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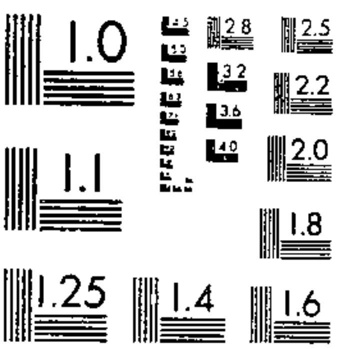

MICROCOPY RESOLUTION TEST CHART
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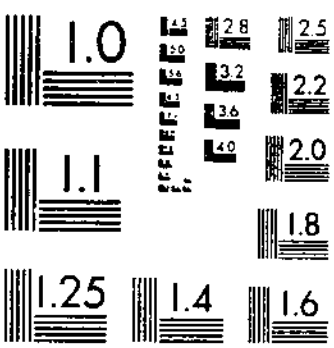

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Methods of Distinguishing Between the Shipmast and Common Forms of Black Locust on Long Island, N. Y.[1]

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CONTENTS

INTRODUCTION

On millions of acres of privately owned farm land, a permanent soil-conserving plant cover is the most effective means of combating the soil-erosion hazard. In order to establish a protective cover on erodible land, large numbers of native trees are being planted. Black locust (*Robinia pseudoacacia* L.) is one of the trees widely used for this purpose because it possesses outstanding soil-building qualities (*1, 5, 9, 10*)[3] and its usefulness on the farm is well recognized. Since farm land on which trees are planted for the control of erosion is frequently diverted from profitable use, it is essential to use forms that yield the highest possible financial return. The most likely method now available for producing improved kinds of black locust is field selection of superior clones and strains.

A number of promising forms of black locust have recently been selected. These selections are being studied to determine whether their desirable qualities are retained under propagation, where they can be grown successfully, and how they can be cultured economically.

[1] Submitted for publication March 14, 1940.

[2] The writer is indebted to S. B. Detwiler, Chief, Hillculture Division, for supplying preliminary information concerning the black locust forms on Long Island and the location of shipmast locust stands. Part of the statistical computations were made by employees of the Work Progress Administration, project 446, of the District of Columbia.

[3] Italic numbers in parentheses refer to Literature Cited, p. 23.

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One of the promising forms under test was found growing on Long Island, N. Y., where it was introduced over two centuries ago. In 1936 Raber (*11*) described this form as a separate botanical variety under the name shipmast locust, *Robinia pseudoacacia* var. *rectissima*.

The origin of shipmast locust is not authoritatively known, but this form has been recognized locally on Long Island for generations as a distinct variant from the usual or common form of black locust (*3*, *7*), such as is found ordinarily in other parts of the country.[4] Only recently, however, has this knowledge become general.

Shipmast locust possesses several outstanding qualities of economic value. The shape of the shipmast locust stem is strongly excurrent and relatively straight in contrast to the stem of common locust, which is often forked and crooked. The effect of stem shape on yield is illustrated by a cutting operation conducted by the writer on 18 shipmast locust trees and an equal number of common locust trees of comparable d. b. h.[5] growing in 10 stands on Long Island.[6] The yield was determined by splitting these trees into 8-foot fence posts. The number of first-grade posts obtained from the shipmast locust trees was approximately 50 percent greater than that obtained from the common locust trees.

The wood of shipmast locust is reported to be much superior to that of common locust. The prevalent belief on Long Island, developed through more than a century of experience with the two kinds of wood in use as fence posts, is that shipmast locust wood is much more resistant to decay than common locust wood. This opinion seems to be well-founded and is borne out by authentic observations on old posts (*3*, *11*). Because of their durability, shipmast locust posts are regularly sold at much better prices than are obtained for common locust posts. For the purpose of obtaining a direct comparison between the two kinds of wood under controlled conditions, a log each of shipmast locust and common locust were collected from freshly cut trees of similar size. The results obtained by exposing small blocks from these logs to pure cultures of four wood-rotting fungi indicate, also, that shipmast locust wood is considerably more durable than the wood of common locust (*8*). This conclusion has since been corroborated by tests on a wider selection of trees.[7]

Another important consideration in determining the value of shipmast locust is its resistance to the locust borer (*Cyllene robiniae* Forst.). According to Hall (*6*), injury by the locust borer is closely associated with growth rate and vigor of the tree. Although these site effects tend to mask genetic differences, Hall reached the conclusion that shipmast locust is much more resistant to injury by the locust borer than the common locust either on Long Island or in the Central States. He states (*6*, *p. 727*) that of the various forms studied, "* * * shipmast locust stands out as being one of the most desirable yet encountered."

These studies clearly indicate that shipmast locust is much superior to the common locust on Long Island. It is therefore desirable to

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[4] In referring to the two forms of black locust described in this bulletin, the term "shipmast locust" is used to mean the shipmast form of black locust, and "common locust" is used to mean the common form of black locust. This method of reference follows the terminology adopted by Raber in the original segregation of the two forms (*11*) and conforms to the procedure customarily used for horticultural selections of subspecies rank.

[5] D. b. h. is diameter at breast height, 4½ feet above the ground.

[6] Unpublished report.

[7] Unpublished reports.

test shipmast locust in other parts of the country where common locust is now generally used for farm planting. As an aid to technicians engaged in studying and using this desirable form, accurate, standardized means of recognizing shipmast locust are necessary. Reliable methods of identifying shipmast locust are needed also in selecting locations suitable for the collection of propagating stock. Since shipmast locust does not produce seed in practical amount it can be propagated only by vegetative methods (*12*). Propagating stock can be collected by digging sprouts that are present in fields or by making root cuttings from older trees, provided methods are available for distinguishing between the shipmast and common forms. Methods of identification are required also in determining the geographic distribution of shipmast locust in other parts of the country and in studying its growth requirements and reactions where its tendency to develop the typical shape is modified by site conditions.

