Arlington, Middlesex County (20 Sep 1880, *Faxon s.n.,* MONT, NY) and in the Finger Lakes region from Keuka Lake, Yates County (House, 1924; Peck, 1879). Dudley (1886) noted that "Dr. Wright says it has increased in L. Keuka, enormously within a few years, to the exclusion of other species once dominant." Herbarium records show that *P. crispus* must have spread rapidly in the Finger Lakes region, as specimens are known from lakes and rivers in Onondaga, Ontario, Schuyler, and Tompkins Counties, all before 1884. By 1886, *P. crispus* had reached farther west in Sharon County in northwestern Pennsylvania (7 Jul 1886, *Aschman s.n.,* NY), and by 1900 was recorded for Buffalo and the Niagara Falls area (Zenkert, 1934). The earliest known record for Ontario dates from 1891 at Ashbridges Bay, Ontario (Montgomery, 1956). It was confirmed for Lake George in eastern New York by 1897 (*Hulst s.n.,* BKL). In agreement with the herbarium records, *P. crispus* was recorded from Massachusetts to New Jersey and west to western New York in the sixth edition of the *Manual* (Gray, Watson, and Coulter, 1889). A similar range was reported by Morong (1893). In the seventh edition of the *Manual,* the range was extended to include Ontario and Virginia (Robinson and

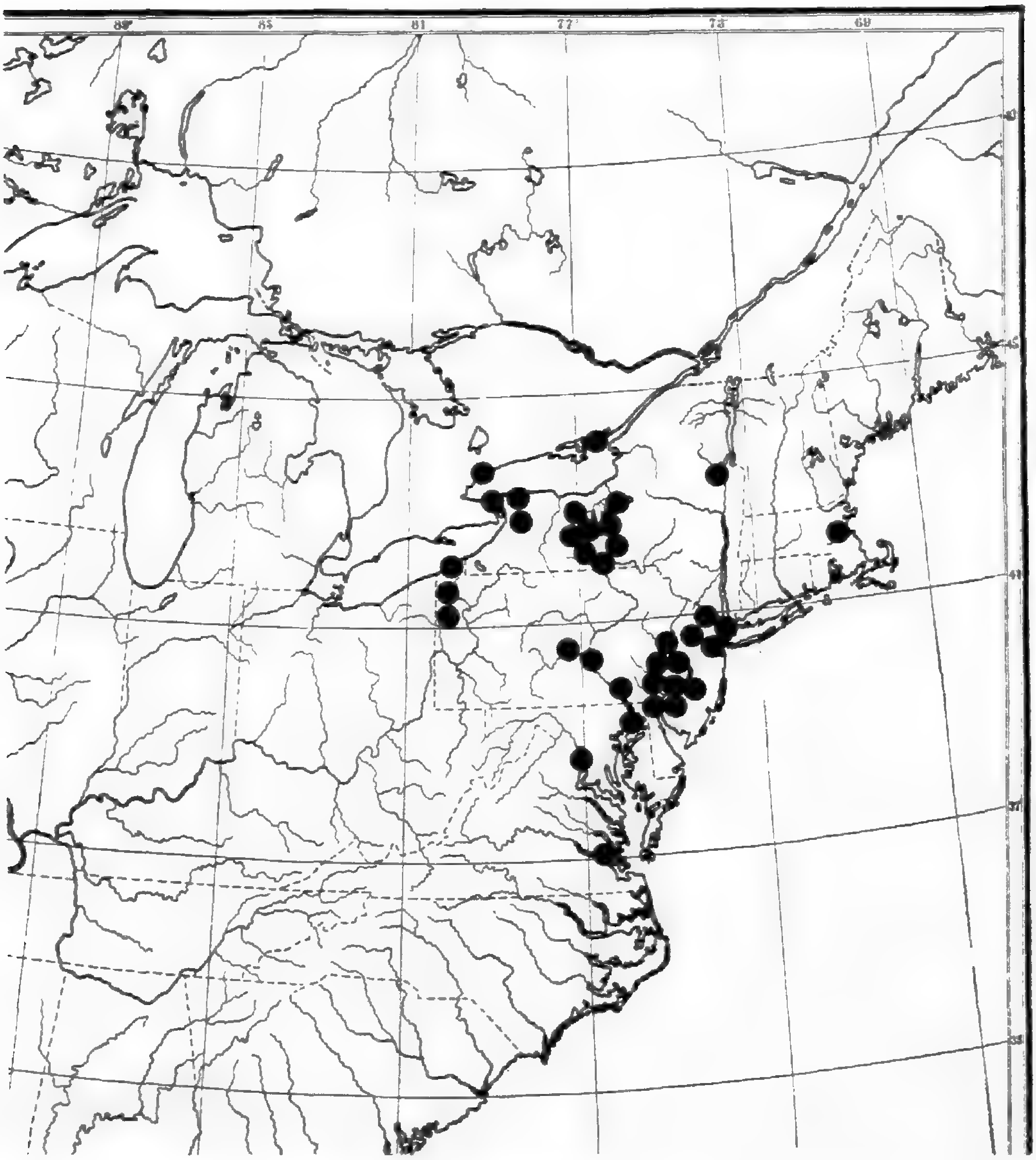

Fig. 2. Known distribution of *Potamogeton crispus* in northeastern United States and southeastern Canada previous to 1900 based on herbarium records, most of which are cited in this paper.

Fernald, 1909). The known distribution of *P. crispus* previous to 1900 is mapped in Fig. 2.

EXPANSION OF THE RANGE INTO THE GREAT LAKES REGION

Before 1900 *P. crispus* had become well established in the waters of the eastern Great Lakes at the town of Erie on Lake Erie and at Niagara-on-the-lake, Toronto, and Bell's Island in Lake Ontario. Beginning about 1900, *P. crispus* began moving into the western Great Lakes region, where it was recorded from several isolated localities. The earliest herbarium specimens date from 1901 at St. Paul in Ramsey County, Minnesota; 1905 at Lake Wingra in Dane County, Wisconsin (noted also in Ross and Calhoun, 1951); 1906 at Duluth in St. Louis County, Minnesota; 1910 at

Cedar Point in Erie County, Ohio, and Van Buren County, Michigan; 1911 at Wolf Lake in Cook County, Illinois; and from farther south in southwestern Missouri at Neosho in Newton County, in 1903. The invasion of *P. crispus* about the shoreline of the upper Great Lakes was apparently first noticed by Hull (1913) who reported the plants as abundant and growing vigorously in the lagoons of Jackson Park, Chicago, Illinois, and in Wolf Lake in northwestern Indiana, both bodies of water being connected with the waters of Lake Michigan. About a mile west of Jackson Park in the lagoons of Washington Park, which did not have a connection with Lake Michigan, no plants were to be found. Hull concluded that *P. crispus* had apparently invaded the area by way of the Great Lakes. He had first encountered the species in 1909, by which time it had already become common, and presented evidence that the species had probably invaded within the previous 10 years.

In Ottawa and Van Buren Counties of southwestern Michigan, Oosting (1932) observed during field work in 1926 that *P. crispus* occurred in several small lakes also connected with Lake Michigan. He suggested a northward migration of the species from the Indiana and Illinois locations. No other records of *P. crispus* were known from Michigan at that time. By 1935, however, curly pondweed had spread in southwestern Michigan "up the Kalamazoo River as far as Augusta and at many . . . southwestern lakes as far north as Lake Macatawa (Black Lake), at Holland" (Pirnie, 1935), even though Oosting's record of the plant in 1926 from Pigeon Lake is farther north.

In 1928, Tehon and Thompson, following four years of surveying Illinois waters, first obtained a fragment of *P. crispus* from Lake Nippersink in the northwest corner of Lake County, Illinois, about 20 miles west of Lake Michigan and about 45 miles northwest of Jackson Lake in Cook County. This record was the first indication that the species was beginning to migrate inland from Lake Michigan and led Tehon (1929) to summarize the distribution of *P. crispus* to that time in North America. He attributed the spread of *P. crispus* into the Upper Great Lakes from eastern United States to migrating ducks. The most likely candidates were the Mallard, Canvasback, and Scaup ducks, since their migration routes are primarily from southeastern United States, where they overwinter, to their breeding grounds, which range northwest from North Dakota to the Great Slave Lake and the entire chain of Aleutian Islands. Tehon cited figures based on the research of McAtee (1911) stating the importance of pondweeds as food for these ducks, and prepared a North American map showing the distribution of *P. crispus* correlated with the duck migration route. Hanna (1932) was quick to lend support to Tehon's theory that *P. crispus* was spreading through the activities of certain aquatic birds. The known documented distribution of *P. crispus* in North America prior to 1930 is mapped in Fig. 3.

The westward spread of *P. crispus* by duck migration is open to question, and a more plausible idea accounting for the movement of curly pondweed is here suggested based on information in the first report of *P. crispus* in Missouri (Metcalf, 1922). Metcalf noted that the species was not previously reported in the state, and that its earliest record was documented by two specimens from fish hatchery ponds

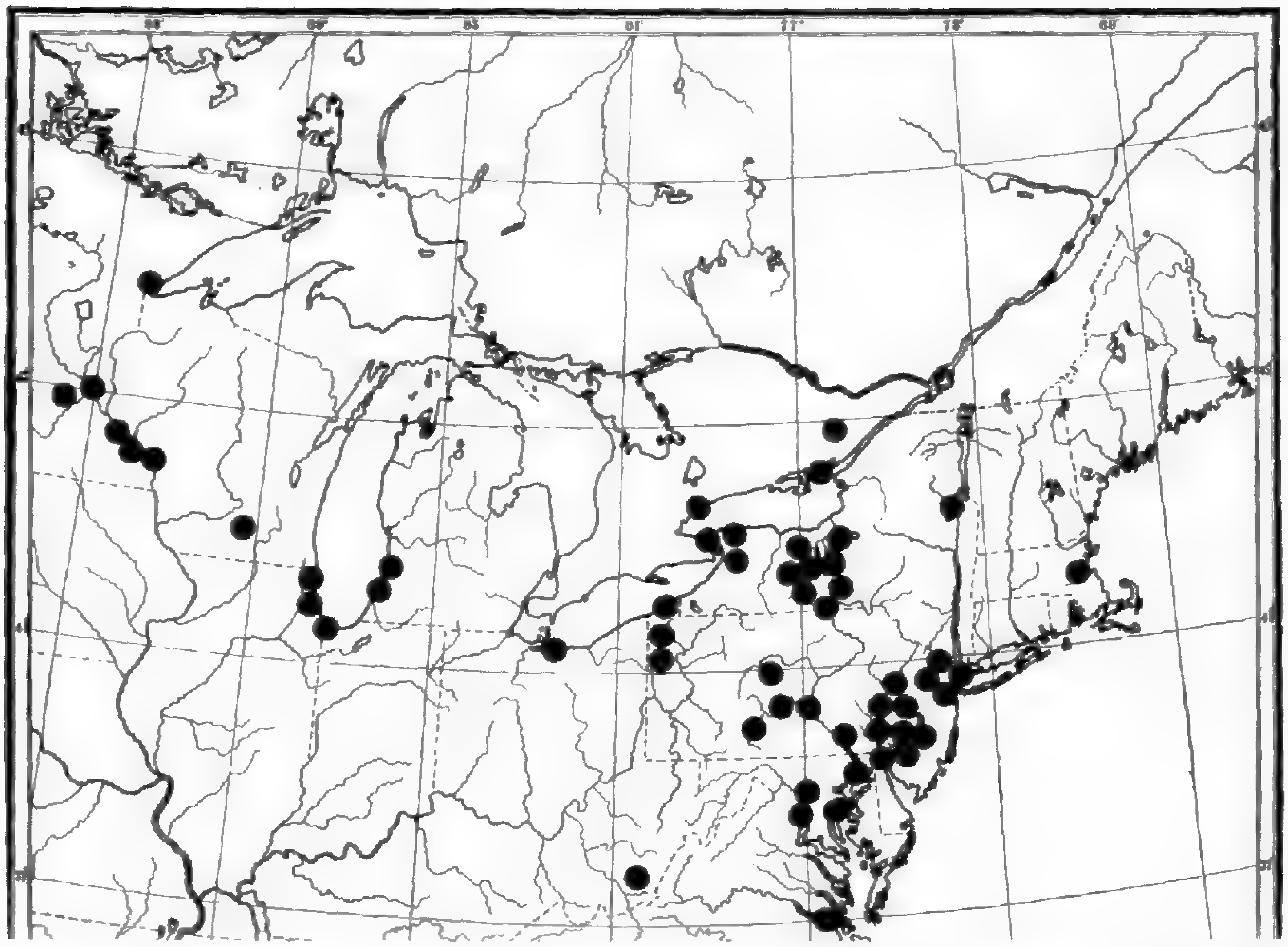

Fig. 3. Known distribution of *Potamogeton crispus* in northeastern United States and the Great Lakes region previous to 1930 based on herbarium records, most of which are cited in this paper.

at Neosho, Newton County, 28 May 1903. On the label of one of these specimens (US) is the note, "Introduced with the fish." Metcalf also reaffirmed the establishment of *P. crispus* at that locality by a specimen he obtained on 20 September 1920 (US). As reported by Moyle and Hotchkiss (1945) *P. crispus* "was first noted in Minnesota about 1910 by N.L. Huff in the Mississippi River near the St. Paul fish hatchery." As cited above, the earliest herbarium specimen seen from Minnesota also comes from St. Paul and dates from 1901. Evidently *P. crispus* spread there locally as Moyle and Hotchkiss further stated that it was "Common in the Mississippi River and flood plain lakes below the Twin Cities and locally abundant in a few lakes in Hennepin, Ramsey, Carver, Fillmore, and Pope Counties." Examination of the first reports and early herbarium specimen records from the states of Iowa (Beal, 1954; Beal and Monson, 1954), Oklahoma (Wallis and Waterfall, 1955), and North Carolina (Radford, 1951) reveals that the plants were taken from waters associated with fish hatcheries. In other areas, the earliest herbarium records are also from similar waters, namely the District of Columbia (11 May 1898, *Steele s.n.*, MSC, US) Ohio (1910, *Jennings s.n.*, CM), West Virginia (24 Jul 1930, *Berkley 1215*, MO) and North Dakota (1975, *Larson 5481*, KANU, NDSU). Schaffner (1938) reported curly pondweed from a state fish farm at the Portage Lakes in Summit County, Ohio. In Crawford County, Missouri, Steyermark (1941) noted that *P. crispus* was dominant and abundant in Blue Spring Lake and Osage Lake, both fed by a spring on which is located a fish hatchery. The first specimen he obtained there was in 1934 (MO, US). He further noted that *P. crispus* was rare in Missouri, at that time known only at this locality and in a spring in Newton County, probably the same record as Metcalf's. From eastern United States, the westward and southward migration of curly pondweed may have resulted at least in part from transport of plant propagules in water with fishes and fish eggs distributed to and from various fish hatcheries.[3] Based on data from herbarium specimens, all of the known localities where *P. crispus* has been reported from waters associated with fish hatcheries or state fish game lakes are mapped, with the dates when they were obtained, in Fig. 4.

Expansion of the Range to the West and South in the United States

Previous to 1940, *P. crispus* had been reported from all of the states bordering the Great Lakes. Since then its range has been expanding westward into the states of the Great Plains and southward, the Rocky Mountains, and the Intermountain region. The earliest dated herbarium records seen for each state of this region are: Oklahoma 1936, Utah 1937, Texas 1942, New Mexico 1945, Colorado 1952, Kansas 1955, Arizona 1957, Nebraska and South Dakota 1965, and North Dakota 1975. In general, *P. crispus* seems to have appeared earlier in the Rocky Mountain and Intermountain states than in the Great Plains. Apparently it has not yet spread in the former region, or if it is spreading or has spread, the documentation is not yet available. Maguire and Jensen (1942) first reported *P. crispus* from the Rocky Mountain and Great Basin regions, based on a plant obtained in 1937 from Ogden Bay Refuge, Weber County, Utah. More recently the species has been considered "naturalized in northern Utah and near Reno in western Nevada at gun clubs and game preserves," and is expected in other similar situations in the Intermountain region (Reveal, 1977). Only one station, Evergreen Lake, west of Denver, is known from Colorado (Harrington, 1954; Weber, 1976). The only known record for eastern Montana is based on the one mapped in Barkley (1977). In western Canada, the species has been known from Calgary, Alberta, since 1943 (Groh, 1944; Moss, 1959). As reported by Porter (1963), *P. crispus* is not known to occur in Wyoming. When curly pondweed was first detected in Arizona, it was growing abundantly in an irrigation ditch near Camp Verde, Yavapai County (McCleary, 1959; Howell and McClintock, 1960). The reports by Correll and Correll (1972) from Hidalgo and Taos Counties, New Mexico, have not been verified, although *P. crispus* is expected to occur sporadically throughout montane areas of northern and western parts of New Mexico (Martin in litt., 1977).

In the Great Plains and southward, *P. crispus* is more aggressive and actively migrating. Even though Ogden (1966) noted *P. crispus* as "not common" in Texas,

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[3] Another method by which *P. crispus* may have been dispersed in the United States is illustrated in a report by Terrell (1918) who planted 625 roots of *P. crispus* in the middle of May 1918 at the Cedar Point Duck Hunting Club in Lucas County, Ohio. Mr. Terrell was a specialist on the development of sites to attract places for birds, game, and fish. The possible dispersal of *P. crispus* by this method to other game and duck hunting clubs bears further investigation.

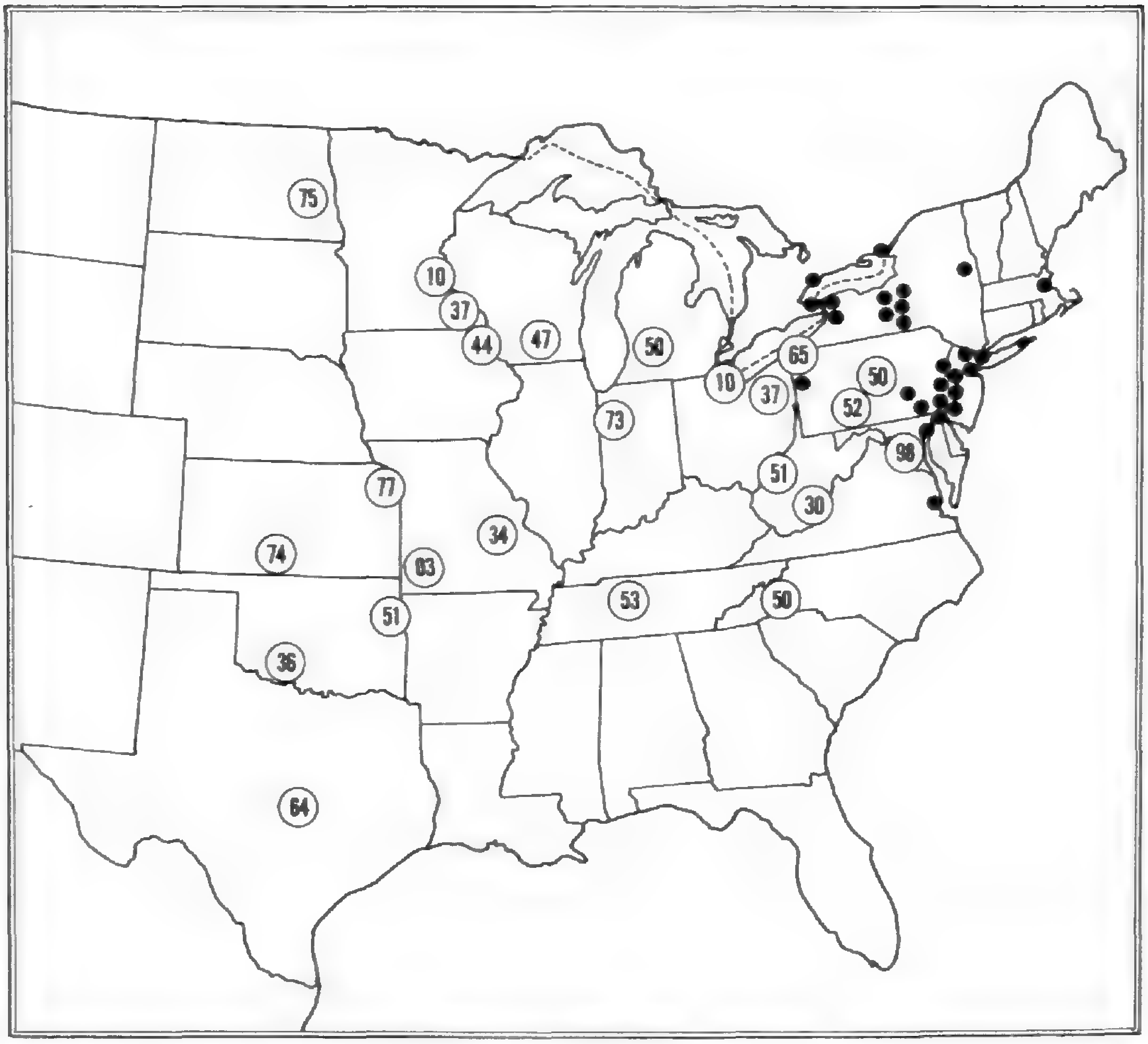

Fig. 4. Known distribution of *Potamogeton crispus* in the United States as reported from waters associated with fish hatcheries or state fish game lakes based on those records cited that are accompanied with an asterisk. The numbers are the last two digits of the year in which the plants were first obtained from that locality. Dots illustrate distribution previous to 1900.