The problem of identifying tree species is in most cases a simple one. Variants within a species usually present a more complex taxonomic problem: First, because the morphological differences between variants of subspecies rank are often in characters that have little taxonomic value; second, because specific differentiating characters often show considerable overlap for individual trees. This is true in the case of the shipmast and common forms of black locust on Long Island. The accurate identification of shipmast locust by means of the type character, tree shape, is impracticable. Although the superiority in tree shape of shipmast locust is in general clearly apparent, this character has not proved susceptible of objective description or measurement. Hence, the utility of tree shape for recognizing shipmast locust depends largely on the experience of the observer. Furthermore, because environment is known to have considerable influence on the shape of trees, even a well-trained observer could not identify shipmast locust on all sites by its general appearance. Therefore, accurate methods for the identification of shipmast locust should be based on morphological characters associated with tree shape.

Some of the morphological characters that differentiate the two forms have been mentioned by Raber (*11*), but heretofore no standardized procedure has been developed for distinguishing these forms objectively. The aim of this bulletin is to discuss the principal external characters by which shipmast locust differs from the common locust on Long Island and to describe how these characters can be used in the field to distinguish both mature and young trees of the two groups. Also, the measurements of these characters are analyzed to determine whether the shipmast form of black locust should be considered a taxonomic variant of the species or only an environmental variation.

SELECTION OF TREES

In order to select trees for study of their morphological characteristics, methods were established for classifying the black locust forms on Long Island into shipmast and common groups. The classification was based on tree shape, the type character of shipmast locust. These standards were developed from Raber's descriptions (*11*) and from a preliminary examination of the locust forms on Long Island.

FIGURE 1.—*A*, Shipmast locust tree at Centerport, N. Y. The erect shape and narrow crown are typical of shipmast locust. This tree contains usable wood almost to the top of the stem. *B*, Common locust tree at Jericho, N. Y. The low forks and wide crown are typical of common locust. Such trees have usable wood only in their butt log, and the wood is of inferior quality in contact with the soil as compared with the wood of shipmast locust. *C*, Interior of a shipmast locust stand. *D*, Interior of a common locust stand. The usable part of the shipmast locust trees is unforked, straight, and free of side branches. Common locust trees, even in closed growth, are usually forked and branchy. The fence-post yield of mature shipmast locust trees was found to be approximately 50 percent greater than that of common locust trees with the same d. b. h.

SHIPMAST LOCUST.—In open growth (fig. 1, *A*) the trees have an excurrent stem, which is mostly unforked throughout its usable length. The main stems are relatively straight, with only one or two slight crooks in the usable part. The crowns are narrow, their diameter being 25 to 40 percent of the tree height. The lower branches are straight and form an angle of approximately 45° with the stem axis. The upper branches are short and almost horizontal. In closed stands (fig. 1, *C*) the main stems show the same general form as in the open-grown trees, but the crown development is confined to short, horizontal branches in the upper part of the tree.

COMMON LOCUST.—Mature trees in the open (fig. 1, *B*) typically fork two or more times in the usable part of the stem. The main stems are fairly straight near the base, but generally have two or more prominent crooks in the usable length. The crowns are relatively wide, their diameter in open growth being 40 to 80 percent of the tree height. The branches are usually long and curved in both the upper and lower parts of the crown. The long upper branches make the crown appear heavier and fuller and give a higher form point than in the shipmast locust trees. In closed stands (fig. 1, *D*) the size of the crown is much smaller, but the branch pruning is not so satisfactory as in shipmast locust. Although the restricted crown somewhat improves the tree form, the characteristically poor shape is readily apparent.

Besides these differences in shape, none of the shipmast locust trees selected bore seed pods, whereas no common locust trees were selected that did not bear seed pods.

In selecting trees for study, an attempt was made to minimize differences between the two groups that were associated with environmental influences. The surest way of doing this would have been to select trees for study only in places where the two forms were growing side by side, had this been possible. It happens, however, that only three such areas were found, so that for the most part the stands used in the study were not paired. Inasmuch as it was impossible to secure a sufficiently large number of paired stands, a somewhat less effective procedure was resorted to. Measurements were made over the entire shipmast locust range on Long Island (fig. 2) in order to get as complete an expression of environmental effects as possible. Within this area a reasonably similar distribution of shipmast locust and common locust samples was obtained. Care was also taken to obtain approximately corresponding proportions of stands of each form on the four principal soil types represented in the area. This procedure assured insofar as it was possible that the factors of environment would affect the two groups of samples in a similar manner.

A total of 99 shipmast locust trees in 21 stands and 93 common locust trees in 18 stands in Nassau and Western Suffolk Counties, Long Island, N. Y. were selected for this study (fig. 2).

DIFFERENTIATION OF MATURE TREES

BARK

The configuration of the bark was found to be the most generally useful character in mature trees for distinguishing the two forms. This is the general belief among Long Islanders and is mentioned by both Hicks (*7*) and Raber (*11*). Raber made a few measurements of the bark furrows of sample trees. This procedure was developed in

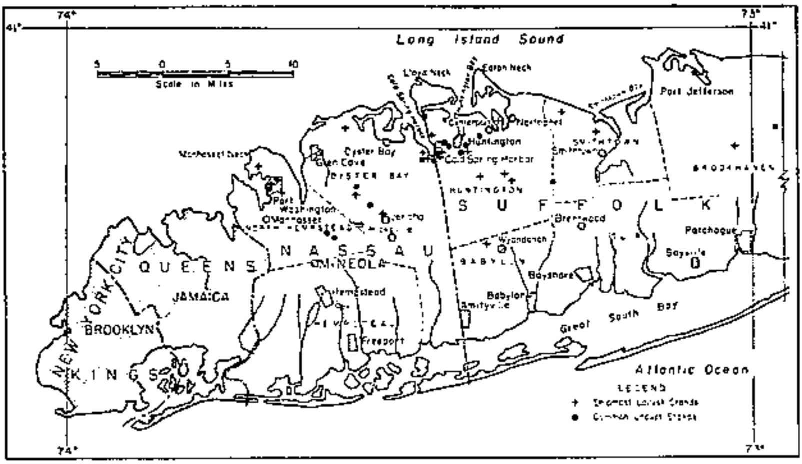

FIGURE 2.—Location of sample plots, Long Island, N. Y.

the present study to give a standardized practical method of differentiating the two types of bark.