Correll and Johnston (1970) and Correll and Correll (1972) revealed that it was "often abundant in quiet muddy calcareous water." These three accounts did point out that when thoroughly established in Texas, *P. crispus* may become an aggressive weed. When first noted in Kansas, *P. crispus* was considered an "aquatic weed" in the water supply reservoir of Oskaloosa, Jefferson County (7 May 1955, *Stroud s.n.*, KANU, KSC, TEX). Since that time "it has been spreading rapidly in the state . . . [but] only on rare occasions reported as a problem weed in Kansas waters" (Brooks and Hauser, 1978). In eastern Nebraska, the species has been present from the mid-1960's and since then has been "spreading rapidly" in man-made lakes (Churchill, Kaul, and Sutherland, 1976a,b), but apparently is not invading natural lakes in the sandhills region of western Nebraska (Churchill in litt., 1978). The first report for North Dakota is from a collection in 1975 in the trailrace below Baldhill Dam on the Sheyenne River in Barnes County (Larson, 1976).

The arrival of *P. crispus* in southern California dates from before 1900 and suggests an introduction separate from its invasion and spread in eastern United States.

The earliest specimen seen is from a pool in Arroyo Seco, Los Angeles County, 1896 (without collector, CAS). In 1918, plants were obtained from the Santa Ana River near Corona, Riverside County, then believed to be the only known station in California as cited by Abrams (1923) and Munz (1935), and planted in the Botany lathhouse at Pomona College (*Parish 19248,* GH, UC: *Munz 2785,* DS, US). Additional herbarium records from subsequent years have been seen from this site. Pollard noted on an herbarium sheet (CAS, TEX) that *P. crispus* was "long established in pond on the Walska Estate . . . Montecito, Santa Barbara," but he was uncertain whether the species had originally been planted or was introduced. By the late 1940's and early 1950's, *P. crispus* had invaded the slow-running streams and canals in the San Joaquin and Sacramento valleys, as well as the San Francisco Bay region (Mason, 1957; Howell, Raven, and Rubtzoff, 1958; Munz and Keck, 1959; Thomas, 1961; herbarium specimens at CAS, DS, and UC). Its invasion northward from San Francisco in the coast ranges was first noted in 1956 when a fragment was obtained in an artificial pond in the Atascadero Creek Marsh, Sonoma County (Rubtzoff, 1960), and later curly pondweed was reported established at the same station, as well as in Salmon Creek about a mile upstream from the town of Salmon Creek (Rubtzoff, 1966). In recent years *P. crispus* has been reported from Santa Catalina Island (Thorne, 1967) and the coastal peninsula, Bodega Head, north of San Francisco (Barbour, 1970).

In the Pacific Northwest, *P. crispus* apparently first appeared in Oregon in 1947 in the Rogue River at Cherry Flat, four miles north of Agness, Curry County (Rubtzoff, 1965). In Washington, the earliest known herbarium specimen was also obtained in 1947 from a stream near the outlet of Lon Lake, five miles east of Olympia, Thurston County (*Meyer 2253,* F, GH, MO, NY, UC). Since then, its spread has been in southwestern Oregon, the Willamette River valley, the area about the southern portion of Puget Sound, and the Columbia and Snake river valleys (Falter et al., 1974).

Most of the records documenting curly pondweed's first appearance by state in the southeastern United States are in the 1940's as follows: Florida 1937, Alabama 1943, Tennessee 1946, Georgia 1947, Louisiana 1949, and North Carolina 1950. For the most part, unless records not yet seen are available, *P. crispus* does not seem to be spreading in the southeast — for example, three counties for North Carolina (Radford, Ahles, and Bell, 1968) and one additional record for Louisiana (Haynes, 1968; Thieret, 1966). Several records from the 1970's, however, have been obtained from reservoirs in the Tennessee River valley in eastern Tennessee and northern Alabama where the species is apparently becoming more common. Its invasion, first noticed in 1959, and rapid spread in the 1960's at Reelfoot Lake in northwest Tennessee has already been noted (Cypert, 1967). Jones (1974) did not report curly pondweed from Mississippi.

Table 1. Erroneous and Questionable Reports of *Potamogeton crispus* in North America.

State	Locality	Collector, Date, Herbarium	Reference	Status of the Record
Arizona	Not Given	Not Given	Britton (1886)	Oral report at a meeting; no further verification located
Oregon	Near Silvies	*D. Griffiths & E.L. Morris,* 19 Aug 1901 (BKL)	Ogden (1943); Tehon (1929)	Specimen is *Potamogeton richardsonii* A. Benn.
South Dakota	Edmonds County	*D. Griffiths,* Jul 1896 (BKL)	Ogden (1943); Tehon (1929)	Specimen is *Potamogeton richardsonii* A. Benn.
Wyoming	Lakes Swastika and Irene, Medicine Bow Mountains	*R.J. Gilmore & L.A. Hanna,* date and herbarium not recorded	Hanna (1932); Ogden (1943)	Specimens not located

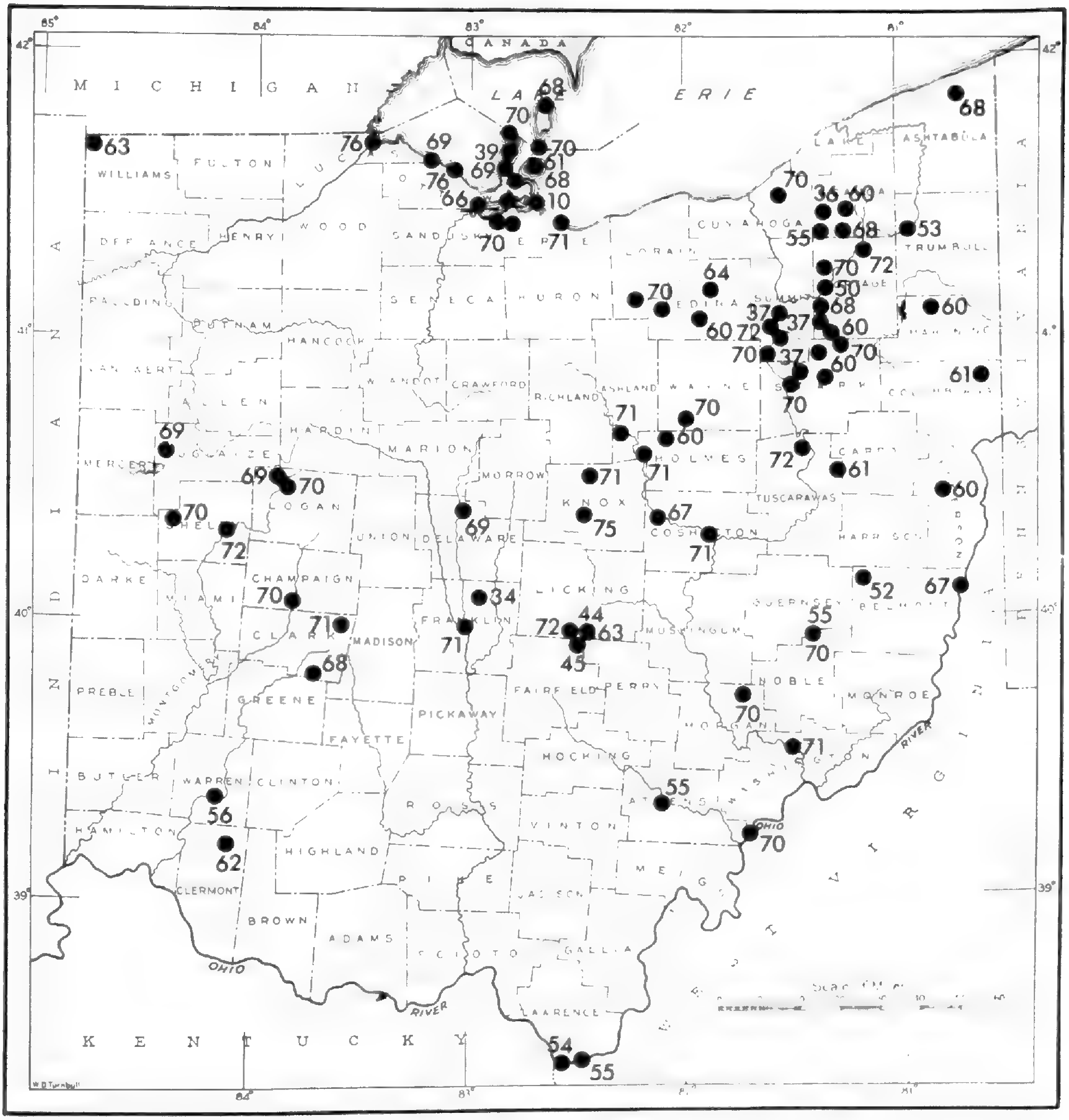

Fig. 5. Known distribution of *Potamogeton crispus* in Ohio based on herbarium records seen. The numbers are the last two digits of the year in which the plants were obtained.

SUMMARY OF PRESENT DISTRIBUTION

In the region where *P. crispus* has mostly been known since 1900 (Fig. 3), the species has now become thoroughly established. In New England, Hellquist (1972) reported that curly pondweed increased in recent years in hard water ponds and lakes that are now severely polluted. Its extensive occurrence in Ontario, Canada, has been documented by Dore and Gillett (1955) and by Montgomery (1956). In Quebec, *P. crispus* is listed as an adventive (Rousseau, 1968) and is known from the

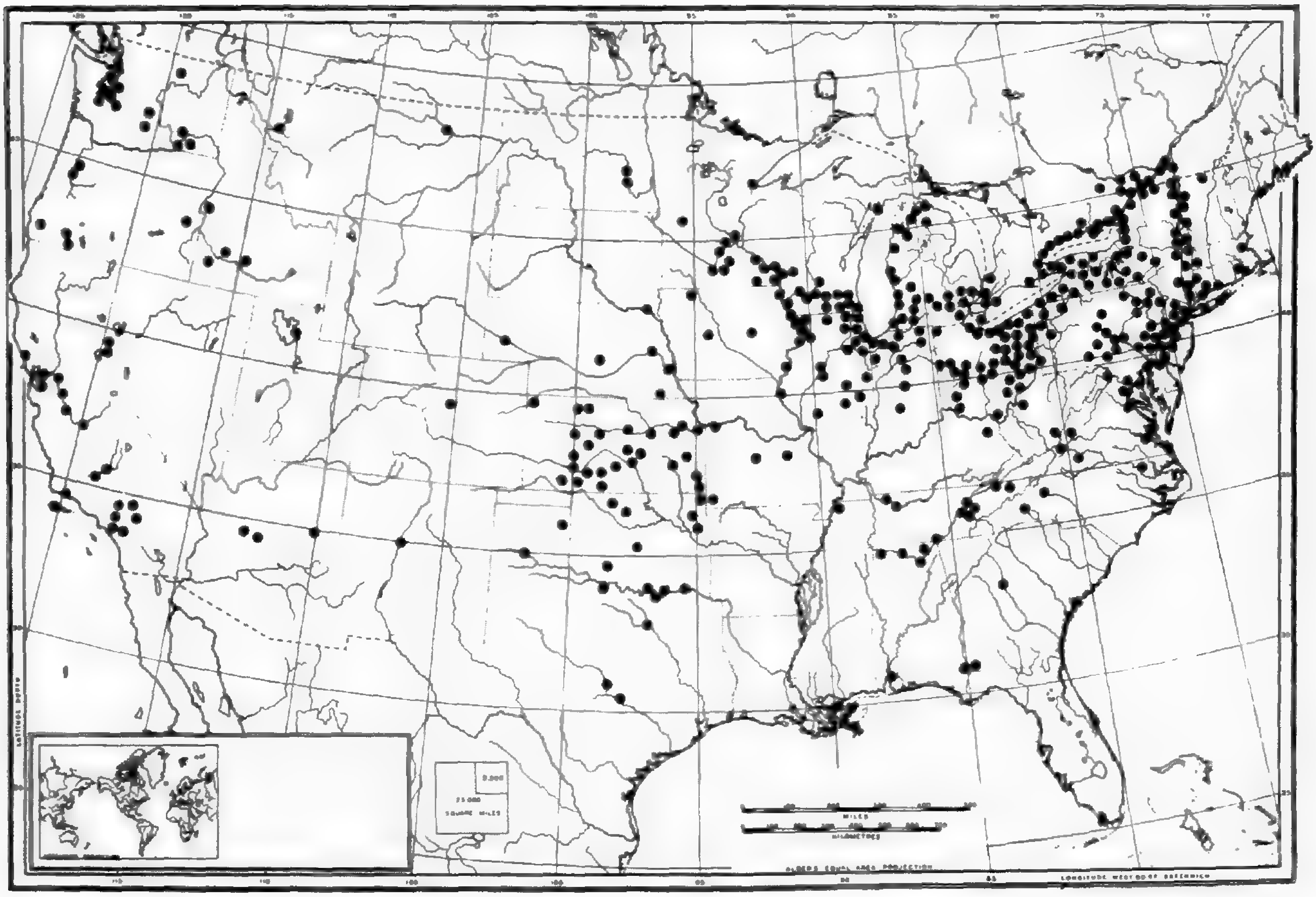

Fig. 6. Present known distribution of *Potamogeton crispus* in the United States and southeastern Canada based on herbarium records and reliable literature records. The known records from Alberta, Canada, are not mapped.

St. Lawrence River and the Richelieu River. The earliest record for the province, obtained in 1933, is from the latter river at Ste. Therese Island (Raymond, 1934). At the south end of Lake Michigan, Swink (1969, 1974) noted that *P. crispus* was becoming more common in lakes and ponds, both old and new, the latter including borrow pits excavated during the construction of expressways. Similar records and personal observations are available for Ohio, where its spread and establishment has occurred primarily since the 1930's, first in the shallow waters of western Lake Erie and the lakes of northeastern Ohio and later in the central and southern portions of the state by the 1950's as shown in Fig. 5. The present metropolis of *P. crispus* in North America is in western Massachusetts and Connecticut, the upper St. Lawrence River valley, the Delaware River valley, throughout large portions of Pennsylvania, New York, and Ohio, southern Michigan, northern Indiana, northern Illinois, and southern Wisconsin. It is more sparingly recorded from northern Michigan, Minnesota, Iowa, Missouri, and the mountains of eastern Kentucky, West Virginia, and Virginia. Its distribution in the latter state is based mostly on the map in Harvill, Stevens, and Ware (1977). *P. crispus* may be expected to become more widely distributed in these areas, as well as in the states farther to the west and south. The known North American distribution of *P. crispus* based on herbarium specimens from over 60 herbaria and selected literature records is mapped in Fig. 6.

Acknowledgements

My thanks are extended to my students who over the past 12 years have assisted in assembling data from various herbaria and field localities. These students are Robert J. Bartolotta, Mark Davis, Thomas Duncan, Karen Fries, Robert R. Haynes, Stephen B. Hurst, Ronnie Johnson, Edna Kirby, Richard M. Lowden, John H. Marshall, David Moore, W. Louis Phillips, Mark F. Reinking, Marvin L. Roberts, Margaret A. Ross, Duncan M. Thorp, John R. Wehrmeister, and W. Alan Wentz.

My thanks are also extended to the curators of the herbaria who made specimens and records available. Those herbaria in which I have examined specimens are: BH, BHO, BKL, CAS, CU, DAO, DS, GH, IND, ILL, ISC, KE, KY, MICH, MIN, MO, MSC, MU, NA, NEBC, NY, OS, OWU, PENN, PH, SD, US, WUD, WVA in part. Those herbaria from which only records were seen are: ASU, BLH, CAN, CM, COLO, CS, F, FLAS, FSU, GA, HAM, IA, ILLS, KANU, KSC, MONT, MONTU, MOR, OKL, OKLA, OSC, SDU, SMU, TENN, TEX, TRT, UNA, UC, UMO, VDB, VT, WIN, WIS, WS, WTU. The following herbaria reported no specimens from the state in which the institution is located: LRU, RM, UNM.

Selected Specimens Cited

CANADA: ALBERTA: Running water (2 ft.) in Elbow River, ¼ mi. above Mission Bridge, Calgary, 23 Aug 1943, *G.H. Turner 3685* (GH); Elbow River, Elbow Park, Calgary, 23 Aug 1943, *W.C. McCalla 7914* (GH); in 2 feet water in edge of Elbow River a short distance above Mission Bridge, Calgary, 16 Sep 1943, *G.H. Turner 3675* (CAN, DAO, OSC). ONTARIO: [Frontenac Co.]: Bell's Island, 14 Jun 1892, *A.H.D. Ross s.n.* (Queen's University); Kingston, 15 Jun 1901, *J. Fowler s.n.* (US). Leeds Co.: Jones' Falls, Rideau River, 5 Oct 1905, *J. Fletcher s.n.* (DAO). Lincoln Co.: Niagara-on-the-lake, 6 Sep 1900, *W. Scott s.n.* (TRT). [Welland Co.]: Ashbridges Bay, Toronto, 16 Jul 1892, (CAN), 18 Jul 1891 (DAO), 21 Aug 1894 (TRT), *W. Scott s.n.*, 19 Jun 1896, *W. Scott 16439* (CAN, CU, DAO, GH, MSC, NY, TRT); pool above Niagara Falls, 10 Jul 1901, *J. Macoun 26830* (CAN, CAS, GH, NY). QUEBEC: St. Jean Co.: Eaux tranquilles du Richelieu, Ile Ste. Therese, 16 Juillett 1932, *F. Marie-Victorin & F. Rolland-Germain 49141* (DAO, GH): Ile Ste. Therese, 29 Juin 1933, *F. Marie-Victorin & F. Rolland-Germain 45189* (CU, GH).