The characteristic appearance of black locust bark results from separation of the tissues into elongated segments. Segmentation first becomes evident when the stem is about 4 inches in diameter. In common locust trees the outer bark continues to split as the stem grows in diameter. As a consequence, the individual segments and intervening furrows of the bark increase in number but not in size as the stem diameter becomes greater. The segments of shipmast locust bark, on the contrary, show less tendency to split. Thus as the stem diameter of the shipmast locust trees becomes greater the segments become wider and the intervening furrows proportionately deeper.

This fundamental difference in the process of bark accretion is the basis for the characters used in this study to distinguish between the bark of the two groups of samples. Since segmentation of the bark is not evident in stems up to 4 inches in diameter, the bark of common locust and shipmast locust trees in the juvenile stage is indistinguishable externally. After the segments have developed, the difference between the bark of the two groups of trees becomes increasingly apparent as the diameter of the stems becomes greater. This may be seen in figure 3. In the two 11-inch stems, the segments and furrows in the bark of the shipmast locust tree are more prominent than those in the bark of the common locust tree. The difference is even greater in the specimens that are 17 inches in diameter. This is plainly ascribable to the differences between the furrows and segments in the shipmast locust specimens; for in the larger of these the segments are wider and the furrows are deeper and longer, whereas in the two common locust specimens they are almost equally prominent.

The character of the bark of the trees in the two groups was analyzed in terms of the following four linear measures (fig. 4): Length of furrows (*A*), width of segments (*B*), depth of furrows (*C*), width of flat crests of segments (*D*). The recommended procedure in making these measurements is described on page 21. The difference between the shipmast locust and common locust groups of data in each of the four characters is shown graphically in figures 5, 6, 7, and 8.[6]

Of the four characters, three are positively correlated with stem diameter, E; the fourth, width of the flat segment crests, is not significantly correlated with stem diameter. In figures 5, 6, and 7 the solid lines indicate the average relation between the indicated bark character and the stem diameter of each group. The range of variation for the 1-percent limit of probability is shown by the broken lines. In figure 8 the 1-percent limit of probability is shown by lines above the histograms. The character of a bark sample may be ascertained by plotting the measured values in each chart and noting the affinity of these points to the mean trend lines and probability limits for the two groups of data.

FIGURE 3. Bark development in shipmast locust and common locust of comparable sizes: A, Shipmast locust, 11 inches d. b. h.; B, common locust, 11 inches d. b. h.; C, shipmast locust, 17 inches d. b. h.; D, common locust, 17 inches d. b. h.

In order to use the bark measurements more effectively for distinguishing between shipmast and common locust and to simplify the mechanics of comparison, the four measures have been combined with stem diameter into a multiple linear function that gives the maximum difference between the two groups of data.[7] This compound

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[6] The charts were constructed from over 7,000 field measurements. These data [illegible] in this bulletin, but are available for examination at the Washington Office of the [illegible] Conservation Service.

[7] Acknowledgment is made of [illegible] A. E. [illegible] Stations Division, Soil Conservation Service [illegible] by Fisher [illegible] and Martin [illegible] mean bark indices, Q, [illegible]

Diff. [illegible]

[illegible] E_1, E_2, E_3, E_4 [illegible] A, B, C, D, and E [illegible]

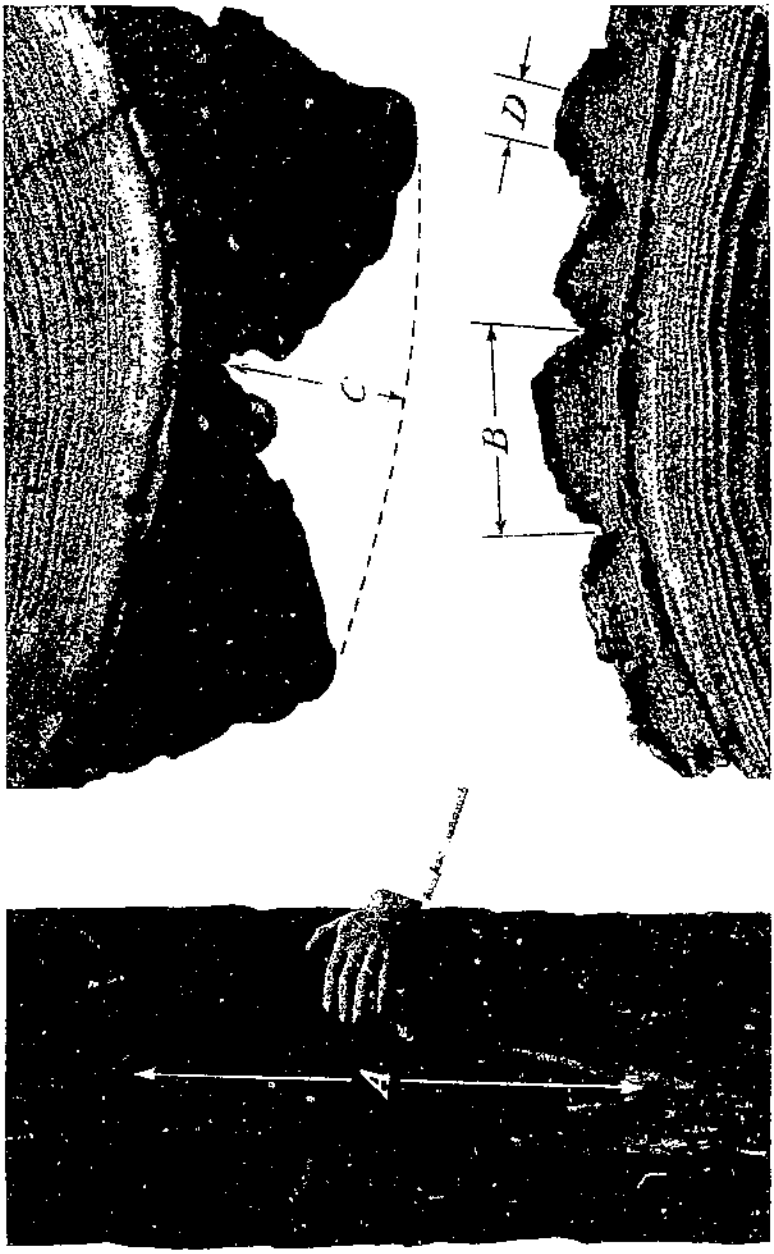

FIGURE 1.—Measurements of bark: *A*, Length of furrows; *B*, width of segments; *C*, depth of furrows; *D*, width of flat crests of segments.

measure of bark character is designated as the bark index, Q. The multiple function for bark index is expressed by the equation:

$$Q=0.1572A+0.0185B+0.1161C-0.1597D-0.0096E \quad (2).$$

The utility of the bark index in comparison with each of the four constituent bark measures is indicated in table 1.

TABLE 1.—*Percentage of 99 shipmast locust and 93 common locust trees differentiated by four individual bark measures and by the bark index, a compound function derived from these measures*

Measure	Trees differentiated	
	Shipmast locust group	Common locust group
Individual measures:	*Percent*	*Percent*
Length of furrows	79	58
Width of segments	66	42
Depth of furrows	70	46
Width of flat crests of segment	26	20
Compound measure:		
Bark index	96	83

The bark index calculated from the mean differences of the characters is 0.0836. This difference between groups is highly significant, as indicated by an analysis of variance between and within groups, which yielded an F-value of 81 (table 2).

TABLE 2.—*Analysis of variance of the mean bark index for a group of 99 shipmast locust trees and a group of 93 common locust trees*

Source of variation	Degrees of freedom	Sum of squares	Mean square
Between groups	9	0.3357	[1] 0.0373
Within groups	182	.0836	.000459
Total	191	.4193	

[1] $F=\frac{0.0373}{0.000459}=81$; $P=>0.01$.

The bark index is determined by substituting the values for each sampled tree in equation (2). The mean Q-value is 0.1520 for the 99 shipmast locust trees and -0.0222 for the 93 common locust trees. Since bark appearance is associated with stem diameter, the Q values for the 2 groups are correlated with stem diameter. The linear regression equations for the two groups of data are:

$$Q_{shipmast}=0.083+0.0050 \text{ times stem diameter, } SE_Q=\pm 0.0452 \quad (3);$$

$$Q_{common}=0.050-0.0058 \text{ times stem diameter, } SE_Q=\pm 0.0315 \quad (4).$$

These equations show that, at small diameters, trees of the two groups are hardly distinguishable; but since the regression is positive in the shipmast locust group and negative in the common locust

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group the difference between the mean *Q*-values for the two groups becomes greater as the stem diameter increases. The equations therefore are a mathematical expression of the field observation that the difference in the bark of the two groups of trees is more apparent in larger than in smaller trees.

Calculation of the bark index from equation (2) and comparison of the bark index with values computed from equations (3) and (4) are facilitated by use of the nomograph in figure 9. This chart permits classification of the two bark types by graphic means directly from the field measurements. The procedure used to determine the identity of a bark sample is described on pages 21–22.

Owing to the similarity in the external appearance of the bark of young trees, the *Q*-values for the two groups overlap at the smaller stem diameters. The range of overlap, which is delimited in the nomograph by the triangle *xyz*, includes approximately 50 percent of the trees at 6 inches d. b. h., 16 percent at 10 inches, and 1 percent at 16 inches. Bark samples falling within the range of overlap are not identifiable by means of the multiple bark measure. Those falling outside the range of overlap and within the range of variation for either group can be identified by this method.

Although bark is a character not ordinarily used for taxonomically differentiating variants of a species, it appears to offer a suitable basis for distinguishing the shipmast and common forms of black locust. A

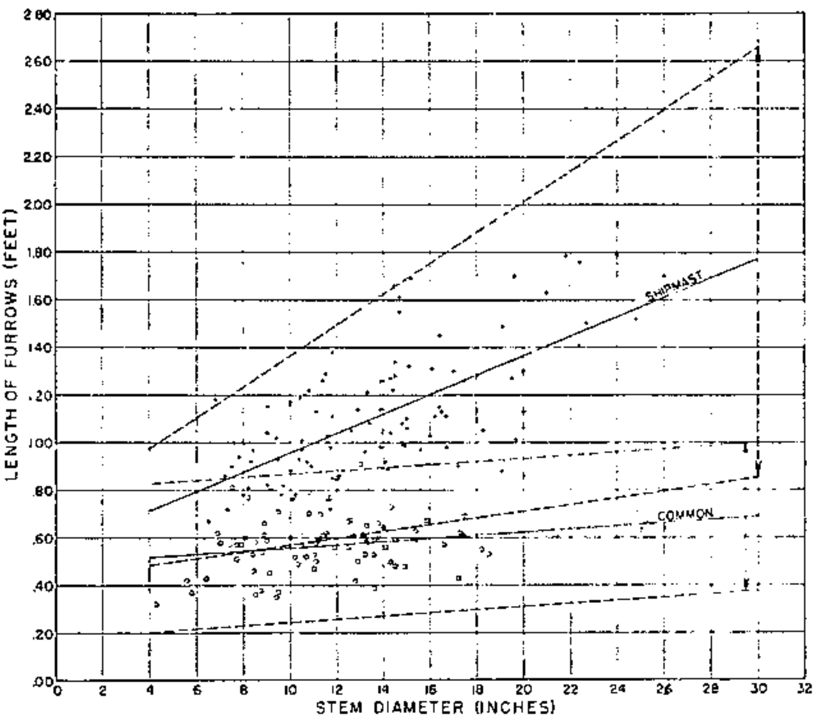

FIGURE 5.—Length of bark furrows in 99 shipmast locust (+) and 93 common locust (○) trees. The solid lines represent the regressions on stem diameter; the broken lines indicate the range of variation for the 1-percent limit of probability. The plotted value for each tree is the mean of 10 measurements.