UNITED STATES: ALABAMA: Baldwin Co.: Bay Minette Creek w where crossed by Alabama 225, 9 June 1969, *R. Kral 35184* (VDB). Jackson Co.: Shallows of Tennessee River & backwaters by Tenn 35 bridge, e shore, e of Scottsboro, 30 Sep 1971, *R. Kral 44571* (GA, OS). Marshall Co.: Mink Creek, Guntersville Reservoir, 3 Jul 1943, *T.F. Hall & D. Isely 2870* (CU). ARIZONA: Navajo Co.: In Little Colorado River, 1 mi n of Woodruff, 13 May 1962, *L. Gardner 217* (ASU). Yavapai Co.: One-half mi from Verde River, Camp Verde, 5 Apr 1957, *G. Crowby s.n.* (ASU); in lake, Granite Basin Lake Recreation Area, ca. 5300 ft, 27 Jul 1965, *D.J. Pinkava 2347-17* (ASU, IND, OSC). CALIFORNIA: Alameda Co.: San Leandro Creek, 28 Jun 1946, *H.L. Mason 12877* (CAS, DS, FSU, UC, WTU). Los Angeles Co.: In pool, Arroyo Seco [Arroyo Seco Park], 20 Jan 1896, Herb. A.J. McClatchie (CAS). Orange Co.: Submerged in pond, Santa Ana River bottom, Santa Ana Cañon, 6 Sep 1928, *J.T. Howell 4079A* (CAS). Riverside Co.: Cultivated at Pomona College, the plants brought from Santa Ana River near Corona, only known station in California, 19 Apr 1919, *S.B. Parish 19248* (GH, UC); pond in Botany lathhouse, Pomona College, planted by Johnston from Santa Ana River, 15 May 1919, *P.A. Munz 2785* (DS, US); Corona Bridge, Santa Ana River, 24 Aug 1929, *F.R. Fosberg S1593* (PENN). San Bernardino Co.:

Common, 6,800 ft, Big Bear Lake, 19 Jul 1941, *G.T. Hastings s.n.* (CU, NY). Santa Barbara Co.: Long established in pond on the Walska Estate (Lotusland), Sycamore Canyon Road, Montecito, Santa Barbara (whether planted or introduced uncertain), 16 Mar 1959, *H.M. Pollard s.n.* (CAS, TEX). COLORADO: Jefferson Co.: Evergreen Lake, 10 May 1952, *Y. Matsumura 226* (CS); common in inlet to Evergreen Lake, Evergreen, 27 Jul 1952, *W.A. Weber 7889* (CAS, COLO, DAO, IND, KANU, MIN, OKLA, SMU, TEX, UC, WS); forming mats in the w end of Evergreen Lake, 8,000 ft, 3 Sep 1953, *C.L. Porter 6425* (DAO, MIN, MO, NY, TEX, UC). DELAWARE: [New Castle Co.]: Wilmington, 1860, *E. Tatnall s.n.* (GH); New Castle, 20 Jun 1866, *A. Commons s.n.* (NY); Brandywine, Jun 1866, *A. Commons s.n.* (PH). DISTRICT OF COLUMBIA: Potomac, 14 Sep 1897, *E.S. Steele s.n.* (MIN);*[4] old fish pond, 11 May 1898, *E.S. Steele s.n.* (MSC, US); fish ponds, 8 Jul 1902, *G.H. Shull 15* (US). FLORIDA: Jackson Co.: Water of Blue Springs, n of Marianna, 17 Mar 1937, *Exploration Party* (FLAS); abundant in Merritts Millpond, e of Mariana, 16 Dec 1967, *R.K. Godfrey 67763* (MO, US). GEORGIA: Putnam Co.: In water about 1-2 ft deep at edge of Rock Eagle Lake, 4 May 1947, *A. Cronquist 4394* (FLAS, GA, GH, MO, NY, SMU, UC, US). Seminole Co.: In water, Lake Seminole, 26 Apr 1969, *J.W. Griffin 185* (SMU). INDIANA: [Lake Co.]: Wolf Lake, 7 Jun 1913, *E.D. Hull s.n.* (GH). Newton Co.:* LaSalle Fish and Game Area, 14 Jun 1973, *T. Stork s.n.* (OS). ILLINOIS: [Cook Co.]: Wolf Lake, Chicago, 10 Jun 1911, *E.E. Sherff s.n.* (GH). Lake Co.: Lake Nippersink, 24 Aug 1928, *D.H. Thompson & L.R. Tehon s.n.* (ILLS). Tazewell Co.: Spring Lake, 21 May 1939, *L.P. Elliott & V.H. Chase 6868* (ILL, MO, NY). IOWA: Allamakee Co.:* State fisheries building, Mississippi River edge of main channel, Lansing, 3 Aug 1944, *I.E. Snead s.n.* (ISC); Mississippi River slough, 2 mi n of Lansing, 21 Jul 1959, *T.G. Hartley 7600* (GH, IA, ILL, ISC, MIN). Scott Co.: Lock 14, below LeClaire, 25 Jun 1955, *L.F. Guldner s.n.* (IA). KANSAS: Woodson Co.: In water along the edge of a lake in an upland woods, T26S, R14E, NE¼ Sec. 14, 21 Jun 1955, *E.W. Lathrop 978* (US). Jefferson Co.: Aquatic weed in Oskaloosa city water supply reservoir, 7 May 1955, *N.E. Stroud s.n.* (KANU, KSC, TEX); extremely abundant along edges of city lake, 1 mi s of Oskaloosa, 27 Oct 1955, *B.L. Wagenknecht 2342* (KANU). Pratt Co.:* Submerged in small pond on e side of State Fish and Game Lake, 2 mi s e Pratt, 17 Jul 1974, *R. Brooks 7575 & R.L. McGregor* (KANU). Wyandotte Co.:* Plants abundant in large mats submerged along lakeshore in Stotler Cove, Wyandotte County State Fishing Lake, 26 May 1977, *R. Brooks 13144* (KANU). KENTUCKY: Carter Co.: Smokey Valley Lake, Carter Caves State Park, 2 Jul 1973, *M.L. Roberts 3735* (OS). LOUISIANA: [Orleans Co.]: Front lagoon, Audubon Park, New Orleans, 31 May 1949, *L.L. Ellis s.n.* (WIS). Plaquemines Parish: Goose Pond, Delta National Wildlife Refuge, 28 Apr 1965, *J.M. Valentine, Jr. s.n.* (GH, US). MARYLAND: [Kent Co.]: In streams, Galena, 4 Jun 1877, *without collector* (US). [Harford Co.]: Spesutic Island, 27 May 1879, *J.D. Smith s.n.* (US). MASSACHUSETTS: Middlesex Co.: Spy Pond, Arlington, 20 Sep 1880, *C.E. Faxon s.n.* (MONT, NY); 21 Sep 1880, *E. & C.E. Faxon s.n.* (CM, GH, NEBC, US, VT). MICHIGAN: [Barry Co.]: *Abundant, Hastings Twp., Hastings State Fish Hatchery, 14 Aug 1950, *S. Hedges 56* (MSC). Ottawa Co.: Pigeon Lake, 26 Jul 1926, *H.J. Oosting 2963* (MIN, MSC 3813, PENN); Pine Creek Bay, Black Lake [Lake Macatawa], 29 Jun 1926, *H.J. Oosting 2664* (MIN, MSC 3884). Van Buren Co.: Without locality, 1910, *L.H. Pennington s.n.* [cited by Oosting (1932), but specimen not located]. MINNESOTA: Filmore Co.: *Common, 2-3 ft mud, pools in Lanesboro Hatchery, 13 Aug 1937, *J.B. Moyle 2844* (MIN). Hennepin Co.: Lake Minnetonka, 17 Aug 1926, *W.N. Keck & C.F. Stilwill 430* (GH) *428* (US); Lake Minnetonka, 18 Aug 1929, *H.J. Oosting 2959* (MIN). [Ramsey Co.]: St. Paul, Jul 1901, *J.A. Anderson s.n.* (MONT); *in the Mississippi River near the St. Paul fish hatchery, 1910, *N.L. Huff*, as cited by Moyle and Hotchkiss (1945). [St. Louis Co.]: Duluth, 1906, *P.H. Hawkins s.n.* (MONT). Wabasho Co.: Mississippi River, 25 Aug 1925, *W.N. Keck & O.A. Stevens 335* (US). [Winona Co.]: Between wing dams [Mississippi River], n w of Fountain City, Wisconsin, 5 Sep 1928, *H.W. Graham s.n.* (CM); Mississippi River bottoms below Winona to Trempealeau, 6 Aug 1931, *H.J. Oosting 316* (MIN, PENN, US). MISSOURI: Crawford Co.: *In Blue Spring Lake and Osage Lake, formed by Blue Springs [fish hatchery located nearby on this stream as stated by Steyermark (1941)], 2 mi s e of Bourbon, 21 Oct 1934, *J.A. Steyermark 16313* (MO, US). Newton Co.: *Neosho, Fish Commission Hatching Ponds (introduced with the fish), 28 May 1903, *without collector* (US); Neosho, 6 Sep 1920, *E.P. Metcalf 948* (US);

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[4] Records with an asterisk were used in making the map in figure 4.

in clear shallow water at head of spring, George Washington Carver National Monument, near Diamond, 6 Nov 1954, *E.J. Palmer 59352* (GH). NEBRASKA: Morrill Co.: Common along sandy margin of lake, Bridgeport State Recreation Area, 22 Aug 1965, *J. Richardson & K. Robertson 1620* (KANU, UC). NEW JERSEY: [Camden Co.]: Very abundant in tidal ditches, Camden, 5 May 1866, *C.F. Parker s.n.* (GH); Camden, Jun 1870, *S.S. Garrigues s.n.* (MICH); Camden, Jun 1879, *I.C. Martindale s.n.* (GH, MIN, MSC, NY, PH, VT). [Union Co.]: Cedar Brook, Plainfield, May 1879, *F. Tweedy s.n.* (CAN, CU, NY, US). NEW MEXICO: [Bernacillo Co.]: Isleta, Tena Indian Reservation, 6 Jun 1945, *W.C. Muenscher & W.T. Winne 16513* (CU). NEW YORK: [Erie Co.]: Delaware Park Lake, Buffalo, 14 Jul 1900, *J.F. Cowles s.n.* (NYS). Niagara Co.: Hopkins Creek w of Olcott, 10 Jun 1900, *E.N.J. Ringenberg s.n.* (Buffalo State Museum). Onondaga Co.: Seneca River, Baldwinsville, 17 Jun 1881, *Mrs. S.M. (Mary Olivia) Rust s.n.* (NYS); Onondaga Lake, Syracuse, 13 Aug 1884, *T. Morong s.n.* (GH). Ontario Co.: Abundant, Geneva, Lake Seneca, 14 Aug 1884, *T. Morong s.n.* (GH, MICH); Geneva Lake Inlet, 14 Jun 1884, *W.R. Dudley s.n.* (ILL). Schuyler Co.: Seneca Lake, Watkins, 16 Aug 1884, *T. Morong s.n.* (GH). Tompkins Co.: Southwest corner of Cayuga Lake, Ithaca, 16 Jul 1881, *F.C. Curtice s.n.* (NYS). Yates Co. Keuka Lake, [before 1879], *S.H. Wright s.n.* (NYS). NORTH CAROLINA: McDowell Co.: *Small stream at state fish hatchery n of Marion, 8 Jun 1950, *A.E. Radford 5281* (PH). NORTH DAKOTA: Barnes Co.: *In the trailrace below Baldhill Dam on the Sheyenne River, 8 mi n, 5 mi w Valley City [the Valley City Fish Hatchery is located below the dam], 1975, *G. Larson 5481* (KANU, NDSU). OHIO: [Erie Co.]: *Cedar Point [fish hatchery at Sandusky is nearby], 1910, *O.E. Jennings s.n.* (CM). Franklin Co.: Minerva Park Lake, Columbus, summer 1943, *F.B. Chapman s.n.* (OS). Geauga Co.: South Russell, Russell Twp., 31 May 1936, *V. Gifford s.n.* (OS). Stark Co.: Lake O'Springs, Jackson Twp., 5 Jun 1937, *D.M. Brown s.n.* (OS). Summit Co.: *Portage Lakes [cited by Schaffner (1938) as from State Fish Farm No. 10], 27 Sep 1937, *F.H. Glenny s.n.* (OS). OKLAHOMA: Cherokee Co.: *Fish pond at Tahlequah, 9 May 1951, *C.S. Wallis 394,* 29 May 1953, *C.S. Wallis 1398* (OKLA). Cleveland Co.: In small lake, 4 mi n e of Norman, 16 Jul 1937, *F.A. Barkley 1418* (OKLA). [Comanche Co.]: *Water 4 ft deep, fish hatchery, Medicine Park, 28 May 1936, *J. deGruchy 47* (MO, NY). Marshall Co.: Lake Texoma, near University of Oklahoma Biological Station, 16 May 1955, *G.J. Goodman & C.D. Riggs 6079* (GH, ILL, KANU, MIN, OKLA, SMU, UC). OREGON: Benton Co.: In pond on bank of Willamette River near Peoria Ferry Landing, 15 Jul 1949, *H.M. Gilkey s.n.* (IA, OSC, WS, WTU). Curry Co.: In the Rogue River at Cherry Flat, 4 mi n of Agness, 1 Aug 1947, *W.H. Baker 4690* (CAS, WS, WTU). Jackson Co.: Irrigation ditch, Medford, Dec. 1951, *C.B. Cordy s.n.* (OSC); Antelope Creek, 2 mi s w of Eagle Point on hwy 62, 19 Aug 1957, *L.J. Dennis & F.W. Sturges s.n.* (CAS, NY, OSC, PENN); Jackson Hot Spring, 1 mi s e of Talent on hwy 99, 19 Aug 1957, *L.J. Dennis & F.W. Sturges s.n.* (DAO, OSC). PENNSYLVANIA: Bedford Co.:*Pond at fish hatchery, 2.5 mi s e of Alum Bank, 30 Jul 1952, *D. Berkheimer 14344* (CM, PENN). Centre Co.: *Spring Twp., fish hatchery, Pleasant Gap [location of the study by Simes (1961)], 2 Sep, 1950, *W.F. Westerfeld 1140* (PENN). Chester Co.: 1863, *W.M. Canby s.n.* (CAN, F, NY). Delaware Co.: Southwest side of the road from the Darby Creek Ferry to the Lazaretta, 25 May 1866, *A.H. Smith s.n.* (PENN). Erie Co.: *Fish hatchery outlet, 1 mi e of Union City, 26 Jun 1965, *W.E. Buker s.n.* (CM). Huntingdon Co.: Juniata River, Aug 1864, *T.C. Porter s.n.* (GH). [Lancaster Co.]: In Conestoga [Creek], near Lancaster, 19 Jun 1861, *T.C. Porter 14993* (PENN, VT), 22 May 1861, *T.C. Porter s.n.* (GH, PH). [Mercer Co.]: Sharon, 7 Jul 1886, *F.T. Aschman s.n.* (NY). [Northampton Co.]: In the Lehigh River, Easton, 11 Jul 1868, *T.C. Porter s.n.* (US). [Philadelphia Co.]: Lemon Hill, Fairmont Park, 25 May 1861, *W.W. Wister s.n.* (PH); Schuylkill River, ca. 1865, *E. Diffenbaugh s.n.* (PH). SOUTH DAKOTA: Clay Co.: Oxbow of Missouri River, Burbank Lake, 1 mi s of Burbank, 15 Jul 1965, *L.J. Harms 2721* (KANU). TENNESSEE: Anderson Co.: Slow water in river, 1 mi e and below Norris Dam, 20 Oct 1946, *H.H. Iltis 2470* (TENN). Cheatham Co.: *Edge of basin, fish ponds, Little Marrowbone Creek, 12 May 1953, *E. Quarterman 4645* (VDB). TEXAS: Burnet Co.: *Plants submerged in fish tanks at Inks Lake Fish Hatchery, Burnet, 19 Jun 1964, *J.R. Massey 627 & C. Lahser* (OKLA, SMU). Grayson Co.: Nov 1949, *M.D. Bryant 51-455* (TEX); rather common, rooted in mud in shallow water of Red River about 1½ mi below Denison Dam, 28 Oct 1967, *D.S. Correll & H.B. Correll 35325* (FSU, GH, NA, OKLA, SD, UC). Travis Co.: 15 Jun 1942, *B.C. Tharp s.n.* (NY, TEX, US); in rapid current of water about three ft deep, forming dense clumps in Colorado River about 5 mi below Austin, 1 Jun 1943, *F.A. Barkley 13310* (CAS, CU, DS, F, FSU,

GH, ILL, IND, NY, NYS, OKLA, PH, SMU, TEX, UC). UTAH: Weber Co.: Ogden Bay Refuge, 2 Aug 1937, *C.S. Williams 1241* (UTC). Specimen not seen. VERMONT: [Chittenden Co.]: Shallow water of cove, Charlotte, 7 Jul 1911, *E.C. Kent s.n.* (NEBC). VIRGINIA: [Fairfax Co.]: Alexandria, 9 Jun 1874, *J.W. Chickering Jr. s.n.* (US); gravelly run, in vicinis Washington, D.C., 26 Oct 1884, *L.F. Ward s.n.* (US). WASHINGTON: King Co.: In shallow water in mud, n of western approach to Evergreen Point Bridge at edge of Lake Washington, Seattle, 18 Jul 1965, *D. Sutherland & D. Simpson 1092* (CAS, COLO, DAO, NY, OSC, TEX, UC, WS, WTU). Kittitas Co.: Yakima River in Yakima River Canyon, ca. 2.5 mi s of Thrall, 19 Jun 1966, *R. & M. Spellenberg 1471* (NY, UC, WS, WTU). Pierce Co.: Fishing area at s end of Ohop Lake, n of Eatonville, 24 Jul 1965, *D. Sutherland & R. Spellenberg 1216* (CAS, COLO, DAO, NY, OSC, TEX, UC, WS, WTU); Steilacom Lake, Aug 1951, *T.H. Scheffer s.n.* (WS). Thurston Co.: In slow moving stream near the outlet of Long Lake, 5 mi e of Olympia, 14 Aug 1947, *F.G. & L.E. Meyer 2253* (F, GH, MO, NY, UC). Yakima Co.: In irrigation ditch at South Wapato Road and Yost Road 4 mi s of Wapato, 2 Sep 1965, *C.L. Hitchcock 24111* (CAS, COLO, F, NY, PENN, WTU). WEST VIRGINIA: Greenbrier Co.: *Pond, fish hatchery, White Sulfur Springs, 24 Jul 1930, *C.L. Berkley 1215* (MO). Wirt Co.: *In upper part of Palestine Bass Hatchery, 6 Jun 1951, *E.A. Bartholomew s.n.* (CM). WISCONSIN: Dane Co.: Lake Wingra, Madison, summer 1905, *A.B. Stout s.n.* (WIS); *Fish hatchery, e side of Fish Hatchery Road at end of Co. Hwy. PD., 3 mi s of Madison, Oct 1947, *T.V. Walker C1* (WIS): Lacrosse Co.: Shallow water of Lake Onalaska, 10 Jul 1956, *T.G. Hartley 1828,* (DAO, NY, SMU, US, WIS). Trempealeau Co.: Shallow water, sand bottom, Trempealeau, 24 Aug 1927, *N.C. Fassett & L.R. Wilson 4347* (MIN, WIS).

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PLANTS OF FRAZIER'S BOG, MONTGOMERY COUNTY, PENNSYLVANIA

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Since one of the purposes of the Philadelphia Botanical Club is the updating of check lists of plants in our local area, some of the members decided to make a botanical survey of Montgomery County's Edgehill Region, including Frazier's Bog. Our herbarium contains specimens of the 130 plants listed in Alexander McElwee's paper, "The Flora of the Edgehill Ridge near Willow Grove and Its Ecology" (1900 issue of the "Proceedings of the Academy of Natural Sciences.")

The oldest specimens in the herbarium from this locality are those collected by club member McElwee in 1893. Others who botanized the area from that time until the 1930's were C.F. Saunders, Witmer Stone, S.S. Van Pelt, Bayard Long, John M. Fogg, Jr. and several of his students.

Philadelphia Botanical Club members planned a field trip for June 25, 1977 and visited the sections of the Edgehill Ridge (a belt of quartzite, sandstone and conglomerate rock) which have been part of the Huntingdon Valley Country Club property since about 1925. Several small streams start at the south side of the ridge and are responsible for the area known as Frazier's Bog. Here was (is?) one of the isolated colonies of coastal plain plants found in a Piedmont region. Witmer Stone, in his, "Plants of New Jersey," mentions it as "probably one of the most remarkable spots of this sort." Alexander McElwee describes it as a bog, "in the center of a three acre field where rills from the base of the hill center," and notes that while, "some of the plants are frequently met with in bogs throughout the state, almost all are common to the pine barrens of lower New Jersey."

On our walk down through the wooded ridge we found the trees of Mr. McElwee's list: *Quercus (alba, palustris, prinus, rubra, velutina), Fagus grandifolia, Fraxinus americana, Liriodendron tulipifera, Cornus florida* and *Sassafras albidum*. We located *Chimaphila maculata, Monotropa uniflora* and *Mitchella repens* but failed to discover *Adiantum pedatum, Cypripedium acaule, Pyrola elliptica, Lyonia mariana,* and many of the herbs known to have grown there in the past.

The bog, now in an open woodland, consists of several sphagnous areas along small streams. Mr. McElwee lists 36 species for the bog and swamp; Mr. Stone mentions 18 additional ones. Red maples and black willows provide the shade. While larger trees of *Magnolia virginiana* may be found along a road in the neighborhood, the specimens thriving now in the historic site are young. Species we were unable to locate include *Eleocharis tuberculosa, Eriophorum virginicum, Scleria muhlenbergii, Xyris torta, Aletris farinosa, Pogonia ophioglossoides,* *Calopogon pulchellus, Drosera rotundifolia, Asclepias rubra, Bartonia virginica,* and *Gentiana saponaria.* Our "finds," not on previous lists, were *Osmunda claytoniana, Thelypteris palustris, Dryopteris cristata, Equisetum arvense, Ranunculus ficaria, Cardamine impatiens, Callitriche stagnalis, Acer negundo, Ilex verticillata, Asclepias incarnata, Myosotis laxa* and *Hydrophyllum virginicum.* Special mention should be made of two young specimens of *Ilex opaca* growing near a sphagnous area, the species not having been cited from there previously. *Bartonia paniculata,* rare in Pennsylvania, had not been collected in Montgomery county between 1945 and 1977. Several small colonies of *Woodwardia areolata* were also discovered and the specimen added to the herbarium is the first for Montgomery County.

Frazier's Bog has now been visited by various members of the Botanical Club in April, June and August of 1977 and in July and October of 1978. To complete a thorough survey, a larger area should be explored, especially in the early spring and fall. It is believed that some species have disappeared because of over-zealous gardeners and the effects of nearby habitation on the streams as well as on natural succession. Although the historic collecting site borders on the country club fairway, it is thus far surviving in the wild state.

NOMENCLATURAL HISTORY OF *QUERCUS MUEHLENBERGII*

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The taxon *Quercus Muehlenbergii* Engelmann commemorates Gotthilf Heinrich Ernst Muhlenberg (1753-1815) (Fig. 1) who was the pastor of the Trinity Lutheran Church in Lancaster, Pennsylvania. In spite of his isolation in this small colonial town, he achieved international fame for his contributions to systematic botany.

On the limestone slopes along the Conestoga River near Lancaster, Muhlenberg discovered a new oak which he named *Quercus castanea* because of the similarity of its leaves to those of the genus *Castanea*. This large forest tree, which is known colloquially as the yellow oak or Chinquapin oak, has an extensive range in the eastern half of the United States, except for the Atlantic Coastal Plain and most of the immediate Gulf Coast (Little, 1971). It reaches its fullest development in the Mississippi and Ohio River valleys. In eastern Pennsylvania it is a rare tree found only on limestone slopes (Illick, 1915).

Muhlenberg (1799) published his *Supplementum Indicis Florae Lancastriensis* in the Transactions of the American Philosophical Society. This list included *Quercus castanea N.S.*, a nomen nudum, since no descriptive information was given. Many of Muhlenberg's names were originally published as nomina nuda (Merrill and Hu, 1949). Muhlenberg carried on an active correspondence and exchange of specimens with the famous German botanist Karl Ludwig Willdenow. Specimens of this new American oak were sent to Willdenow, who prepared a Latin description. Willdenow (1801, April) published a formal description of *Quercus castanea* in the German literature, thus validating Muhlenberg's previous nomen nudum.

The type specimen of *Quercus castanea* Muhlenberg ex Willdenow is preserved in the Willdenow Herbarium (Number 17620) at the Botanischer Garten und Botanisches Museum in Berlin-Dahlem (Butzin, pers. comm.). The Willdenow Herbarium was moved to an abandoned mine in Thuringia during the early part of the Second World War and thus saved from destruction when the herbarium building at Dahlem was bombed on the night of March 1-2, 1943 (Merrill and Hu). A presumed duplicate specimen (Fig. 2) is preserved in the Muhlenberg Herbarium at the Academy of Natural Sciences of Philadelphia.

André Michaux (1801) also published a formal description of this oak. However, he interpreted this taxon as a variety of *Quercus prinus* L. and published the name *Quercus prinus acuminata* in his Histoire des Chênes de l'Amerique.

Three-quarters of a century later, George Engelmann (1876, 1877), a practicing physician in St. Louis, Missouri, took a critical look at the nomenclature of this oak. Engelmann discovered that Muhlenberg's name (*Quercus castanea*) and Michaux's name (*Quercus prinus acuminata*) were both preoccupied. He therefore applied the

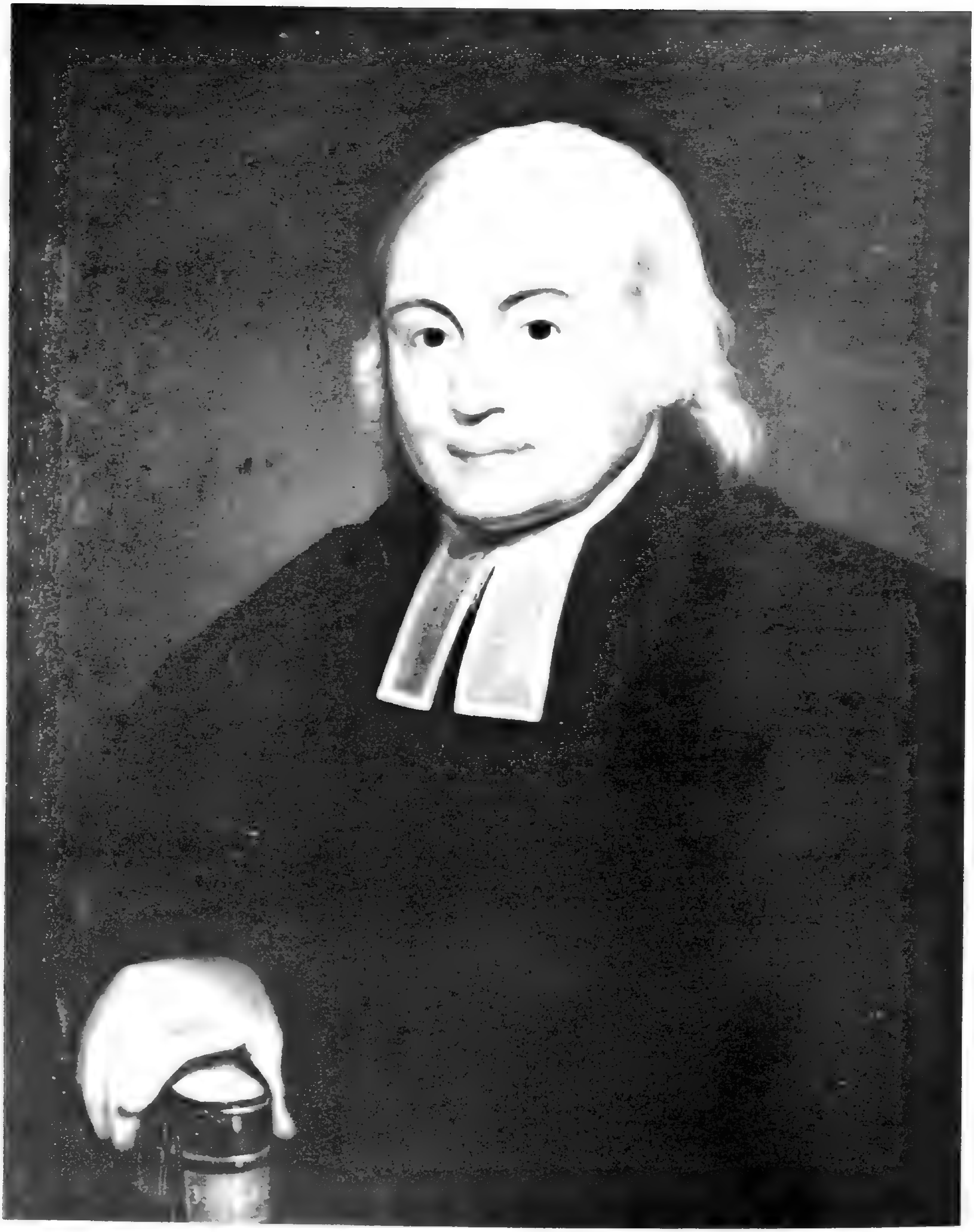

Fig. 1. Portrait of Gotthilf Heinrich Ernst Muhlenberg by Jacob Eichholtz (1811) (Photograph courtesy of North Museum, Franklin and Marshall College, Lancaster, Pennsylvania).

Fig. 2. The specimen on the right (Number 468) is a presumed duplicate of the type of *Quercus castanea* Muhlenberg ex Willdenow which is preserved in the Muhlenberg Herbarium at the Academy of Natural Sciences of Philadelphia (Photograph courtesy of the Academy).

name *Quercus Muehlenbergii* to this taxon. However, Engelmann did not indicate where and when these names had been previously applied to other oaks.

By coincidence, the Spanish botanist Luis Née (1801, March) published a description of a new Mexican oak, *Quercus castanea*, in the Spanish literature one month before the description of the North American oak by Willdenow (1801, April) appeared in the German literature. A member of the Malaspina Expedition, Luis Née, a naturalized Spaniard of French birth, spent 5 years traveling and collecting botanical specimens in western South America, Mexico, the southern Pacific islands, and the Phillipines. Between April and December 1791, he made an extensive collection of Mexican oaks. Muller and McVaugh (1972) reported that Née's descriptions of the Mexican oaks were "extraordinarily good, for his time." His specimens, including the type of *Quercus castanea* Nee, are preserved in the Herbarium of the Instituto Botanico A.J. Cavanilles in Madrid.

Engelmann could not elevate Michaux's variety name *acuminata* to specific rank because it had already been applied to an Indian oak. William Roxburgh (1814) originally published *Quercus acuminata* as a nomen nudum. This name was later validated in his posthumous *Flora indica* (Roxburgh, 1832). Charles Sprague Sargent (1895) argued in favor of retaining Michaux's varietal name as the specific name for the North American oak. He therefore used the name *Quercus acuminata* Sargent in his famous *Silva of North America.* Sargent's interpretation is prohibited by modern rules of priority.

It is very appropriate that Muhlenberg's name should continue to be associated with this oak, which he had so well distinguished. Several fine specimens of *Quercus Muehlenbergii* Engelmann can still be found on the limestone slopes along the Conestoga River near Lancaster, Pennsylvania, where Muhlenberg first studied this oak almost 200 years ago.

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ADDITIONS TO THE CHECK-LIST OF THE FLORA OF MONTGOMERY COUNTY, II

ANN NEWBOLD
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Six new species of Montgomery County flora (see Dr. Edgar T. Wherry's *Check-List* Bartonia 41:71-84 and Ann Newbold's *Additions* Bartonia 45:15) bring the current county total of recorded taxa with herbarium specimens to 1837, of which 1233 are presumed to be indigenous and 604 introduced.

Arthraxon hispidus (Thunb.) Makino was collected this year at the Community Diversified Services Camp in Green Lane. It was found in a wet depression along the power line. This is a first specimen collected in Montgomery County and apparently the third for the state of Pennsylvania, though it has made inroads into New Jersey. An aggressive East Asian arrival, it is a weedy grass of damp roadsides and ditches, rapidly naturalizing and advancing from south to north. The specimen from Berks County in the local herbarium of the Academy of Natural Sciences is *Arthraxon hispidus* (Thunb.) Makino var. *cryptatherus* (Hack.) Houda; from Montgomery, it is *A. hispidus* var. *hispidus.*

One genus which grew wild and in great profusion from the inception of the author's wild flora preserve in Congo, Douglass Township was *Muscari.* Not until this past year was it noticed that *M. racemosum* (L.) Mill was growing side by side with *M. botryoides* on a steep wet bank intermixed with quantities of *Sanguinaria canadensis.* Some of the *Muscari* bloomed two weeks after the first of the blooms had waned. The later blossoming plants were discovered to be *M. racemosum* — with linear, subterete, attenuate, nodding leaves and perianth obovoid and elongated. It would be interesting to check other naturalized populations of *Muscari* in the County to determine if some of the other supposed *M. botryoides* would turn out to be *M. racemosum.*

Galium concinnum T. & G. located recently at Sunrise Mill Park in Zieglerville has been represented in the Herbarium since 1925, but had not been listed in Dr. Wherry's *Check-List of the Flora of Montgomery County.*

On the Philadelphia Botanical Club field trip at Frazier's Bog in June, 1977, *Woodwardia areolata* (L.) Moore was one of the exciting finds. Grace Tees of the Herbarium Committee uncovered the fact that it had never before been collected from Montgomery County and was therefore not in the Check-List.

In Salford Township, on the east side of Route 563, about 3 kilometers north of its junction with Route 63, a small stand of *Eupatorium altissimum* was discovered. This plant has been recorded in the counties to the north and to the west of Montgomery County, but not heretofore in Montgomery.

Jussiaea uruguayensis Camb. was found on the PBC field trip of August, 1978, at Montclare, Pennsylvania, in the canal locks 1 kilometer west of Route 29. Fernald lists this plant as *Jussiaea michauxiana* Fern. though others apparently do not recognize this as a species separate from *J. uruguayensis*. None of the specimens in the Local Herbarium with these names had been collected in Montgomery County.

DISTRIBUTION AND ECOLOGY OF *SIDA HERMAPHRODITA*: A RARE PLANT SPECIES

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National Park Service

Several years ago I developed an objective and scientifically based method or set of criteria for determining or identifying significant natural phenomena at any given site (Thomas, 1968, 1969, 1970). In essence, uncommoness or rarity on a world scale is the criterion. A species may be rare generally or rare in certain situations under natural conditions. In making a survey of the National Capital Region of the National Park Service to test out the method, several plant and animal species, as well as geologic and soil features, were identified. *Sida hermaphrodita* (L.) Rusby (Virginia Mallow) was one such plant species identified.

At that time, this species occurred on a natural substrate on Park Service land in only two places: Plummers Island (Montgomery County, Maryland) and Theodore Roosevelt Island (District of Columbia). Both islands are on the Potomac River. Since then the species has disappeared from Plummers Island and greatly declined on Theodore Roosevelt Island.

The purpose of this report is to (a) show how *S. hermaphrodita* was determined to be rare, (b) its present status as determined by field trips, and (c) some ecological factors that have been gleaned from such field trips.

Determination of Rarity

The assessment of rarity of a species over its distribution range is often a somewhat subjective or at least qualitative conclusion drawn by taxonomists and taxonomic geographers based on the number of specimens examined. Such assessments are often made by authors of state or other local floras and seldom made by authors of regional floras. An exception to this generality is the assessment by Fernald (1950) that *Sida hermaphrodita* (L.) Rusby is rare.

The assessments of authors of local floras involving and around the parks verify the assessment of Fernald in the regional flora. The local literature for Maryland (Shreve et al., 1910) and Virginia (Massey, 1961), which include or are adjacent to the parks, do not show this species as a part of the flora for these states, although Massey cites Fernald (1950) to show that Virginia occurs within the range of the species. The flora for the District of Columbia and vicinity lists this species as occurring along a 10.8 mile (17.4 kilometers) stretch of the Potomac River, but makes no mention of abundance (Hitchcock and Standley, 1919). After an examination was made of the herbarium sheets at the National Herbarium upon which their flora was based, it was realized from personal knowledge of the area that almost all the

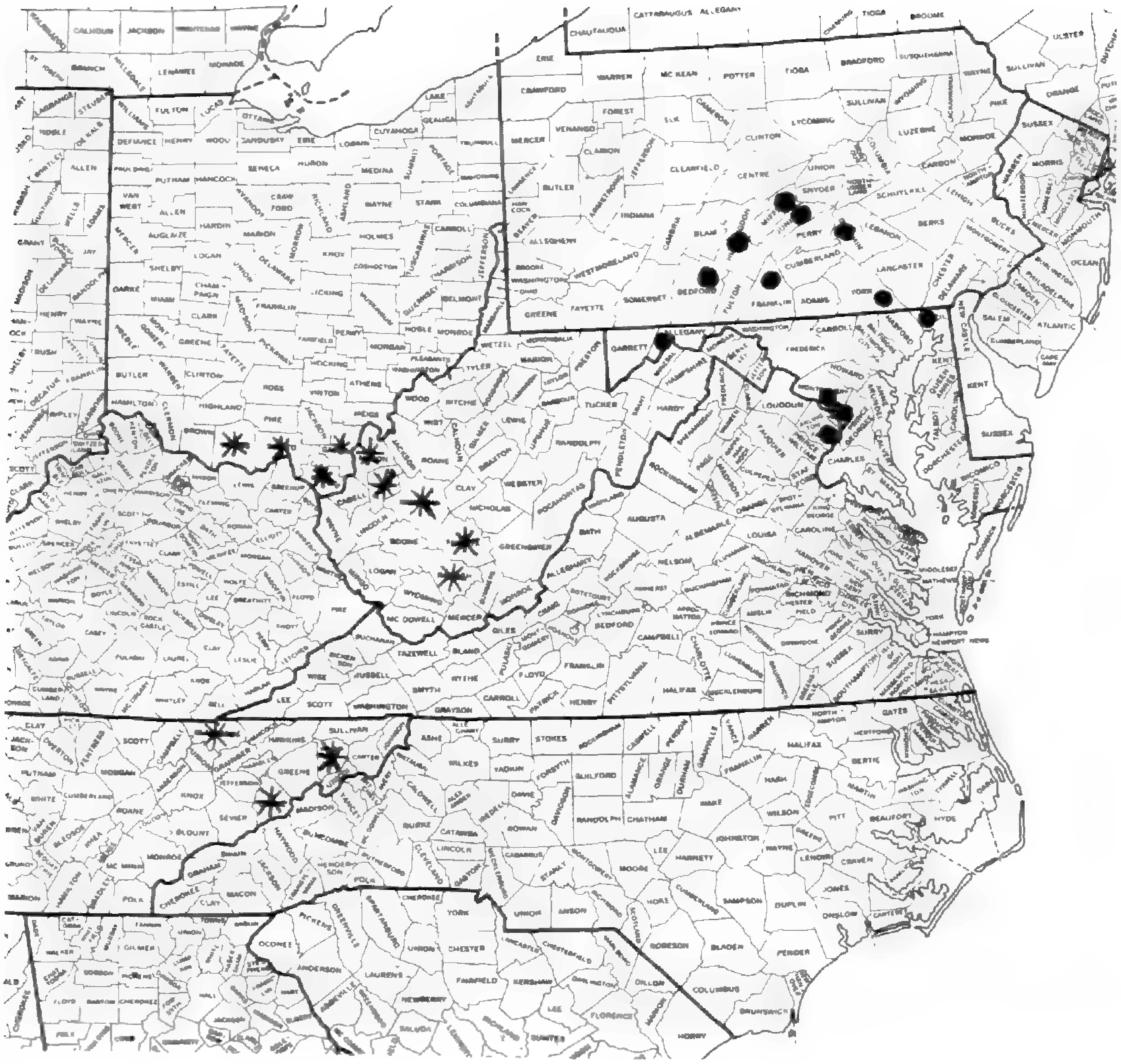

Fig. 1. Distribution of *Sida hermaphrodita*. Asterisks are in Mississippi River watershed and solid circles are in Atlantic Ocean watershed.

sites from which these specimens came, have now been destroyed.

Some additional local floras for the Carolinas (Radford et al., 1965) and southern New Jersey (Stone, 1911) do not show the species at all, while other local floras for the Delmarva peninsula (Tatnall, 1946), West Virginia (Strausbaugh and Core, 1958), and western Pennsylvania and the upper Ohio Basin (Jennings, 1953) state that this is a rare species. Thus, for hundreds of square miles around the park sites, this species is rare. These local floras covered both Atlantic and Mississippi watersheds and constitute a sample of about 95% of the range of the species as shown in Figure 1.

Herbarium specimens from the main herbarium of the Smithsonian Institution (National Herbarium) together with the above mentioned literature, were used to construct a distribution map (Thomas, 1970). The more complete distribution map (Fig. 1) presented here was constructed using citations given by Iltis (1963) as well as additional material from the above local floras, National Herbarium (main collection and District of Columbia collection), from the Academy of Natural Sciences of Philadelphia, and field trips. Specimens and locations which are thought to be adventive (some mentioned by Iltis) are not shown on the map. Likewise, those areas which no longer have the species, as determined by field work, are not shown.

By using a polar planimeter the total distributional range is estimated to be about 128,000 square kilometers (about 114,000 square miles) of which about 36% is in the Atlantic watershed. These very rough estimates are probably maximum and need to be revised as more is known about the distribution.

Status of the Species in the Atlantic Watershed

The data indicated that in the Atlantic watershed, the species only occurred in the Potomac River and Susquehanna River drainages. At the time of the aforementioned distribution map (Thomas, 1970) it was thought that the whole Potomac distribution was on Park Service land and the whole Susquehanna distribution was near the mouth in Pennsylvania and Maryland.

With the loss of the Plummers Island population and a decline in the Theodore Roosevelt Island population (both probably influenced by hurricane Agnes in June, 1972), and the fact that the National Museum records for the Susquehanna basin were 1901 or older, there was some concern that perhaps T.R. Island might have the only population growing on a natural surface this side of the Appalachian Mountains. (There were a few plants growing on artificial fill at Rock Run in Montgomery County, Maryland.) Many colleges and herbaria in Pennsylvania and Maryland were contacted as well as the herbarium at the National Arboretum, to determine whether there were other locations. In this regard, Dr. A.E. Schuyler of the Academy of Natural Sciences at Philadelphia has been most helpful. Collections had been made at other locations in both the Potomac and Susquehanna basins.

Field trips were planned and made to determine whether the species still existed at former collection localities and to obtain elementary ecological data that might eventually prove helpful in saving the species from extinction in the park.