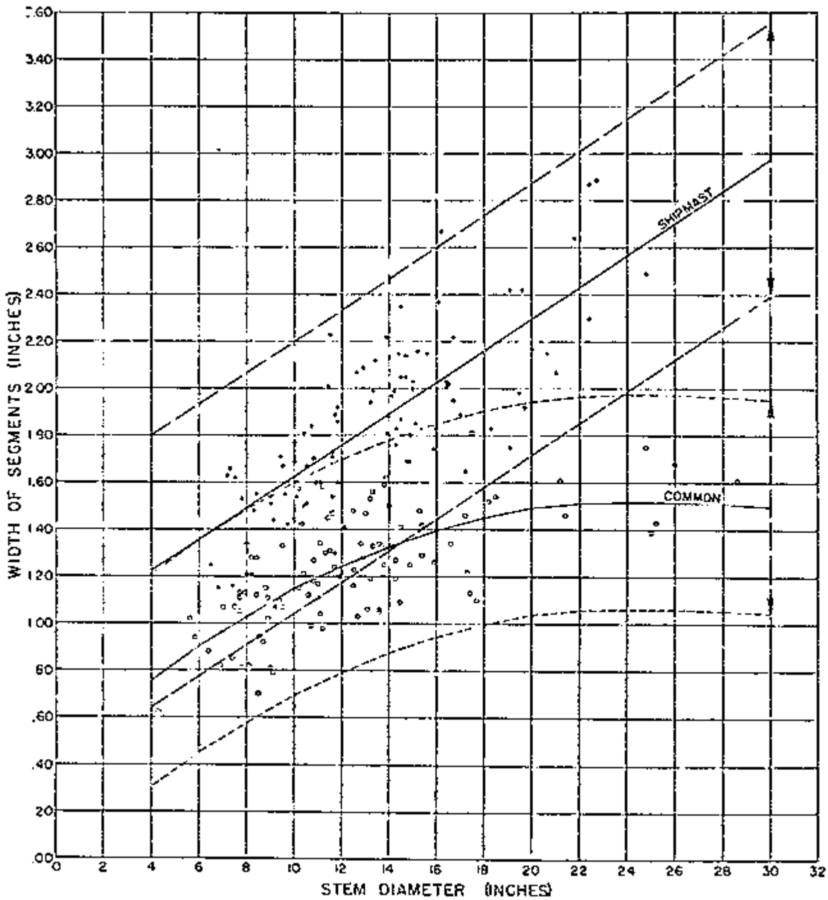

FIGURE 6.—Width of bark segments in 90 shipmast locust (+) and 93 common locust (○) trees. The solid lines represent the regressions on stem diameter; the broken lines indicate the range of variation for the 1-percent limit of probability. The plotted value for each tree is the mean of 10 measurements.

character, to be used successfully for taxonomic purposes, must be susceptible of objective description and should not be influenced essentially by environment. As shown above, the bark index, *Q*, supplies a numerical method of expressing the bark difference between the two groups, a difference that cannot be accurately described in qualitative terms. Furthermore, this difference between the two groups is not accounted for by environmental variations. This was determined by an analysis of variance of *Q* classified according to (1) stands, (2) soil types, (3) rate of diameter growth, and (4) rate of height growth. Significant differences were found between stands within both groups, but neither this source of variation nor any of the three other sources of variation accounted for the difference in the average *Q*-value between the two groups. Hence, despite variations that may have been associated with environment, the bark index proved to be an effective means of distinguishing shipmast locust from the common locust on Long Island.

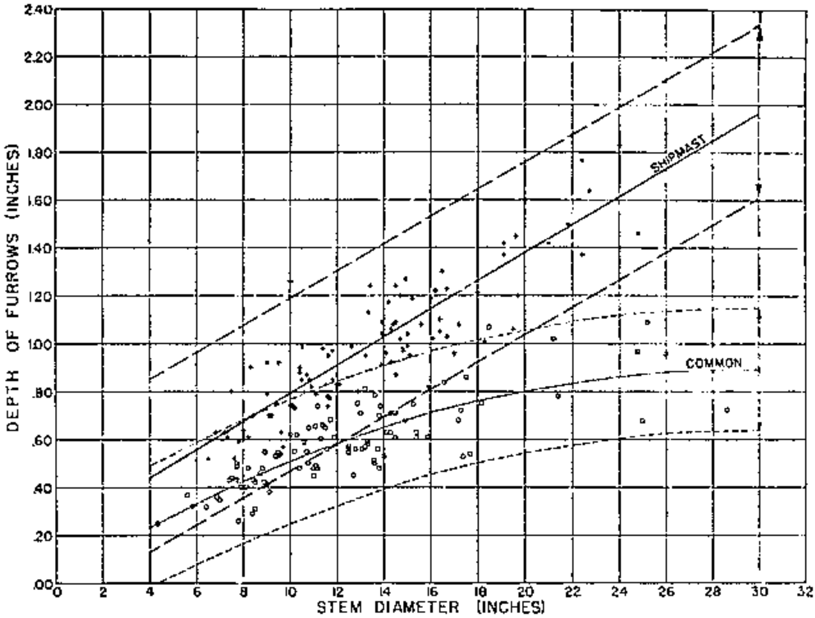

FIGURE 7.—Depth of bark furrows in 99 shipmast locust (+) and 93 common locust (○) trees. The solid lines represent the regressions on stem diameter; the broken lines indicate the range of variation for the 1-percent limit of probability. The plotted value for each tree is the mean of 10 measurements.