On October 19 and 20, 1977, a field trip was made to the lower Susquehanna River to examine sites in Cecil County, Maryland and York and Lancaster Counties, Pennsylvania. Besides my two employees, Cindy Larson and Judy Barger, I received assistance from several volunteers: Ann Newbold, Elizabeth Keller, and Hans Wilkens from the Philadelphia Botanical Club and Dr. James C. Parks of Millersville State College, Pennsylvania. This trip was financed by a grant from The Washington Biologists' Field Club whose center of activity is Plummers Island, Maryland.

Six sites were examined, but *S. hermaphrodita* occurs now at only two: Cecil County, Maryland, 0.15 kilometer (0.1 mile) south of the Pennsylvania boundary along the river and York Furnace, York County, Pennsylvania. This is a 67% decrease in the number of sites in the lower Susquehanna since the beginning of recorded observations in 1861. One of the locations, Lockport in York County, Pennsylvania, could not be found on any map, so that site was not searched. It appears that the species is no longer found in Lancaster County, Pennsylvania.

On October 26, 1978, my assistant, Michelle Powers, and I, reexamined the York

Furnace site. We found only two stems and the whole area heavily overgrown with *Phalaris arundinacea* L., *Humulus japonicus* Sieb. & Zucc., and *Polygonum perfoliatum* L.; the latter two species are exotics from Asia. In 1977 there were 45 stems.

Subsequent to this 1977 field trip, several trips were made along the Potomac River on November 18, 19, 21, December 1, 7, 1977, either alone or usually with one or both my assistants. Nine sites were examined at this time (four others had been seen at various other times previously). In July of 1978 Cindy Larson discovered another site located on artificial fill at Dyke Marsh, Fairfax County, Virginia. Along the trunk stream of the Potomac River, *S. hermaphrodita* is found in five out of fourteen sites: Luke and Westernport (both in Allegany County, Maryland), Rock Run near the Potomac (Montgomery County, Maryland), Theodore Roosevelt Island, District of Columbia, and Dyke Marsh (Fairfax County, Virginia). This is a 64% decrease in the number of sites along the Potomac trunk since the beginning of recorded observations in 1886. This is a comparable decrease with the lower Susquehanna River. Most of these sites, in fact, all but two or three of the fourteen sites, are now located on National Park Service property.

In the course of searching for location records, specimens from the Delaware River (Schuylkill River) basin were discovered. From the Academy of Natural Sciences of Philadelphia, two records: Philadelphia Co., Woodlands, Philadelphia, herb. Thomas C. Porter; west of the Schuylkill below Ph^{a} *rare,* Durand (both apparently 18th century). From Iltis (1963), two records: Delaware Co., banks of Schuylkill below Philadelphia, 1863, E. Durand; and Schuylkill Co., Wild Cat Falls, Aug 1891, Eby. A fifth record comes from Dr. Bates of Cornell University: Berks Co., Oley Furnace, Oley Town, Jul 27, 1969.

The Schuylkill River is not at all in Delaware County. Woodlands is an estate, now a cemetery, which had extensive gardens where rare and new American plants were brought and planted (Harshberger, 1899). On October 18, 1978, my assistant, Michelle Powers, and I examined all possible sites on the west bank of the Schuylkill River from the confluence with the Delaware River to and including Woodlands Cemetery (and also Bartram Gardens Park). The species was not found. The Woodlands specimen of record was in all probability planted and the other two records may well have come from the same vicinity. The evidence at hand strongly suggests that *Sida hermaphrodita* is not native to the Philadelphia area.

Moving up the Schuylkill River we come to the Oley Furnace site and record. Dr. Bates apparently collected a cultivated specimen in 1969 from this location. Hans Wilkens who is well acquainted with the botany of the area said (personal communication) that the only plants of this species that he knew of in the area were those he had planted.

This leaves only one record to be accounted for in the Schuylkill River watershed, that of Iltis (1963) at Wild Cat Falls in Schuylkill County. Iltis says (1963) regarding this record, that Clement (1957) confused Wild Cat, Pennsylvania with Wild Cat, West Virginia and erroneously cited this record for West Virginia. The collection date given by Iltis is Aug 1891, that by Clement is Aug 1890. The only Wild Cat geographic name in Schuylkill County is Wild Cat Mountain. Both Dr. Maurice Broun and William Hart, old time residents of the area, when asked where Wild Cat Falls was located, said it would have to be on Cold Run, north of Hecla but there was no falls known by that name (personal communication). Mr. Hart also said that Wild Cat, Pennsylvania might be around the old Wild Cat Hotel, which is now boarded up on Wild Cat Mountain (Reynolds, Pennsylvania). On October 27, 1978 my assistant, M. Powers, and I along with three members of the Philadelphia Botanical Club, Ann Newbold, Elizabeth Keller, and Hans Wilkens, searched the Cold Run area as well as around the Wild Cat Hotel and Stump Run, which runs past the hotel. We went almost to the Little Schuylkill River in our search along Stump Run. The species was not found in any of these areas.

On Frank A. Gray's new map of Pennsylvania, 1883, there is a W.C. Falls in York County. The U.S.G.S. Quadrangle, Columbia West, Pennsylvania, 1964, shows a Wild Cat Run in the same location. Hans Wilkens says (pers. comm.) that this latter area is more in line with where Mrs. Eby did her work. The evidence indicates no collections were made of *Sida hermaphrodita* in Schuylkill County, Pennsylvania.

The conclusion of these investigations in the Schuylkill River basin is that *Sida hermaphrodita* is not native to this watershed.

There are four more anomalous records to be explained: two from the University of Pennsylvania collections and one each from the National Herbarium and Academy of Natural Sciences of Philadelphia. The Academy has a record from Long Island from the Wm. Wynne Wister Herbarium presented by estate in 1899 (herbarium no. 506181) and the University has a collection by Arthur Stanley Pease, 10 Oct 1906, from waste ground, Fens, Boston, Mass. (collection no. 9973). Fernald says (1950) that *S. hermaphrodita* is cultivated and adventive north to Massachusetts from Pennsylvania. The National Herbarium has a collection by Hall with no date that simply states Illinois as the collection site (herbarium no. 1381898, collector's no. 566). This site is west of the limits given by both Fernald (1950) and Gleason (1952) and quite out of line with Iltis revised distribution which goes no further west than Ohio (1963). The fourth anomaly is a University of Pennsylvania specimen from the Herbarium of Isaac Burk. It has no date; the label says "Plants of New Jersey, Atlantic Co., Atlantic City Meadow." Stone (1911) does not list this species for southern New Jersey. I contacted the Brigantine National Wildlife Refuge which is on the north side of Atlantic City. After checking their records and consulting with Gilbert Cavileer, an amateur botanist with intimate knowledge of the area, John Gallegos of the refuge reported to me November 9, 1978 that there was no record of *Sida hermaphrodita* in or around the refuge. These four collections are probably all from either cultivated material or escapes, which leaves *S. hermaphrodita* essentially as centered in the Appalachian Mountains and migrating or drifting out of them on both sides along some of the rivers.

The Office of Endangered Species, Fish and Wildlife Service, U.S. Department of the Interior, has informed me (personal communication) that although *Sida her-*

TABLE 1. Summary of soil tests.

Site	Soil Texture	pH	Organic Matter	Soluble Salts
Luke	Sandy loam	6.0-7.7	4.3-4.6% +	520-1150 ppm
Westernport	Sandy loam	6.1-6.5	4.6% +	1150-2200 ppm
York Furnace	Sandy loam to loamy sand	7.0-7.1	0.8-2.0%	180-250 ppm
Rock Run	Loamy sand	6.55	1.3%	< 100 ppm

maphrodita has significantly declined in the Potomac River area, sufficient field checking has not been done in other areas of its range to determine its status. Since a plant species cannot be listed as endangered or threatened in only a part of its range, *S. hermaphrodita* cannot be listed at present.

ECOLOGY OF THE SPECIES

Gleason says (1952) *S. hermaphrodita* grows in moist alluvial soil, and Fernald reports (1950) it in glades and riverbanks. A glade is a clearing in the woods. Both references appear to be at least partly right, although Fernald appears to be more complete.

Eight populations of *Sida hermaphrodita* have been observed: *Potomac Watershed:* Luke, Westernport, Rock Run, and Plummers Island (now extirpated), in Maryland; Theodore Roosevelt Island, District of Columbia; Dyke Marsh, Virginia; *Susquehanna Watershed:* York Furnace, Pennsylvania; Cecil County, Maryland near Pennsylvania state boundary.

Only two of these populations, Dyke Marsh and York Furnace are on moist alluvial soils. Both are on definite flood plains that probably receive some inundation almost annually. The Luke and Westernport populations, however, are on talus, colluvial deposits. The Luke population, which had the largest areal extent of any population observed, was in a ravine. All populations except these two were closely associated with a stream of water, but the association at Rock Run appears rather obscure. At this location Rock Run has been channelized and the population, which is on artificial fill is about eight meters up from the stream.

The one aspect of the substrate which is common to seven populations (Plummers Island site not checked) is that it is loose. With the exception of York Furnace and Rock Run which are very sandy, all other sites checked had very rocky soil. This would allow good aeration and there is some evidence, that the decline on Theodore Roosevelt Island may be due to soil compaction. There are three trails that pass by and through the area.

Soil samples were taken and sent out for analysis for four populations: Luke (Dec 7, 1977), Westernport (Dec 7, 1977), York Furnace (Oct 26, 1978), and Rock Run (Nov 8, 1978). Table 1 summarizes the results. All soils are sandy with fairly low, but variable organic matter. The soluble salt range is considerable and in soil close to neutral or slightly acidic such salts are generally available to the plants. This may

TABLE 2. Summary of vegetation at six *Sida hermaphrodita* sites

Site	Partial Shade From	Dominants in herb and ground layer
Luke	*Robinia psuedoacacia* L.	*Glechoma hederacea* L. *Solidago* spp. *Alliaria officinalis* Andrz.
Westernport	*Robinia pseudoacacia* L. *Rhus typhina* L.	
Rock Run	*Robinia pseudoacacia* L. *Carpinus caroliniana* Walt.	*Lonicera japonica* Thunb.
T. R. Island	*Liriodendron tulipifera* L. *Fraxinus* spp. *Ulmus americana* L. *Populus grandidentata* Michx.	*Lonicera japonica* Thunb. *Eupatorium rugosum* Houtt.
York Furnace (1977)	*Robinia pseudoacacia* L. *Rhus typhina* L.	*Phalaris arundinacea* L.
Cecil County	*Rhus typhina* L. *Prunus serotina* Ehrh.	*Lonicera japonica* Thunb. *Eupatorium rugosum* Houtt.

be a factor in their survival as well as their rarity if they can tolerate high nutrient concentrations when many other species cannot. This would reduce their competition. As mentioned above, the York Furnace population is being overgrown.

Perhaps the recent spring flood on the Susquehanna (1978) together with a more favorable soil environment (Table 1) are the factors which have allowed *Phalaris arundinacea, Humulus japonicus,* and *Polygonum perfoliatum* to expand rapidly in one season.

In seven sites (Plummers Island not examined) *S. hermaphrodita* is in an open situation. All seven are in partial or semi-shade and in additional two sites, Luke and Cecil County have plants growing in the open without shade. The Cecil County site in the open is obviously dominated by *Lonicera japonica* Thunb. Table 2 summarizes the vegetation in six of the partially shaded habitats. Note the pioneer nature of the vegetation.

This species is associated with disturbed habitats, but apparently does not compete well under the usual conditions since disturbed habitats are very common.

The tallest plant seen in the wild was 4 meters (13 feet) at York Furnace in 1977. The Luke population was the most extensive being 49 M (160 ft) long and 12 to 14 M (40 to 45 ft) wide as determined by pacing. Six plants, two each from base, middle, and highest elevation, measured between 1.45 M and 2.37 M in height with an average of 1.83 M. Although a two plant sample can hardly be definitive, they may give some indications. The average of the two plants at each topographic level were 2.3 M at the highest elevation, 1.6 M at the middle elevation, 1.6 M at the base. The tallest plants are associated with the shadiest area and associated with the lowest pH of 6.0 and highest soluble salts. Table 3 summarizes the data. Under these conditions the plants at the top of the slope get little phosphorus, calcium, and magnesium. Plants in the middle slope get little iron, manganese, boron, zinc, and

TABLE 3. Environmental factors for Luke, MD, population.

Topographic Position	Average Plant Height	Phosphate P_2O_5	Potash K_2O	pH	Soluable Salts PPM
High	2.3 M	129	337	6.0	1150
Middle	1.6 M	20	143	7.7	520
Low	1.6 M	78	450+	7.2	780

copper (See Truog, 1953, for nutrient availability at various soil reactions (pH)). The pH may vary in the course of a year. These soils were sampled in the dormant season.

SUMMARY AND CONCLUSIONS

Sida hermaphrodita is a rare species centered in the Appalachian Mountains and extending outward from this center into both the Mississippi watershed and the Atlantic watershed.

The natural distribution of this species on the eastern side of the Appalachian Mountains is confined to the Potomac and Susquehanna River watersheds. Within about the last 100 years, approximately two-thirds of the *S. hermaphrodita* populations have been extirpated in those parts of each watershed that have been examined. More work needs to be done to learn of its status in the rest of its range.

As thus far observed in the field *Sida hermaphrodita* occurs on loose, sandy soil, (often rocky) which contains a variable amount of organic matter. The soluble salts (cations) cover a considerable range from less than 100 p.p.m. to 2200 p.p.m. which may be a factor in their survival. All populations observed were associated with successionally pioneer vegetation in a habitat that allowed plenty of sunlight. All populations were partially shaded, but some parts of some populations were in the open without shade.

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LOST SPECIMENS, NEW CLUES

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Late in October, 1838, a trunk of botanical specimens was loaded onto the steamboat which was to carry it from Fort Snelling, then the outpost of the upper Mississippi Valley, to St. Louis, the center of river commerce and the thriving "Gateway of the West." The party led by Joseph N. Nicollet, French cartographer and scientific observer, under the newly formed Corps of Topographical Engineers, was returning from the first of the two expeditions which were to map the triangle of land that lies between the Missouri and the Mississippi Rivers. The "young, active and indefatigable" German botanist, Charles A. Geyer, traveling at his own or at Nicollet's expense with the expedition, had dried and pressed his specimens so carefully that when they were put on the steamboat, "they still preserved . . . their freshness and their colors so as to be as pleasing to the eye as if they were seen on the prairie." Furthermore, the collection was "more complete than any yet made, bringing together . . . the plants of the northwest prairies in all the different stages of their growth from their beginning through their flowering up to the fall of their seeds."

The members of the expedition, including Nicollet's assistant, John Charles Fremont, of later fame as an explorer of the Rocky Mountains, had planned to board another steamboat at Prairie du Chien, a settlement farther downstream. Here, unfortunately, they were overtaken by the onslaught of winter. The thermometer fell to zero overnight. River navigation was closed, and the small band of explorers set out overland for St. Louis. They arrived on December 21, discouraged and exhausted, their baggage and instruments badly damaged. It was a sorry end to an expedition which for six months had been, "so full of success and activity."

Their disappointment was bitter indeed when they learned that the precious trunk was not awaiting them. Every effort, including an urgent appeal in the newspaper, was made to trace it but without success. Nicollet elected to stay in St. Louis while the rest of the party returned to Washington to make arrangements for the next summer's work. He would stay, he wrote to the Secretary of War, Joel R. Poinsett, until the trunk was found and, "if it were otherwise I would be inconsolable." He waited, lonely and impatient, all winter, but in the end was forced to tell John Torrey, who was to prepare the catalogue of plants collected by Geyer on the 1839 expedition, that somewhere, "between the rapids of the Des Moines and St. Louis," the irreplacable cargo had been lost. So disappeared the first collection of plants made along the St. Peter's River (now the Minnesota) and across the lake-dotted landscape of the rise of land between Minnesota and South Dakota known as the *Coteau des Prairies*.

Or so we thought — my husband and I — when we undertook to edit the journals of Joseph Nicollet. We found then, however, that specimens from the expedition of 1839 were preserved in the Herbarium of the Academy of Natural Sciences of Philadelphia. Imagine the wild surge of hope we felt when some years later we were told that an entry in the *Proceedings* of the Academy, under, "Donations to the Museum," listed at the meeting of March 11, 1845 read thus:

> A collection of plants made during a trip up the Mississippi and St. Peter's, and over the Lakes in 1838. From Mrs. Rachel Blanding.

This must be the lost trunk! And who in the world was Mrs. Rachel Blanding? There was no party other than Nicollet's in that country in 1838. There was no officer at Fort Snelling named Blanding nor any visitor to the fort by that name. We regretfully admitted — though it would have added immeasurably to the sensational appeal of the journals — that no Mrs. Blanding could have traveled in Indian guise with Nicollet or any member of his party. Perhaps as a passenger on the steamboat she could have stolen the trunk between the Des Moines and St. Louis. If so did she recognize the value of the specimens or did she expect fine clothes? This possibility we also dismissed.

With high hopes, therefore, we came to Philadelphia and under the helpful guidance of Dr. James Mears we followed every possible lead, as indeed we are still doing.

But each specimen bearing the name of Geyer and/or Nicollet, or attributed to either, turned out to have been collected in 1839. Finally, we found *Amorpha nana Nutt.* in the Herbarium's type collection. Its undated label was numbered 175 in a hand that resembled Geyer's. Eagerly we wrote to the Minnesota Historical Society to check this against the numbers which Geyer habitually inserted after plant names in his surviving 1838 journal — and waited. Alas, there was no *Amorpha nana,* and 175 was assigned to *Betula populifolia.* Other discoveries of the same sort have led to similar disappointment.

It remained to find out more about Mrs. Rachel Blanding. She was possibly, we thought, the wife of Dr. William Blanding who had been elected a corresponding member of the Academy on September 27, 1825. The Academy manuscript collections revealed a few entries under his name from which we gleaned that he had collected reptiles. Further research revealed him to have been born in Massachusetts, to have practiced in Camden, South Carolina, from 1807 to 1832, from which place he moved to Philadelphia in 1835. Transferring our search to Camden we found to our horror that his wife, Susan, had died in 1809, but were reassured when we learned further that he had moved to Philadelphia, "whence his Quaker wife had come." We persevered. Dr. Blanding, we found, had retired to Rehoboth, Massachusetts, in 1840 and had died there. Cemetery records reveal that his second wife, Rachel Willet Blanding, a Quaker, had died in Philadelphia in 1845 at the age of 56. So there we are. When the collection of specimens was presented to the Academy, Rachel was within six months of her death. Nothing connects either her or her husband with the plants collected on the prairies of Minnesota in 1838. No herbarium specimens have been found labelled as coming from the Rachel Blanding donation.

All ingenuity failed to find a fruitful course of investigation as to how the plants could have come to Philadelphia. The fact that Dr. Blanding was proposed as a member of the Academy by William S. Keating, who, in 1820, had accompanied Stephen H. Long on the first expedition into the country of the St. Peter's provides only the remotest grounds for speculation. Mrs. Blanding, active in the "benevolent institutions of the day" particularly the "African Colonization Society" seemed to leave no record of other associations. But imagination will not rest as it once did with the certainty that the trunk was lost. The entry remains undeniably real.

I wish this story had a proper ending. Perhaps, however, it will serve to bring a few suggestions as to the solution to the mystery. It will at least point up once more that the Herbarium of the Academy of Natural Sciences of Philadelphia, an ancient and honorable institution, is as full of unfinished stories as it is of botanical specimens.

TIMING OF SEED GERMINATION IN THE WEEDY SUMMER ANNUAL EUPHORBIA SUPINA

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Euphorbia supina Raf. (Euphorbiaceae) is a prostrate summer annual that branches from the base forming mats up to 1 m in diameter (Fernald, 1950; Steyermark, 1963). This native North American *Euphorbia* ranges from southern Ontario and Quebec to North Dakota south to Florida and Texas (Deam, 1940; Steyermark, 1963) and has been introduced into Oregon, California, Arizona, and Idaho (Reed, 1971). Plants of this species are commonly found growing in cultivated soils of gardens and fields, on roadsides and in waste places (Fernald, 1950; Steyermark, 1963), and Steyermark (1963) considers it to be one of the most common weeds in the eastern United States. Economically, the species is an important weed in cultivated soils where vegetable crops are grown (Slife et al., 1960).