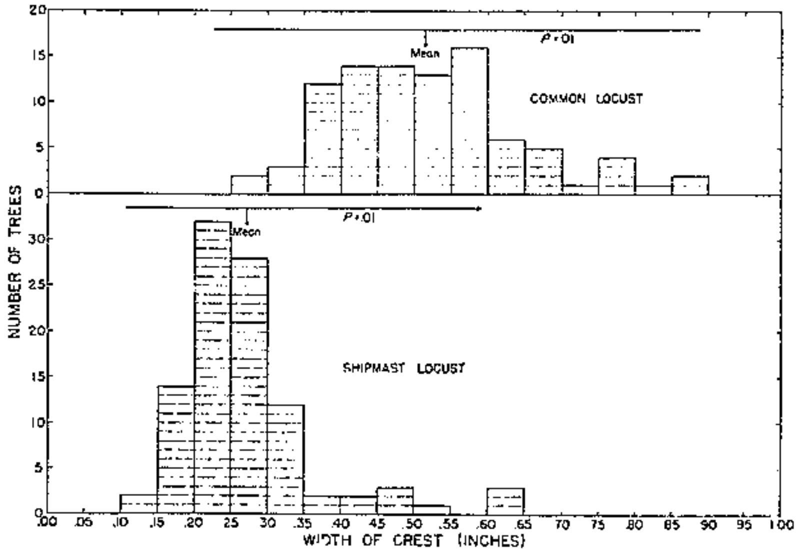

FIGURE 8.—Width of flat crests of bark segments in 99 shipmast locust and 93 common locust trees. Each block represents the mean of 10 measurements on a tree. For each group the range of variation for the 1-percent limit of probability is indicated by the line above the histogram.

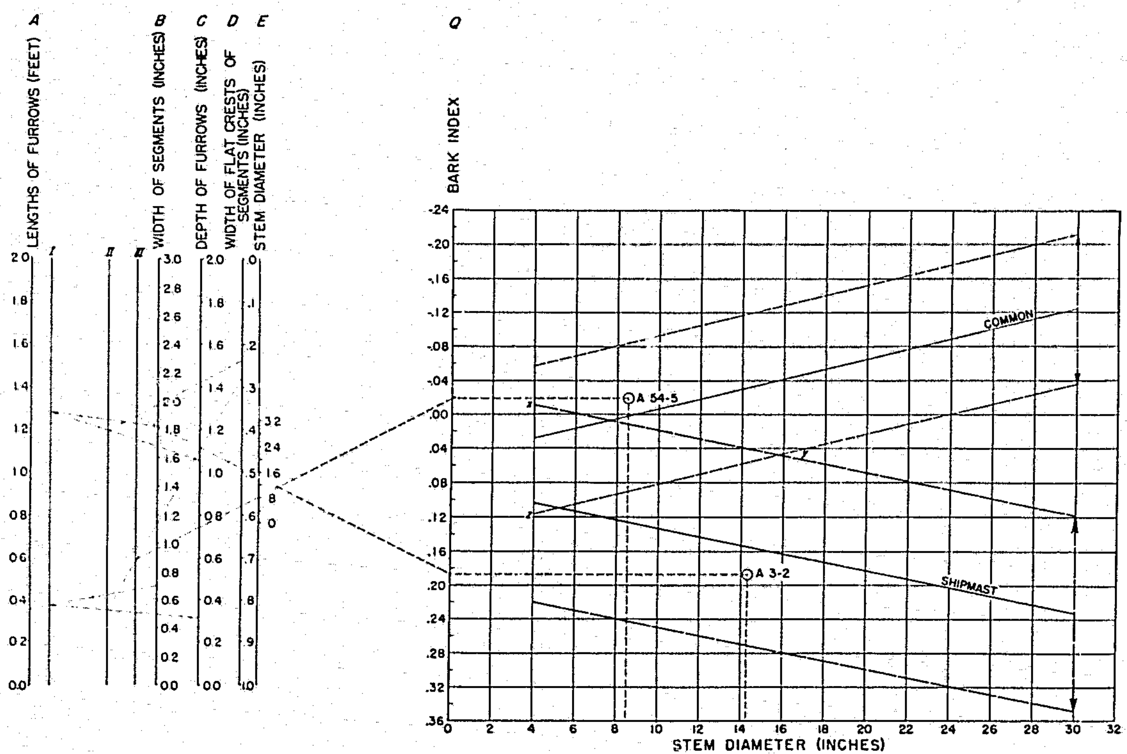

FIGURE 9.—Nomograph for discriminating between shipmast locust and common locust types of bark. The solid trend lines in the perpendicular scales indicate the regressions of bark index, Q, on stem diameter in the two groups. The broken lines indicate the range of variation for the 1-percent limit of probability. This chart has been developed from equations (2), (3), and (4).

Calyx Pigmentation

Raber (*11*) stated that the extent of calyx pigmentation is one of the distinctive characters of shipmast locust. This statement was confirmed in this study by examination of flowers in the same shipmast locust and common locust stands that had been selected for bark measurement. It was observed that the calyx of common locust flowers is tinged with red pigment over a considerable part of its surface, whereas the calyx of shipmast locust flowers is greenish yellow, with only a few red blotches. Occasional individual calyces on common locust trees are only slightly colored with red pigment, but the difference between the average pigmentation for individual trees of the two groups is pronounced.

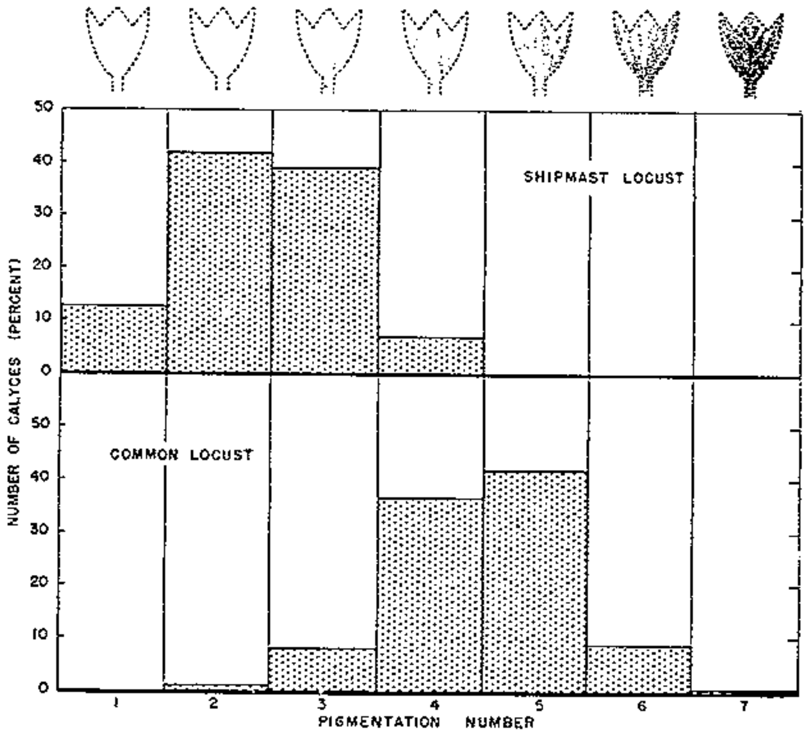

Figure 10.—Variation in the extent of red color on the surface of 631 shipmast locust calyces and 423 common locust calyces. The field standards for the 7 pigmentation numbers are shown above the histograms.