Our observations indicate that the timing of germination of *E. supina* seeds is one of the adaptations allowing the species to behave as a weed in summer crops. In nature germination of seeds of *E. supina* does not begin until late spring, and seeds germinate sporadically throughout the summer. Both of these germination characteristics help to ensure the presence of *E. supina* plants in cultivated fields. Since germination of *E. supina* seeds is delayed until late spring, germination frequently does not begin until after the crops are planted. Even if all *E. supina* plants are eradicated from a field during summer cultivations, new plants from summer-germinating seeds soon become established. Thus, a key to understanding the weedy nature of *E. supina* is a knowledge of the timing of germination, which leads to the question: How is the timing of germination controlled in seeds of *E. supina*?

Methods

Mature seeds of *E. supina* were collected from plants growing in the University of Kentucky horticultural garden in Fayette County, Kentucky on 3 October 1975. On 12 October 1975, approximately 3,000 seeds were placed in each of 15 nylon bags, and each bag was buried to a depth of 7 cm in greenhouse potting soil in a 15-cm-diameter clay pot. The pots were placed in a nonheated greenhouse in which the windows were open all year and temperatures were near those out-of-doors. Mean daily maximum and minimum monthly temperatures calculated from thermograph records from October 1975 to April 1977 previously have been published (Baskin and Baskin, 1978). Watering regimes were given to simulate soil moisture conditions in the field throughout the year. From 1 September to 1 May the soil was watered to field capacity once each day, except when the soil was frozen during parts

TABLE 1. Germination percentages of freshly matured (12 Oct. 1975) seeds of *E. supina* and of seeds that were exhumed on various dates. An asterisk indicates the germination percentage obtained for seeds incubated at the simulated field temperature for that month.

Date beginning	14-h photoperiod				darkness			
of germ. test	15/6	20/10	30/15	35/20	15/6	20/10	30/15	35/20
12 Oct. 1975	0	0*	12	55	0	0*	0	1
1 Dec. 1975	0	0	84	91	0	0	60	27
5 Jan. 1976	0	0	90	84	0	1	18	11
2 Feb. 1976	0	0	86	91	0	0	8	54
1 March 1976	0*	1	99	99	0*	1	5	85
1 April 1976	0	5*	99	99	0	0*	10	89
1 May 1976	0	0	100*	99	0	0	52*	20
9 June 1976	0	4	93*	87	0	9	5*	12
1 Sept. 1976	0	10	98*	100	0	4	18*	97
3 Nov. 1976	0*	23	100	100	0*	3	98	98
15 Dec. 1976	0	44	96	98	0	0	90	84
1 Jan. 1977	0	54	100	100	0	18	85	69
1 March 1977	0*	29	96	92	0*	23	91	80
22 June 1977	0	2	100*	99	0	0	26*	84
3 Oct. 1977	0	3*	100	100	0	0*	0	40
1 June 1978	0	6	100*	100	0	8	21*	77

of the winter, and from May to September the soil was watered to field capacity once each week.

Germination tests were performed on freshly matured seeds and on seeds that had been buried for 1 to 31 months. The dates when seeds were exhumed are given in Table 1. Germination tests were done in temperature- and light-controlled incubators at a 14-h photoperiod or in continuous darkness at four (12/12 h) alternating temperature regimes (15/6, 20/10, 30/15, and 35/20°C); all temperatures were ±1°C. The alternating temperature regimes closely approximate the mean daily maximum and minimum monthly temperatures 2.5 cm below bare soil in north-central Kentucky in spring, summer, and autumn (Jerry Hill, Advisory Agricultural Meteorologist, unpubl. data): March, 15/6°C; April, 20/10°C; May and June, 30/15°C; July and August, 35/20°C; September, 30/15°C; October, 20/10°C; and November, 15/6°C. At each temperature regime, the photoperiod extended from 1 h before the beginning to 1 h after the ending of the high temperature period. The light source was 20-W cool-white fluorescent tubes, and light intensity at seed level was approximately 2.1 Klx.

Seeds were incubated in 5.5 cm Petri dishes on clean, white sand moistened with distilled water. For dark-incubated seeds three replications of 50-100 seeds each were placed at each temperature, and for light-incubated seeds three replications of 50 seeds each were used. All Petri dishes were wrapped with Saran wrap and those containing seeds to be incubated in darkness were wrapped with aluminum foil. All manipulations of dark-incubated seeds were carried out in total darkness; therefore, the seeds were never exposed to any light after they were buried until the germination tests were terminated. Seeds incubated in light were plated out in room light. Final germination percentages were determined after 15 days, and protrusion of the radicle was the criterion of germination. For each treatment, the germination percentage was based on the number of good seeds and was rounded off to the nearest whole number.

RESULTS

There was no germination at the 15/6°C temperature regime in either light or darkness for freshly matured seeds or for seeds exhumed on any of the 15 dates (Table 1). Similarly, at 20/10°C there was no germination of freshly matured seeds in light or darkness, and exhumed seeds germinated to 0 to 54% in light and to 0 to 23% in darkness. In the light at 30/15 and 35/20°C, freshly matured seeds germinated to 12 and 55%, respectively, while all exhumed seeds incubated at these temperatures germinated to 84 to 100%. In darkness at 30/15 and 35/20°C, there was essentially no germination of freshly matured seeds, and exhumed seeds germinated to 0 to 98%, depending upon the date when seeds were exhumed and the incubation temperature.

During the first 12 months of the study 80 to 90% of the exhumed seeds were viable. However, after the seeds had been buried for two winters viability decreased, and in the spring of 1977 only 40-50% of the exhumed seeds were alive. When seeds were exhumed on 1 June 1978 after three winters of burial, viability had decreased to about 20%; therefore, the study was terminated.

DISCUSSION

When seeds of *E. supina* mature in autumn, some of them can germinate in light at 30/15 and 35/20°C. However, germination does not occur in the field during autumn because habitat temperatures are below those required for germination (Table 1). Habitat temperatures remain below those required for germination through April, and seeds do not germinate. From May through September, habitat temperatures are high enough to stimulate germination, and germination percentages are high if light and soil moisture are not limiting. If seeds fail to germinate during summer, low temperatures of late autumn, winter, and spring prevent germination, and the seeds lie in or on the soil until the combination of temperature, light, and moisture again become favorable for germination during the next or some subsequent summer.

At the time of dispersal in autumn, seeds of *E. supina* were somewhat dormant. That is, they did not germinate in darkness at any temperature and germinated to only 55% in light at 35/20°C, the most optimal temperature at which they were tested. During burial some afterripening occurred, and exhumed seeds germinated to higher percentages in light and darkness at 30/15 and 35/20°C than freshly matured seeds. However, seeds of *E. supina* did not afterripen to the extent that they could germinate at 15/6°C the following spring. Furthermore, seeds germinated to only a low percentage at 20/10°C. In some species (*e.g.*, *Aster pilosus*

Willd.) whose seeds are dispersed in autumn, the seeds are capable of germinating to high percentages in autumn at 30/15 and 35/20°C but not at 15/6 or 20/10°C. As the seeds afterripen during the winter, they gain the ability to germinate at the lower thermoperiods. Consequently, germination can begin in the field in March when daily temperatures are around 15/6°C, although the seeds could not germinate at the same temperature regime the preceding autumn (Baskin and Baskin, 1979).

Since seeds of *E. supina* do not germinate at March (15/6°C) temperatures and germinate to only a low percentages at April (20/10°C) temperatures in spring, seedlings do not become established in the early spring when soil moisture conditions are favorable for good seedling growth. Therefore, seedling establishment in *E. supina* is delayed until May or later when there is a good chance of limited soil moisture due to the sporadic occurrence of summer rains. The establishment and growth of *E. supina* seedlings during the summer may be explained, in part, by the fact that the species has the C_4 pathway of carbon fixation (Welkie and Caldwell, 1970). Physiological characteristics of C_4 species (Black, 1971) which may be adaptations to a dry, hot habitat are low transpiration ratio, maximum rate of photosynthesis at high temperatures and high light intensities, and high net rate of photosynthesis. Thus, although seedlings of *E. supina* do not become established until late spring and/or summer, the plants can grow well under the prevailing habitat conditions in summer.

In some species of summer annuals, such as *Ambrosia artemisiifolia* L., seeds that fail to germinate in early spring enter secondary dormancy and must be restratified before they are capable of germinating again (Bazzaz, 1970; Willemsen, 1975). In contrast, the seeds of *E. supina* that do not germinate when temperture conditions first become favorable for germination do not enter dormancy and can germinate throughout the summer if light (for most of the seeds) and soil moisture are nonlimiting. Seeds of *Chenopodium album* L. and *Amaranthus retroflexus* L., two other summer annual weeds of arable land, also remain nondormant during summer. In the latter two species, as in *E. supina,* germination may occur throughout the summer but ceases in autumn because field temperatures drop below those required for germination (Baskin and Baskin, 1977).

At simulated summer temperatures in summer, there was some germination in darkness (Table 1). For example, at 30/15°C in May, June, and September 1976, seeds germinated to 52, 5, and 18%, respectively. Furthermore, some buried seeds that do not germinate the first summer after burial may do so during some subsequent summer. In darkness at 30/15°C in June 1977, 26% germination was obtained, while in June 1978, 21% germination was obtained. The ecological implication of germination in darkness is that there is a gradual depletion of buried seed reserves because seedlings from seeds that germinate in the soil may (depending on depth of burial) die before they reach the soil surface.

In this study there was some tendency for germination percentages in darkness at the two higher temperatures, and especially at 30/15°C, to be higher during winter than during summer, suggesting that when buried seeds are exposed to seasonal temperature cycles there also are seasonal changes in the optimum temperatures for germination. If the temperatures required for germination of buried seeds were out of phase with the prevailing habitat temperatures, the species would have a very effective means of preventing seed germination in darkness. Any mechanism that would prevent high germination percentages of buried seeds would be of survival value to the species because it would reduce the number of seeds that germinate too deeply in the soil for the seedlings to be able to emerge. However, the results obtained in this study on seasonal shifts in temperature requirements for germination in darkness are only suggestive, and more work needs to be done to clarify this point.

Data from a 50-year buried seed study initiated by Egley and Chandler in Mississippi in 1972 indicate that seeds of *E. supina* do not remain viable for long periods of time after burial in soil. At the time of burial, 83% of the seeds were viable, but after 6 months at 8, 23, and 38 cm only 22, 23 and 32%, respectively, were viable. After 18 months 4, 8, and 5% were viable and after 30 months 10, 9, and 4% were viable. In our study most of the seeds were viable after 1 year of burial, but viability declined thereafter. Thus, regardless of whether or not seeds germinate in the soil, the life expectancy of buried seeds seems to be relatively short, and if there are large seed reserves at a population site the supply must be replenished frequently.

SUMMARY

This study was undertaken to better understand why seeds of *Euphoriba supina* Raf. do not germinate until late spring and why they do germinate throughout the summer, attributes which contribute to the weedy behavior of the species. Seeds were buried in soil, exposed to natural seasonal temperature changes, and tested at intervals in light and darkness over a range of temperatures simulating those that occur in the field from late spring to late autumn. Seeds are nondormant at the time of dispersal in October, but they require light and high temperatures (30/15 and 35/20°C) for germination. Therefore, seeds can not germinate at this time because field temperatures (15-20 maximum and 5-10°C minimum) are below those required for germination. The temperature requirement for germination is not lowered during winter; thus, seeds can not germinate in early spring. Habitat temperatures are within the range of those required for germination from May through September, and since seeds do not enter secondary dormancy they can germinate well whenever soil moisture and light conditions are favorable. Some seeds can germinate in darkness in summer, and those that fail to germinate in darkness during one summer may do so during some subsequent summer. Thus, there is a depletion of the buried seed reserves. In addition, buried seeds do not remain viable for long periods of time. Consequently, if large seed reserves exist at a population site the supply must be replenished frequently.

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CHECK LIST OF THE AQUATIC VASCULAR PLANTS OF LAKE LACAWAC, PENNSYLVANIA

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Lake Lacawac is a small (about 20 hectares) glacial lake in southwestern Wayne County, Pennsylvania. It is about 1 kilometer north of the western end of Lake Wallenpaupack and is owned by the Nature Conservancy. There are thirty species of vascular plants in the lake which grow with all or at least their basal portions continuously inundated. However, some judgment was used in determining this restriction; other botanists might include more shoreline plants (e.g., *Juncus acuminatus*) and plants (e.g., *Menyanthes trifoliata*) in the boggy wetland adjacent to the west side of the lake. This check list was compiled during the summer and fall of 1970 and I am grateful to Clyde E. Goulden and L. Arthur Watres for courtesies extended to me while doing this work. Nomenclature follows Fassett (1957) for the most part; if a different name is used, the name from Fassett's book follows in parentheses. Voucher specimens are in the herbarium of The Academy of Natural Sciences of Philadelphia.

This list provides base-line data which, in the future, will aid in detecting whether or not vegetation changes have occurred. Two of the thirty species listed, *Eleocharis robbinsii* and *Nymphoides cordata,* are rare in Pennsylvania. Monitoring populations of these two species periodically may help prevent their extirpation from the state.

ANNOTATED LIST

Brasenia schreberi — scarce near SE side. *Dulichium arundinaceum* — SE and NE corners. *Elatine minima* — abundant on S and E sides. *Eleocharis obtusa* — scattered along E side. *Eleocharis palustris (smallii)* — abundant on S side. *Eleocharis robbinsii* — locally abundant on E side. *Eriocaulon septangulare* — common around lake. *Gratiola neglecta* — in pools in rocks along S shore. *Hypericum virginicum* — SE corner. *Isoëtes muricata (braunii)* — abundant in shallow water along S and E sides. *Juncus pelocarpus* — abundant on S and E sides; in shallow water and on shore. *Leersia oryzoides* — scattered along S side. *Ludwigia palustris* — scattered along S and E sides. *Lysimachia terrestris* — scattered along S side. *Nuphar luteum (variegatum)* — scattered along W side. *Nymphaea odorata* — scattered along E and W sides. *Nymphoides cordata* — scattered along W and SW sides. *Orontium aquaticum* — abundant around lake. *Peltandra virginica* — scattered along W side. *Pontederia cordata* — abundant around lake. *Potamogeton bicupulatus (capillaceus)* — scattered along S and E sides.

Potamogeton epihydrus — SE corner and N side. *Potentilla palustris* — scattered along S and W sides. *Sagittaria latifolia* — near dock and along E side; small vegetative underwater plants, probably of this species, are abundant near the dock and near the SE corner. *Scirpus pungens (americanus)* — scarce near outlet. *Scirpus tabernaemontanii (validus)* — scarce near outlet. *Sparganium americanum* — scarce W of dock. *Sparganium angustifolium* — abundant on E side. *Typha latifolia* — scattered along E side. *Vallisneria americana* — SE corner and N side.

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VEGETATION RECONNAISSANCE OF THREE WOODLAND STANDS ON BUCKINGHAM MOUNTAIN, BUCKS COUNTY, PENNSYLVANIA

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During the early 1960's, three stands on Buckingham Mountain, in Bucks County, southeastern Pennsylvania, were among those I surveyed to determine their composition and to compare them with the vegetation described in a general way by two local historians (Davis, 1876; Bean, 1884).

The mountain lies in the Piedmont Province (Lull, 1968) three miles east of Doylestown and rises to an elevation of 161 m (530 ft); some 70 m (200 ft) above the surrounding countryside (Fig. 1). It is linear, about .4 km long, .8 km wide at the southwestern end, and .4 km at the northeastern end. Its complex geology consists of limestones and dolomites, laminated siliceous limestone, and quartzite and quartz-schists of the Cambrian Conococheague Group, Elbrook Formation, and Hardystone Formation respectively (Gray, 1960).

All three stands were sampled on the broader southwestern end of the mountain (Fig. 1). Stand 1 occurs mostly on the Hardystone Fm. where the 14% northwest-facing slope is from 67-85 m above sea level. Underlying soil is the Towhee extremely stony silt loam (Tompkins, 1975). Stand two, on an 80% slope is at an elevation of 91-140 m uphill from stand one and is underlain by the Chester extremely stony loam and the Hardystone quartzite. Stand three is on the 80% southeast-facing slope at an elevation of 104-134 m. The Hardystone Fm. predominates here and the soils are the Chester extremely stony loam at the top and bottom of the stand with a band of Manor-Chester extremely stony loam through the stand's center.

The area has a yearly precipitation of 40-44 inches, and mean temperatures of 22°-24°F. minimum in January and 60°-64°F. maximum in July. The length of the freeze-free period is 150-180 days (Lull, 1968).

The vegetation is classified by Braun (1950) as being in the glaciated section of the Oak-Chestnut forest region, by Hawley and Hawes (1912) as in the sprout hardwoods section of "New England," and by Lull (1968) as part of the Oak-Yellow Poplar forest region.

METHODS

Three stands each not less than four hectares in area and displaying a homogeneous appearance were selected for this study. Forty, 30, and 20 sampling points were taken in stands 1, 2, and 3 respectively.

This study was made possible by a grant from the Faculty Research Committee of Temple University.

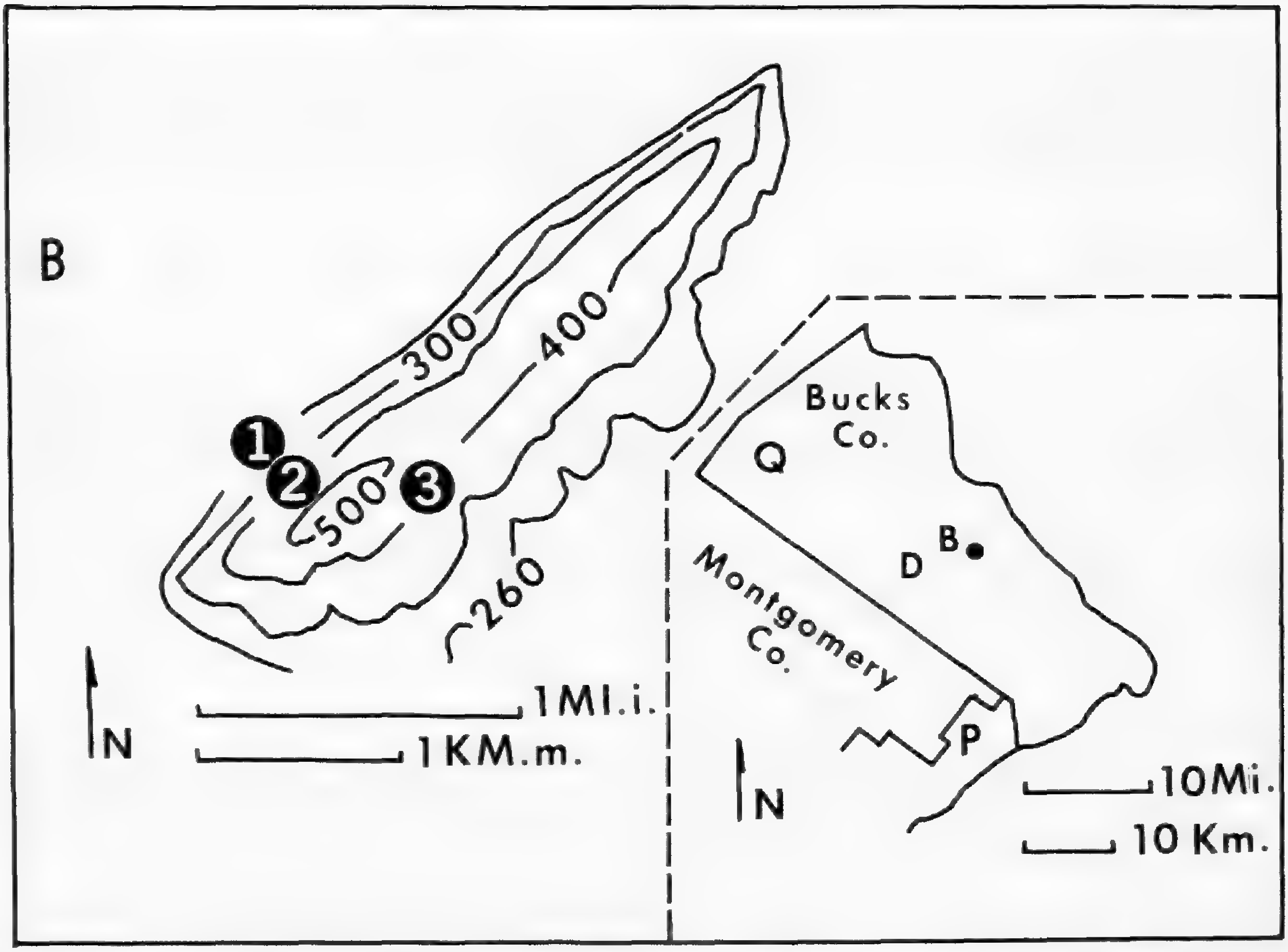

Fig. 1. Location of stands on Buckingham Mt. Metric equivalents are 260 ft = 79 m, 300 ft = 91 m, 400 ft = 122 m, 500 ft = 152 m. Inset map. — The solid circle is the location of the Mtn. B = Buckingham, D = Doylestown, P = Philadelphia, and Q = Quakertown.

At each sampling point, trees were measured using the variable radius method (Grosenbaugh, 1952) and importance values calculated on the basis of relative frequency and relative basal area. Using visual estimate and dbh tape, stems were tallied in 5 size classes. A circular 23.3m^2 plot centered on each sighting point was used to tally tree seedlings and saplings and to record the presence of shrubs, vines, and herbs. Trees were considered to be individuals $\geq$ 2.5 cm dbh, saplings $<$ 2.5 cm dbh but $\geq$ 0.5 m tall, and seedlings $<$ 0.5 m tall.

Local slope and tree heights were measured using a clinometer and stand age was estimated from a minimum of 10 cores taken from trees in the most abundant size class. T-tests determined if the stands differed significantly in age. The Sørenson coefficients of similarity (Brower and Zar, 1977) were used to compare overall species composition and the composition of the trees, shrubs, vines, and herb layers.

In tabulating tree species it was found convenient to follow Keever's (1973) groupings of overstory climax, overstory successional, and small trees (Tables 1, 2). Nomenclature follows Gleason (1952).

RESULTS

Based on cores taken from the most frequently occurring size class of leading tree species, stands 1, 2, and 3 respectively averaged 60, 137, and 37 years old. T-tests indicated that in each pairing the age of these stands is significantly different. Eighty-nine species were recorded with stands 1, 2, and 3 respectively having 21, 15, and 17 tree species; 12, 9, and 5 shrub species; 4, 2, and 4 vine species; and 33, 11, and 18 herb species. Sørenson coefficients of similarity (Brower and Zar, 1977) indicated that the species composition of stands 1 and 2 were 61.6% similar, stands 1 and 3 were 50.8% similar, and stands 2 and 3 were 43.7% similar. In each instance, the greatest degree of similarity was between the tree components of the stands with similarities of 83.3%, 78.8% and 43.7% for the above pairs respectively. The shrub-vine elements of these stands were 66.6%, 48%, and 30% similar for the respective pairs while the similarity for the herb components was 40.9%, 31.3% and 27.5%.

Stand 1 was the richest in species with 71 being recorded. The canopy was closed, 18.5 m tall, over a sparsely developed 5.5 m understory. A thinly developed shrub layer was present. Dominant tree species were tuliptree (*Liriodendron tulipifera*), beech (*Fagus grandifolia*), black oak (*Quercus velutina*), red maple (*Acer rubrum*), white oak (*Quercus alba*), and chestnut oak (*Quercus prinus*) (Table 1). Flowering dogwood (*Cornus florida*) dominated the understory which included individuals of ironwood (*Carpinus caroliniana*). Tree reproduction was uneven with the exception of red maple, beech, white oak, white ash (*Fraxinus americana*), black gum (*Nyssa sylvatica*), red oak (*Quercus rubra*), and sassafras (*Sassafras albidum*) (Table 1). As table 2 shows, the dominant trees tended to have much of their stems concentrated in the greater than 30.5 cm size classes.

In order of decreasing frequency, the sixteen shrub and vine species were *Viburnum acerifolium* 73%, *Hamamelis virginiana* 33%, *Parthenocissus quinquefolia* 33%, *Rhododendron nudiflorum* 28%, *Lindera benzoin* 25%, *Viburnum dentatum* 20%, *Vaccinium stamineum* 15%, *Vitis* spp. 15%, *Clethra alnifolia* 10%, *Rhus radicans* 10%, *Vaccinium vacillans* 10%, and *Corylus americana, Lonicera japonica, Sambucus canadensis, Vaccinium angustifolium,* and *V. corymbosum* with less than 10% each.

The 33 herbaceous species are recorded in table 3. Most outstanding, each having a frequency of more than 20%, were *Arisaema triphyllum, Dennstaedtia punctilobula, Desmodium nudiflorum, Fragaria* sp., *Medolea virginiana,* and *Smilacina racemosa.*

Stand 2 had an 18.5 m open canopy dominated by chestnut oak (Tables 1, 2) with red and scarlet oak (*Quercus coccinea*) as the other canopy trees. An understory was lacking. Red maple with red and chestnut oaks had reproduction in both the seedling and sapling categories (Table 1) as did flowering dogwood and black gum. American chestnut (*Castanea dentata*) sprouts were present in the seedling and sapling sizes (Table 1) and numerous chestnut logs and stumps were noted throughout this stand.

Table 1. Importance values[1] of trees (T), saplings (Sp), and seedlings (Sd).

	STAND								
	1			2			3		
SPECIES	T	Sp	Sd	T	Sp	Sd	T	Sp	Sd
					Overstory Climax Trees				
Acer saccharum			2.5			1.8	1.3		
Carya cordiformis							4.3		
Carya ovalis	3.4		2.5				12.7		
Carya ovata	0.8						3.2		
Carya tomentosa	0.8						3.2		
Carya spp.		4.2	2.5			1.9			
Fagus grandifolia	30.7	15.5	7.0	10.3		3.0	18.0		
Quercus alba	21.3	9.4	9.1				13.8		
Quercus coccinea	1.5			4.8					
Quercus palustris	1.5								
Quercus prinus	15.8	4.2	2.5	105.2	76.1	123.1	21.0		15.2
Quercus rubra	4.1	4.2	4.4	41.6	28.0	11.6			
Quercus velutina	29.2		4.4	6.7		1.9	16.8		26.3
					Overstory Successional Trees				
Fraxinus americana	1.8	26.7	16.3	1.4		1.9	1.3	12.9	17.1
Liriodendron tulipifera	34.7	18.9		4.1			36.3		6.0
Nyssa sylvatica	4.0	20.6	17.0	1.5	9.7	2.9		12.9	
Prunus serotina		4.2	6.5		6.7				
Sassafras albidum	2.6	4.2	24.9	3.3		16.1			5.1
					Small Trees				
Acer rubrum	24.7	29.3	54.3	19.1	59.1	25.5	9.6		9.0
Carpinus caroliniana	0.8								
Castanea dentata					6.7	1.9			
Celtis occidentalis									4.0
Cornus florida	12.4	42.3	42.3	1.5	14.6	5.4	56.9	173.0	108.4
Prunus avium		4.2	2.5			1.9	1.3		8.0

[1] Based on relative frequency and relative basal area for trees; on relative frequency and relative density for saplings and seedlings.

TABLE 2. Number of stems measured, percent species' stems in each stand, and percent species' stems in a given size class for each stand. Size class 1 = 2.5-9.9 cm, 2 = 10.1-20 cm, 3 = 20.3-30.2 cm, 4 = 30.4-40.3 cm, 5 = 40.6 + cm, dbh respectively.

Species	Size Class																	
	Stand 1; 375 stems					Stand 2; 264 stems					Stand 3; 183 stems					Percent of Stems in Stand		
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3
	Overstory Climax Trees																	
Acer saccharum												100						1
Carya cordiformis												67	33					2
Carya ovalis		50			50						44	34	22			1		5
Carya ovata			100								100					1		1
Carya tomentosa		100									67			33		1		2
Fagus grandidentata	9	9	9	9	64	45	45	10				17	17	17	49	3	4	7
Quercus alba	5	48	2	25	20						11	11		22	56	11		5
Quercus coccinea				100			33	34	33							1	1	
Quercus prinus		52	26	22		1	10	21	40	27		11	32	26	31	7	68	10
Quercus rubra	3	23	27	33	14	44	28	5	11	11						23	14	
Quercus velutina		34	22	25	18	25	25	25		25		7	21	21	50	15	3	8
Quercus palustris			100													1		
	Successional Overstory Trees																	
Fraxinus americana	67	33					100				100					1	1	1
Liriodendron tulipifera		16	20	44	20	25	50	25			5	3	5	31	56	19	2	21
Nyssa sylvatica			20	60	20	100										1		
Sassafras albidum		100				100										1	1	
	Small Trees																	
Acer rubrum	14	29	23	20	14	76	18			6	17	50		17	16	12	6	3
Carpinus caroliniana	100															1		
Cornus florida	96	4				100					72	28				6	1	35
Prunus avium														100				1

TABLE 3. Percent frequency of herb layer species, species present outside the measurements are indicated by p.

Species	Stand		
	1	2	3
Amphicarpa bracteata	3		5
Aralia nudicaulis	13	17	
______ racemosa			5
Arisaema triphyllum	30	3	5
Aster divaricatus	5	3	5
Athyrium filix-femina	3		
Botrichium virginianum			5
Carex sp.	3		p
Chimaphila maculata	3	17	
Circaea quadrisulcata	5		30
Collinsonia canadensis	10		
Dennstaedtia punctilobula	30	3	
Desmodium nudiflorum	48	3	
Dioscorea sp.	18		
Dryopteris marginalis		7	
________ novaboracensis	8		
Eupatorium rugosum			p
Fragaria sp.	23	3	5
Galium circaezans	5		
______ lanceolatum	5		20
______ triflorum	3		
Geranium maculatum	3		
Hepatica americana			5
Lycopodium lucidulum	p		
Lysimachia quadriflora	3		
Medeola virginiana	28		
Mitchella repens	15		
Monotropa uniflora	3		
Osmunda cinnemomea	15		
________ claytoniana	5		
________ regalis	p		
Pilea pumila			5
Phytolacca americana			5
Podophyllum peltatum			5
Polygonatum biflorum	8		
Polypodium virginianum		p	p
Pteridium aquilinum	3	7	
Ranunculus abortivus	5		
Sanguinaria canadensis			35
Smilacina racemosa	23		40
Solidago caesia	3		
Uvularia perfoliata	3		
______ sessilifolia			5
Viola sp.	10		
Total spp.	33	11	18

Frequencies of the 11 species of shrubs and vines recorded were: *Kalmia latifolia* 50%, *Parthenocissus quinquefolia* 30%, *Rhododendron nudiflorum* 30%, *Vaccinium vacillans* 30%, *Gaylussacia baccata* 27%, *Hamamelis virginiana* 27%, *Viburnum acerifolium* 27%, *Vaccinium angustifolium* 20%, *V. stamineum* 20%, and *Rhus radicans* 7%.

Table 3 records the herb layer species with only *Aralia nudicaulis* and *Chimaphila maculata* having frequencies of more than 10%.

Seventeen tree species were recorded in an open canopy and well-developed subcanopy in stand 3 (Table 1). Flowering dogwood had the highest importance value, was present in all categories, and accounted for 35% of the stems recorded in this stand. Tuliptree, chestnut oak, beech, and black oak respectively composed 21, 10, 7, and 8 percent of the trees recorded (Table 1). The size-class distributions (Table 2) of the above species indicated that flowering dogwood was confined to the smaller size classes while tuliptree, chestnut oak, black oak, and beech tended to have most of their stems in the intermediate and larger sizes.

Only flowering dogwood and ash have stems recorded in the seedling, sapling, and tree categories (Table 2). Species with only the seedlings and trees recorded are tuliptree, chestnut oak, black oak, red maple, and sweet cherry (*Prunus avium*) (Table 1). Three of the remaining genera (*Celtis, Nyssa,* and *Sassafras*) are seen only as seedlings and saplings and the remaining species (sugar maple, beech, white oak, and hickories) had no observed reproduction.

Nine species of shrubs and vines having a frequency of 20% or more were recorded in stand three. They are *Lonicera japonica* 45%, *Lindera benzoin* 40%, *Viburnum acerifolium* 30%, *Parthenocissus quinquefolia* 20%, and *Viburnum prunifolium* 20%. *Celastrus scandens* and *Vitis* sp. had 5% each.

Outstanding among the 18 herbaceous species (Table 3) were *Circaea quadrisulcata, Galium lanceolatum, Sanguinaria canadensis,* and *Smilacina racemosa.*

DISCUSSION

It was originally hoped that the three stands on Buckingham Mountain could be considered as representative of the differing slopes and elevations of a common geological feature that was distinct from the surrounding lowlands. The stands, however, are significantly different in age, lie in varying degrees on different soils, and lack historical documentation. This latter fact alone reenforces Braun's (1950) remark that the Pennsylvania piedmont vegetation has a long history of unrecorded disturbances and that the precise original composition of the forests can never be accurately determined.

Despite this lack of specific history, the stand's composition is quite similar compared to those reported by other workers. For example, red maple, sugar maple, sweet birch, hickories, dogwood, beech, white ash, tuliptree, and white, chestnut, red, and black oaks appear repeatedly, in varying combinations, in the literature of southeastern Pennsylvania (Harshberger, 1904, 1919; Gordon, 1941; Keever, 1973; and Pearson, 1963, 1974, 1975). Cantlon (1953) and Buell et al. (1966) report these same species as being prominent in the stands of nearby New Jersey. Keever (1973), Cantlon, (1953), and Gordon (1941) note that beech, sugar maple, sweet birch, bitternut (*Carya cordiformis*), white ash, chestnut oak, red oak, and black oak as being particularly prominent on the slopes. The Buckingham Mt. stands definitely show the same trend and, with the exception of red maple which assumes a greater importance in the contemporary Buckingham Mt. stands than those of Keever (1973), the tree species on the mountain are consistent with her groupings.

In stand 1, beech, black oak, white oak, red oak and chestnut oak have the highest importance values and, excepting black oak, are all represented in the seedling and sapling categories. Thus, the overstory dominants are established and should characterize the stand in the foreseeable future. Hickories are present only in small amounts with little reproduction present and (Table 2) they are also scattered through the intermediate size classes. Pin oak is a species that only occasionally appears in upland forests (Harlow and Harrar, 1958). Sugar maple, the only climax dominant appearing only as seedlings will probably increase in importance in this mesic habitat as long as fire is excluded.

Tuliptree by far is the most important overstory successional tree. Ash, black gum, and black cherry are present but are unlikely to attain greater importance as long as the overstory climax species are abundant.

The small trees are dogwood and American hornbeam (*Carpinus caroliniana*) with dogwood firmly established as the understory dominant (Table 1). Red maple, as noted above, is of far greater importance than it was in the stands of Keever (1973) and in this stand forms an important part of the overstory in addition to being well represented in the reproductive classes and in all size classes of trees (Tables 1, 2). This is probably due to the developmental stage of this stand since the overstory successionals white ash, black gum, and tuliptree show generally similar reproductive patterns. The reproductive patterns of several of the overstory climax trees indicate the probability that red maple, while being important in this stand for some time, will gradually be reduced as the more shade tolerant climax dominants develop.

Stand two, higher on the slope, has more than half of the total possible importance value recorded by chestnut oak (Table 1). The other important overstory climax trees having reproduction in one or more classes are red oak, black oak, and beech. The sugar maple and hickories are present only as seedlings. This stand with its open canopy has five successional overstory species; black gum, white ash, sassafras, sweet cherry, and black cherry; but none of them in large amounts. These species have irregular reproduction patterns and are mostly represented in the small size classes (Tables 1, 2). As in stand 1, red maple is important in the overstory and has ample reproduction (Table 1).

Dogwood dominates the small trees and since the blight (Harshberger, 1919), the chestnut has been reduced from its once abundant numbers. A former codominance of chestnut and chestnut oak is suggested by the large numbers of chestnut logs lying on the rocky parts of this slope in conjunction with sprouting chestnut stumps.

Stand three, the youngest of the stands, is on the southeast-facing slope. Indicative of the open canopy found in this stand, dogwood, an understory tree, has the highest importance value. Another indication of the youth and openness of the stand is the occurrence of tuliptree as a leading overstory dominant and its presence in all the size classes except that of the saplings (Tables 1, 2). It is also in this stand that hackberry (*Celtis occidentalis*), as seedlings, makes its sole appearance.

The other successional overstory species are not important as trees but their reproduction is better than that of the overstory climax trees (Table 1). These latter are strongly represented by chestnut oak, black oak, beech, white oak, and pignut hickory. Other hickories and sugar maple are present in small amounts (Table 1). Of these climax species, white, chestnut, and black oaks along with beech have the most consistent distribution throughout the size classes (Table 2) indicating more steady reproduction over a longer period of time.

With the larger number of overstory climax species confined to the tree category, it seems likely that these species are residuals from some pre-disturbance forest and their reproduction cannot yet compete with the established dogwood and successional trees.

The shrubs and vines found in this study are those mentioned by Cantlon, 1953, Harshberger, 1904, 1919, Keever, 1973 and Pearson, 1963, 1974 as being present in varying amounts at the sites they studied. These authors mentioned *Viburnum acerifolium, Hamamelis virginiana, Rhododendron nudiflorum, Vaccinium stamineum, V. vacillans,* and *Lindera benzoin* as being particularly prominent and *Parthenocissus quinquefolia, Vitis* spp., *Rhus radicans, Kalmia latifolia* and *Gaylussacia* spp. as being typical in many piedmont locations.

In this study, *Viburnum acerifolium* is definitely more prominent on the northern slopes as Harshberger (1919) and Cantlon (1953) noted. Other species showing the trend toward north-slope abundance recorded by Cantlon (1953) are *Hamamelis virginiana, Rhododendron nudiflorum, Vaccinium angustifolium,* and *V. vacillans.*

The herbaceous species recorded in this study are typical for this region and have been listed in whole or part by the previously cited authors. They are typical of the herbaceous populations found in the piedmont but, due to limited data, further comments other than the obvious abundance in the mesic stand one do not seem justified.

SUMMARY AND CONCLUSIONS

The stands on Buckingham Mountain are similar in species composition to stands described by other authors for this region and are compatible with the general historical descriptions of Bean (1884) and Davis (1876). Although the stands cannot be considered unique for the region, they do give a general idea of the current successional composition of stands occurring on minor elevations and slopes in this part of the piedmont.

While differing significantly in age and being in different stages of development from previous unknown disturbances, they definitely are representative of the Oak-Chestnut region described by Braun in 1950.

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ADDITIONS TO THE FLORA OF ISLAND BEACH STATE PARK, NEW JERSEY

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In the years since the first check-list of plants from Island Beach appeared (Small and Martin, 1958), both authors have visited the State Park on numerous occasions, always with an eye toward gathering additional plant records from the region. During that time, a formal bathing area, complete with bath houses, refreshment stand, and parking lots, was constructed. The upper third of the Park is still closed to casual visitors, with guided tours for nature lovers permitted by special arrangement. The lower third of the peninsula and Park is a bird sanctuary. Our plant collections have been made with special permission of the appropriate governing body in Trenton and with full co-operation of Mr. John Verdier, superintendent of the Park for the entire period of study. Voucher specimens are filed in the herbarium of Douglass College (RUT) and at Michigan State University (MSC). Cyperaceae are also at SIU. At this time, we add 36 species to the original flora.

GRAMINEAE: *Agrostis alba* L. var. *alba,* redtop; shore of Barnegat Bay near end of Reed's Road, *Gillis 5654. Cenchrus longispinus* (Hack.) Fern., sandbur; restricted to dunes at a few sites near the southern tip of the bar (This may be *C. incertus* M.A. Curtis, depending upon one's species concept within this group, see DeLisle, 1963). *Digitaria sanguinalis* (L.) Scop., crab-grass; occasional, ruderal. *Eragrostis pilosa* (L.) Beauv.; near bath house and refreshment stand, local, *Gillis 14249. Panicum amarulum* Hitchc. & Chase, beachgrass; shore of Barnegat Bay, uncommon, *Gillis 5672. Tridens flavus* (L.) Smyth, tall red-top; rare, ruderal, *Gillis 2399.*

CYPERACEAE: *Cyperus globosus* Subl.; shore of Barnegat Bay, *Gillis 5656* (Duplicate determined by Dr. Robert Mohlenbrock). *Cyperus strigosus* L.; growing with *Polygonum punctatum* at the border of open water in a salt marsh, *Gillis 5655* (Duplicate determined by Dr. Robert Mohlenbrock). *Fimbristylis autumnalis*

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[1] Over 10 years ago, Dr. Small had prepared with Dr. William E. Martin an addenda to their original annotated check-list of vascular plants reported from Island Beach State Park, New Jersey. Dr. Gillis, a periodic visitor to the Park, also noted plants new to the region. A joint paper was planned. Due to the pressure of other matters, the joint paper was discussed at length but never published. There was always that hope that yet another species would turn up. Meanwhile Dr. Martin felt that he had been away from Island Beach too long to feel that he should be associated with the publication. In October 1978, Dr. Small died at the age of 78. It seems appropriate to bring out this paper at last, and to attribute senior authorship to him, as it would have been in his lifetime. Island Beach was very special to Dr. Small, especially his discovery of *Carex kobomugi* there. Hence, this paper which bears his name is a special tribute to him.