A numerical estimate of this character was made by the use of a scale that permits classification of calyces according to the extent of red pigment on the calyx surface. The scale was established by arbitrarily designating seven degrees of pigmentation. The field standards for the seven pigmentation numbers are shown in figure 10.

Since black locust flowers, particularly those on shipmast locust trees, are ephemeral, remaining on the trees but 1 to 3 days in the mature stage, the calyces of only a relatively few trees have been classified by means of the pigmentation scale. A total of 1,054 calyces have been so classified on 11 trees, 1 in each of 7 shipmast locust and 4 common locust stands (table 3). The data are subjected to analysis in table 4.

TABLE 3.—*Pigmentation of the calyx in 7 shipmast locust and 4 common locust stands*

Group and stand designation	Calyces counted	Calyces in pigmentation class—							Mean pigmentation class
		1	2	3	4	5	6	7	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Shipmast:									
A 11	85	15	45	24	1	0	0	0	2.1
B 28	25	6	12	6	1	0	0	0	2.1
A 18	113	17	55	37	4	0	0	0	2.3
A 5	144	24	47	64	9	0	0	0	2.4
A 10	94	8	45	38	3	0	0	0	2.4
A 1	112	6	47	54	5	0	0	0	2.5
B 13	58	4	15	26	13	0	0	0	2.8
Total	631	80	266	249	36	0	0	0	2.4
Common:									
A 51	128	0	2	14	53	56	3	0	4.3
A 53	113	0	0	8	61	30	5	0	4.4
A 55	92	0	1	12	34	40	5	0	4.4
B 52	90	0	0	1	13	49	27	1	5.2
Total	423	0	3	35	160	184	40	1	4.5

TABLE 4.—*Analysis of variance of calyx pigmentation for a group of seven shipmast locust stands and a group of four common locust stands*

Source of variation	Degrees of freedom	Sum of squares	Mean square
Between groups	1	1,173	[1] 1,173
Between stands within groups	9	69	7.7
Within stands	1,043	591	.567
Total	1,053	1,833	

[1] $F=\frac{1,173}{7.7}=152$; $P=>0.01$.

The utility of this character for distinguishing individual trees of each group is shown by the fact that the mean square between groups is significantly greater than the mean square between trees of each group.

The distribution of calyces on the pigmentation scale is shown in the frequency diagrams of figure 10. Most of the calyces of the shipmast locust group show only a slight amount of red color, and no calyces are more than moderately pigmented. The largest proportion of the calyces in the common locust group are considerably pigmented, and only a very few are slightly pigmented.

OTHER CHARACTERS

Shipmast locust trees differ from the common locust trees growing on Long Island also in the width of the sapwood and of the inner bark. These characters are not very effective, however, for differentiating individual trees, because the variance between observations within each group is large. Measurements of these characters are useful only as a further check on diagnoses made by other methods.

Since these characters are of minor value taxonomically, they will not be discussed at length. Measurements are conveniently made on fresh increment borings with a scale graduated in sixty-fourths of an inch. As the data are correlated with stem diameter, the mean values for the two forms of black locust may be expressed by the following regression equations:

Width of sapwood in sixty-fourths of an inch:
- Shipmast locust = 9.52 + 0.174 times stem diameter in inches.
- Common locust = 9.83 + 1.146 times stem diameter in inches.

Width of inner bark in sixty-fourths of an inch:
- Shipmast locust = 4.16 + 0.295 times stem diameter in inches.
- Common locust = 3.92 + 0.604 times stem diameter in inches.

The mean values for trees of several stem diameters are given in table 5, from which the affinity of any set of measurements can be judged. Values for trees of intermediate stem diameter can be readily calculated from the regression equations.

TABLE 5.—*Mean sapwood width and mean inner bark width based on measurements of 99 shipmast locust and 93 common locust trees*

Character	Standard error	Values for trees with stem diameters of—			
		5 inches	10 inches	20 inches	30 inches
Width of sapwood:		*1/64 inch*	*1/64 inch*	*1/64 inch*	*1/64 inch*
Shipmast	±3.4	10	11	13	15
Common	±8.1	15	21	33	44
Width of inner bark:					
Shipmast	±2.1	6	7	10	13
Common	±2.3	7	10	16	22

DIFFERENTIATION OF YOUNG TREES

Stipular Spines

Since the diagnostic characters mentioned above appear only in mature trees, they cannot be used to differentiate shipmast and common locust plants in the juvenile stage. Neither does the stem shape differentiate the two forms, because shipmast locust and common locust plants appear much alike when young. The typically excurrent shape of shipmast locust does not plainly develop until the trees are 10 to 20 feet tall.

The best external character for differentiating young trees of the two forms proved in the present study to be the shape of the stipular spines. Stipular spines can be observed only on young plants and on fast-growing shoots of mature trees, since slow-growing twigs in the crowns of mature trees are practically devoid of spines. Although the spines are annual and are produced only on the current year's growth, they usually remain on the stems several years before sloughing off.