(L.) R. & S.; wet spot in shade along Reed's Road, *Gillis 5669* (Duplicate determined by Dr. Robert Kral). *Scirpus rubricosus* Fern.; Roadside ditch, one mile south of entrance near former Adams lease, *Gillis 5682.*

ORCHIDACEAE: *Habenaria lacera* (Michx.) Lodd., ragged orchid; edge of thicket in moist sand near *Populus gileadensis* on Reed's Road, *Gillis 5094.*

CARYOPHYLLACEAE: *Spergularia marina* (L.) Griseb., sand-spurrey; occasionally on wetter salt marshes, with *Salicornia.*

ROSACEAE: *Pyrus melanocarpa* Michx., choke-berry; thicket near southern end of road, *Gillis 14223.*

EUPHORBIACEAE: *Euphorbia cyparissias* L., cypress spurge; rare, ruderal and in sand mixed with eel-grass on shore of Barnegat Bay, *Gillis 2719.*

GUTTIFERAE: *Hypericum canadense* L.; in moist sand on path from Coast Guard Station 112 to bay shore, *Gillis 3476* (Verified by Dr. W.P. Adams). *Hypericum perforatum* L.; edge of thicket in moist sand, *Gillis 5106* (verified by Dr. W.P. Adams).

ERICACEAE: *Vaccinium vacillans* Torr., lowbush blueberry; in a few shady sites in red cedar and pine woodland.

VIOLACEAE: *Viola pedata* L., pansy violet; rare (one plant in fruit); ruderal.

LYTHRACEAE: *Lythrum salicaria* L., spiked loosestrife; reported in ms by senior author as "rare, marsh margins and wet, open thickets;" now common along channels and fresh water marshes.

LABIATAE: (This entire family was inadvertently omitted from the paper by Small and Martin, 1958) *Lycopus americanus* Muhl.; near shore of Barnegat Bay at end of Reed's Road, *Gillis 5663. Lycopus amplectens* Raf.; path to bay shore in wet sand east of southern end of paved road, *Gillis 14241. Stachys palustris* L., woundwort; sand ridge and road gravels on shore of Barnegat Bay, area often flooded by bay water (salinity in bay measured at 26 parts per thousand), *Gillis 2732, 3097. Teucrium canadense* L. var. *candense,* American germander; near shore of Barnegat Bay, in pile of decaying eel-grass, *Gillis 5664.*

VERBENACEAE: *Verbena hastata* L., blue vervain; rare, in wet, open thickets, *Gillis 5681.*

SCROPHULARIACEAE: *Linaria vulgaris* Hill, butter-and-eggs; rare, ruderal.

RUBIACEAE: *Diodia teres* Walt., buttonweed; swales along dunes and ruderal sites, growing with *Cyperus grayi, Gillis 14241.*

PLANTAGINACEAE: *Plantago rugelii* Dcne., plantain; along Reed's Road, *Gillis 5690.*

COMPOSITAE: *Ambrosia artemisiifolia* L., ragweed; common, ruderal, *Gillis 2387. Aster pilosus* L.; crest of foredune, *Gillis 5014. Conyza canadendis* (L.) Cronq., horseweed; lee side of dune near Coast Guard Station 112, *Gillis 5685. Pluchea odorata* (L.) Cass., marsh fleabane; edge of salt marsh, *Gillis 2785* (This will key to *P. purpurascens* in Fernald (1950), Gleason and Cronquist (1963), and Godfrey (1952); recent work by Gillis (1977) has shown by typification that what was heretofore based on the epithet *Conyza purpurascens* is *P. odorata* and what was known in these same works as *P. odorata* is *P. symphytifolia* (Mill.) Gillis).

Eupatorium perfoliatum L., thoroughwort; path to bay shore from southern end of road in wet sand, *Gillis 14240. Solidago graminifolia* L.; crest of fordune, *Gillis 2401. Solidago odora* Aiton, sweet goldenrod; crest of foredune, *Gillis 5006. Solidago rugosa* Mill.; roadside, upper third of park, *Gillis 14239. Solidago tenuifolia* Pursh; cranberry community in wet sand, *Gillis 5007.*

ACKNOWLEDGEMENTS

We appreciate the aid given to us by Dr. William Martin and Superintendent John Verdier, as well as other local naturalists who have pointed out plants to us from time to time. Dr. Robert Mohlenbrock determined *Cyperus* specimens; Dr. Robert Kral, the *Fimbristylis;* Dr. W.P. Adams verified *Hypericum* species; Dr. David Fairbrothers verified the *Eragrostis.* We are grateful for their help.

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EDITOR'S NOTE: Dr. Gillis died on 20 June 1979 after this paper went to press.

CHECK LIST OF THE AQUATIC FLOWERING PLANTS OF FLATHEAD LAKE, MONTANA

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Flathead Lake, located in northwestern Montana, is the largest natural freshwater lake in the United States west of the Mississippi River. Although the lake is not densely populated with aquatic flowering plants, there are extensive submergent and emergent stands of macrophytes at the northern and southern ends. During the summer of 1978, I was able to record the kinds of plants growing in the lake with the help of students[1] taking the course on Aquatic Flowering Plants at the University of Montana Biological Station. I am grateful to them and also to Bruce McCune, Patricia Schuyler, and John F. Tibbs for help in connection with this work.

The dominant emergents in Flathead Lake are *Typha latifolia, Scirpus acutus,* and *Butomus umbellatus* (the latter not seen at the southern end of the lake). Among the dominant submergents are *Potamogeton pectinatus, Potamogeton richardsonii,* and *Ranunculus aquatilis.*

It is difficult to make a sharp distinction between aquatic and land plants along the margin of Flathead Lake. This is partly because the water level is periodically raised and lowered by Kerr Dam, about 7 kilometers below the lake in the Flathead River. Some plants which are marginal aquatics (e.g., *Polygonum aviculare*) are included in this list because they were found with their basal parts in water at the time they were collected and/or observed.

This list is not all inclusive and undoubtedly more aquatic flowering plants will be found. Hopefully, it will provide a starting point for further exploration.

The names follow Hitchcock and Cronquist (1973) for the most part. When other names are used, those of Hitchcock and Cronquist follow in parentheses. Specimens of many plants listed in this report have been deposited in herbaria at the University of Montana and the Academy of Natural Sciences of Philadelphia.

Acorus calamus; Alisma gramineum, triviale (plantago-aquatica); Alopecurus aequalis; Beckmannia syzigachne; Berula erecta; Butomus umbellatus; Callitriche verna; Cardamine pensylvanica; Carex lanuginosa, rostrata; Ceratophyllum demersum; Eleocharis acicularis, palustris; Elodea nuttallii; Epilobium watsonii; Galium trifidum; Glyceria borealis, grandis; Hippuris vulgaris (including *montana*); *Iris pseudacorus; Juncus articulatus, balticus, nodosus; Lemna minor; Lysimachia thyrsiflora; Mentha arvensis; Myosotis laxa, scorpioides; Myriophyllum spicatum*

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[1] The students were Marianne Shields, Carolyn Sanford, Mark Ramp, Lizabeth Peckham, Marjorie Mueller, Janis Lindsey, Henry Komadowski, Jon Feldman, Luce Dumont, and Fred Barrie. Miss Mueller compiled a preliminary version of the list.

(spicatum var. *exalbescens), verticillatum (spicatum* var. *spicatum); Najas flexilis; Nasturtium officinale (Rorippa nasturtium-aquaticum); Phalaris arundinacea; Polygonum amphibium* (including *coccineum*), *aviculare, lapathifolium, persicaria, punctatum; Potamogeton gramineus, natans, pectinatus, pusillus* (including *berchtoldii*), *richardsonii; Potentilla palustris; Ranunculus aquatilis* (including *longirostris* and *subrigidus*), *cymbalaria, flammula; Rorippa islandica; Sagittaria cuneata; Scirpus acutus, microcarpus, tabernaemontanii (validus); Scutellaria galericulata; Sium suave; Solanum dulcamara; Sparganium eurycarpum; Spirodela polyrhiza; Triglochin maritimum; Typha latifolia; Utricularia vulgaris; Veronica americana, anagallis-aquatica; Zannichellia palustris.*

LITERATURE CITED

HITCHCOCK, C.L. AND A. CRONQUIST. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle. xix + 730 pp.

FIELD TRIPS 1977

Members of the Philadelphia Botanical Club enjoyed visits to seven diverse sites during the 1977 growing season. Some of these sites had been visited by the club two or more generations earlier and the purpose was to monitor and survey as they are today; others were well known to the individual leaders, who wished to explore them more thoroughly and to collect specimens for the local herbarium.

May 29: Spring Mount, Montgomery County, Pennsylvania. This location is used now in the winter for recreational skiing. It had been explored by the club in the past, and there is an old record of *Adlumia fungosa* growing here. The search followed from the parking lot area, to a pond, onto the open field of the ski slope, and the open woods of the entire north-facing slope. The *Adlumia* was not found; but, as always, other things of particular interest were. On the ski slope field were three species of grape: *Vitis vulpina, labrusca,* and *aestivalis;* also, *Rubus odoratus, Potentilla intermedia,* and *Pentstemon hirsutus.* The cool diabase of the open woods was rich with ferns, including *Dryopteris disjuncta* and *Camptosorus rhizophyllus. Trillium cernuum, Actaea pachypoda,* and *Prunus virginiana* were there, too.

The trip concluded with a walk along a path by the Perkiomen Creek, which was especially notable for the presence of thirteen species of *Carex;* three of the more unusual Umbelliferae: *Zizia aurea, Thaspium trifoliatum* var. *atropurpureum,* and *T. barbinode;* and *Veronicastrum virginicum.* Trip organizer: Ann Newbold.

June 12: Friedensville Zinc Mine, Lehigh County, Pennsylvania. *Cerastium arvense* var. *viscidulum* was photographed and collected from this site; it is from the only known population growing in Pennsylvania. Also found was one sterile-flowered hybrid of *C. arvense* var. *viscidulum* × *C. vulgatum.*

The most abundant trees in this stressed habitat were *Populus tremuloides, grandidentata,* and *alba;* they were everywhere, very variable and probably had hybridized. *Betula populifolia* was also abundant. The list of herbaceous plants was rather typical of a dry limestone sand, or of simply a waste place; such as: *Anagallis arvensis, Arenaria serphylifolia, Chelidonium majus, Plantago aristata, Trichostema dichotomum,* and the more rarely encountered *Reseda lutea, Polansia graveolens,* and *Diplotaxis* spp. *Xanthium echinatum* was spotted, as is usual, even though this is a coastal plain species and is unusual in Lehigh County. Trip organizer: Robin Hart.

June 25: Fraziers Bog, Montgomery County, Pennsylvania. See article by Grace Tees in this issue.

July 31: Bridgeton, Cumberland County, New Jersey. The primary search was an attempt to locate some of the uncommon and spectacular aquatics which have been recorded as here in the past — such as *Nymphoides aquatica* and *cordata,* which were not found and *Nelumbo nucifera,* which was found and flourishing in a pond in the city park.

The trip was extended to include an area by the Cohansy River and Fairton, the highlight being the great numbers of southern and wetland species everywhere. Here is a selective list; *Woodwardia areolata, W. virginica, Typha angustifolia, Tripsacum dactyloides, Peltandra virginica, Carya pallida, Dianthus prolifer, Magnolia virginiana, Asimina triloba, Chionanthus virginica, Decodon verticillata,* and *Rhododendron vicosum.* Trip organizer: Wayne Ferren.

August 14: Brigantine Island, Atlantic County, New Jersey. The island featured varied environments of beach, dunes, hollows and salt marshes. Wayne Ferren had searched old records and compiled a list of infrequently encountered plants that just might be found in one of these places. And some were, such as: *Atriplex arenaria, Sesuvium maritimum, Carex silicia, Euphorbia polygonifolia,* and *Spergularia marina.* Other finds were: *Cakile edentula, Limonium carolinianum, Sabatia stellaris, Centaurium pulchellum,* and our very own eponym, *Bartonia.* The *Centaurium* finding is the first Atlantic County record! Trip organized through the Academy of Natural Sciences.

September 11: Nockamixon Narrows, Bucks County, Pennsylvania. This Delaware River site is a well documented refuge for many northern species, which are found both on the cliffs and on the alluvial soil. Our list of them included; *Cystopteris bulbifera, Taxus canadensis, Carex plantaginea, Trillium erectum* and *cernuum, Arenaria stricta, Geranium robertianum, Acer spicatum, Viola canadensis, Hydrophyllum canadense,* and *Sedum roseum. Selaginella rupestris* was not sighted; it has been reported as here in the past, but perhaps we overlooked it because the very dry weather had affected many of the rock dwelling plants.

The other noteworthy finds were: *Woodsia ilvensis, Asplenium trichomanes, Equisetum hyemale, Anemone quinquefolia, Cerastium arvense* var. *oblongifolium, Cornus rugosa, Sambucus pubens, Salix cordata, Cymbalaria muralis, Campanula rotundifolia,* and *Acer saccharum* var. *rugelli.* Trip organizers: Grace Tees and Wayne Ferren.

October 2: University Camp, Green Lane, Montgomery County, Pa. at Deep Creek and Green Lane Roads. Located at the west end of the Upper Perkiomen Valley Park, this area seemed to save its glory for autumn and to be rich in total number of species and in the numbers of species within their genera. Some among the nine species of *Solidago* were: *S. caesia, graminifolia, rigida* (west one mile on Deep Creek Road), *bicolor,* and *flexicaulis.* Among the eleven *Asters: A. laevis, sagittifolius, lateriflorus, macrophyllus,* and *prenanthoides.* Three *Andropogons: A. scoparius, virginicus,* and *gerardii;* four *Setarias,* the most unusual being *S. geniculata.* The two gentians, *G. crinata* and *andrewsii* were in full flower and very evident.

These diverse discoveries, from among the 250 counted, also demand mention: *Gerardia tenuifolia, Cirsium altissimum, Galium boreale, Triosteum perfoliatum, Hypoxis hirsuta, Zizea aurea, Quercus bicolor, Spiranthus gracilis, Corallorhiza odontorhiza, Panax quinquefolia, Monarda clinopodia,* and *Rudbeckia fulgida.* Trip organizer: Ann Newbold.

FIELD TRIPS 1978

April 23: Doe Mountain, Longswamp Township, Berks County, Pa. Again we started the season with a visit to a skiing area. The trip had been scheduled to coincide with the flowering of *Polygala paucifolia,* but it and most of the other species were late because of the long winter. There is an excellent stand of the *Polygala* here, located in the cool, wet woods at the base of the slope. Also abundant in the same place were: *Goodyera pubescens, Viola pallens* and *rotundifolia,* and less abundant, *Xyris tortua.* Among the non-flowering plants were: *Lycopodium lucidulum, obscurum* and *flabelliforme; Selaginella apoda, Sphagnum* sp. and *Conocephalum.* At the edge of the woods, near the clearing we found a single specimen of *Panax trifolius* along with, among the many typical plants — *Rhododendron nudiflorum, Sedum telephioides,* and *Epigaea repens.*

Then, lunch at Newbold's — close by in Montgomery County. There, naturally growing and in bloom was a stand of *Muscari racemosum;* great quantities of *Hepatica americana; Sanguinaria canadensis* — many with double or triple and one with quadruple rows of petals; and although not all in bloom — seven species of *Veronica.* Leader: Ann Newbold.

May 30: Fellowship Farm and Sanatoga Road stations, Montgomery County, Pa. This trip was hastily rescheduled by a few members following a rain-out on the original date. The woods behind Fellowship Farm featured *Orchis spectabilis, Medeola virginiana, Cimifuga racemosa, Obolaria virginica,* and *Hyposis hirsuta.*

The Sanatoga station was notable for several lovely, less commonly seen spring flowers — such as: *Dentaria laciniata, Cypripedium acaule, Smilacina racemosa, Epigea repens,* and *Silene pensylvanica.* Also evident were: *Chimaphila maculata, Pyrola elliptica, Aureolaria pedicularia Hieracium venosum,* and near to the roadside — *Pueraria lobata.* Leader: Ann Newbold.

June 11: Albion, Camden County, New Jersey. This was the promised site of the southernmost stand of *Rhododendron maximum* in New Jersey. Indeed, the rhododendron did stand, a robust specimen, accessible only by a long trek through hip-deep bog. It was a good opportunity to see Pine Barrens variety: five species of *Vaccinium — vacillans, caesariense, corymbosum, angustifolium,* and *frondosum; Melampyrum lineare; Clethra alnifolia; Lyonia mariana* and *ligustrina; Chamaedaphne calyculata; Rhus copallina* and *vernix; Drosera intermedia; Magnolia virginiana; Xerophyllum asphodeloides; Cypripedium acaule; Vallisneria; Sparganium americanum; Aralia nudicaulis; Uvularia sessilifolia* and *Lycopodium inundatum.* On higher, drier ground: *Tephrosia virginiana* and *Solidago odora.* Leader: Joe Arsenault.

July 15: Middlesex County, New Jersey — east of Deans and Dayton. The original plan was to explore Pigeon Swamp, which we were unable to enter. However, we did search a rather poorly drained Inner Coastal Plain site and then shifted to an area of dry, sterile sand near the village of Halmetta.

At the first site and on dry ground near the parked cars were *Stachys hyssopifolia* and *Yucca smalliana.* On the wet ground: *Spirea latifolia* and *tomentosa, Bartonia* *virginica, Clethra alnifolia, Polygala sanguinea* f. *viridescens, Viola brittoniana, Liquidambar styraciflua, Eleocharis tenuis, Osmunda cinnamomea* and *regalis, Dryopteris simulata,* and *Woodwardia areolata.*

The Halmetta site was more typical of Pine Barrens vegetation, marked by the absence of *Liquidambar* and by little duplication of the species seen earlier. Most notable were: *Trientalis borealis, Aster umbellatus, Aronia arbutifolia, Aralia hispida, Magnolia virginiana, Woodwardia areolata* and *virginica* — and growing in a drainage ditch, *Decodon verticillata* and *Rhus vernix.* Leader: Vincent Abraitys.

August 5: Mont Clare — Phoenixville area, Chester County, Pa. This is an especially attractive old canal site along the Schuylkill River. At the outset we encountered a stone wall of the old canal and the following plants were seen growing on its vertical surface: *Pellaea glabella, Aster simplex, Potentilla norvegica* and *recta, Eclipta alba, Acalypha virginica, Plantanus occidentalis,* and *Poa compressa. Wolffia* and *Jussiaea repens* flourished in the slow moving waters at the base of the wall. We then proceeded on a path upriver — here is a partial listing of the plants recorded: *Desmodium canescens, glutinosum,* and *canadensis; Cassia hebecarpa, nictitans,* and *fasciculata; Lonicera dioica; Penthorum sedoides; Senecio obovatus; Woodsia obtusa; Arctium lappa* and *minus; Amaranthus spinosus; Aralia racemosa; Pellaea atropurpurea; Amorpha fruticosa; Heteranthera dubia; Humulus japonicus* and *Rumex altissimum.*

During the previous summer, on an exploratory trip, *Arisaema dracontium* and *Campanula americana* (in flower) were seen. However, they were located too far upriver to be reached on this very wet day.

The area also has a wide variety of trees including: *Alnus glutinosa, Tilia americana, Asimina triloba, Prunus avium, Albizzia julibrissin, Robinia pseudoacacia* and a huge *Betula nigra.* And the shrubs — *Hydrangea arborescens* and *Rosa setigera.* Leader: Harrison Rigg.

September 16: New Egypt, Ocean County, New Jersey. For the final trip of the season we traveled to a region transitional between middle district and Pine Barrens vegetation. It was marked by an unusual mix of plants, ones ordinarily not seen together — such as *Hudsonia ericoides* and *tomentosa.* The overall character of the place is reflected by a listing of some of the species; *Croton glandulosis, Monarda punctata, Polygonella articulata, Hypericum virginicum* and *gentianoides, Digitaria filiformis, Uniola laxa, Paspalum laeve, Aristida tuberculosa, Eriophorum virginicum, Salix fragilis; Quercus prinoides, phellos,* and *ilicifolia; Liquidambar styraciflua, Prunus maritima, Ilex glabra, Chimaphila maculata, Tephrosia virginiana, Rhexia mariana, Gaultheria procumbens, Monotropa uniflora, Drosera intermedia, Nymphaea odorata, Xyris torta, Gerardia purpurea* and *Aster spectabilis.* Leader: Jim McGrath.

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