The length of the stipular spines is not constant on a tree but is correlated with (1) position of the spine on the shoot, (2) length of the shoot, and (3) height of the shoot in the tree. The shape of the stipular spines, likewise, is related to the position of the spine on the

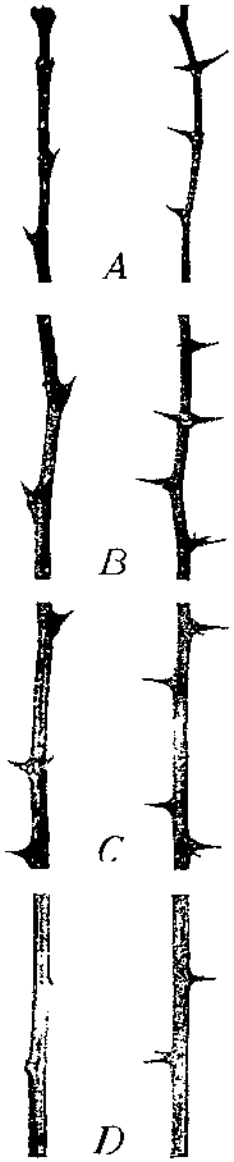

FIGURE 11.—Variation in the shape of stipular spines at four intervals along the length of the year's growth: A, Tip of shoot; B, 18 inches high on shoot; C, 9 inches high on shoot; D, base of shoot. The shoot on the left is from a shipmast locust tree, that on the right from a common locust tree. Approximately 0.5 natural size.

shoot. Figure 11 shows the spines on 1-year-old shoots of a shipmast locust and a common locust sprout, at the following four positions on the year's growth: The tip of the shoot, 18 inches high on the shoot, 9 inches high on the shoot, and the base of the shoot. These photographs illustrate the general relationship between the shape of the spine and its position on the shoot. The spines at the basal and apical extremities of the year's growth are relatively short and blunt; those in the midpart of the year's growth are the longest and narrowest. Despite differences in size and shape of the spines associated with variations in the growth of the shoot, there is a definite uniformity in the appearance of the spines on a single tree.

The spine shape of the 2 groups was studied on fast-growing sprouts, 2 to 4 feet long, collected from the base of 46 mature shipmast locust trees in 20 stands and 37 mature common locust trees in 15 stands. To compare twig specimens, the longest, best-developed spines were used. It was found that the spines of shipmast locust trees are characterized by an ogee or double-recurved ventral margin. The dorsal margin is concave to straight. The spines of nearly all shipmast locust specimens are slightly acute and of moderate length, 0.2 to 0.6 inch. Spines notably different from this type were found in only 1 stand, near Wyandanch, N. Y. The spines on the trees in this stand possess the typical double-recurved ventral margin of shipmast locust spines but are reflexed and 0.8 inch long. The variation in spine shapes among the shipmast locust trees is shown in figure 12, A.

The common locust trees on Long Island show a wide assortment of spine shapes. The spines are straight or curved and vary from subulate to acicular. On different common locust trees they vary in length and width, in the shape of the apex, in the shape of both dorsal and ventral margins, and in the angles of axillary and transaxillary insertion. Examples of spine variations among common locust trees are shown in figure 12, B.

The spines from 3 of the 37 common locust trees are similar to those on the shipmast locust trees. Since most common locust trees on Long Island possess spines of other shapes, however, this character distinguishes the greater number of these trees from shipmast locust trees.

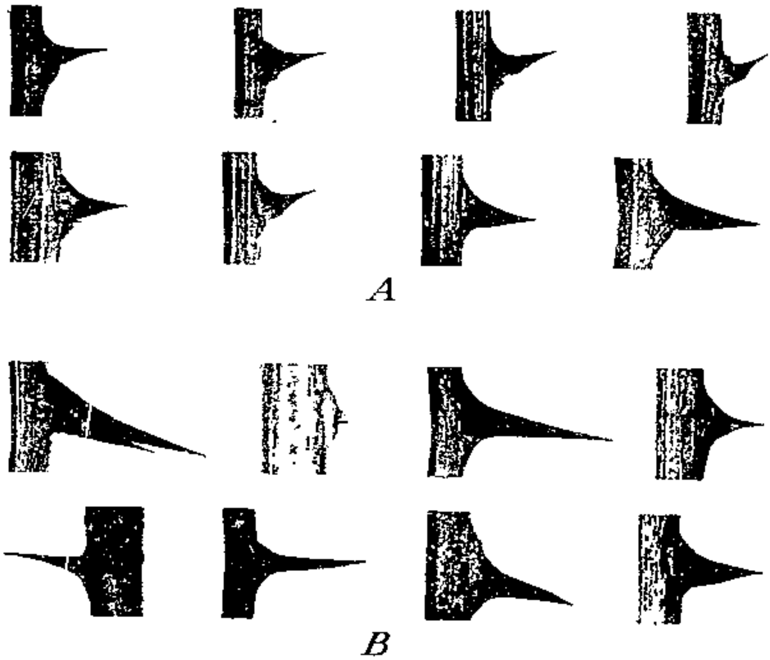

FIGURE 12.—Stipular spines from fast-growing, 1-year-old shoots, showing the range of variation in shape: *A*, Shipmast locust. The spines uniformly have a double-recurved ventral margin and are 0.2 to 0.6 inch long. An exception was found in a group of shipmast locust trees growing near Wyandanch, N. Y. The spines from these trees are reflexed and 0.8 inch long. One of these spines is shown at the extreme right in the lower row. *B*, Common locust. In contrast to the uniformity in spine characters among shipmast locust trees, the spine shapes vary considerably among different common locust trees. Although the spines of most common locust trees are distinct from those borne on shipmast locust trees, a few have been found that are indistinguishable from the shipmast locust type. One of these spines is shown at the extreme right in the lower row. Approximately 0.75 natural size.

LEAVES

The leaflets of young shipmast locust plants are ovate (fig. 13, *A*). This characteristic can best be seen on leaflets from the midpart of the leaf, since ordinarily those toward the extremities are more variable. The apex of shipmast locust leaflets is emarginate but not at all, or only slightly, mucronate. Stipels are usually lacking, but they may be present on large, fast-growing leaves. When present, they are always less than one-sixteenth of an inch long.

The leaflets of young common locust trees are of various shapes. Although they may be similar to those of shipmast locust trees, in roughly 50 percent of the common locust trees examined the leaflets at the midpart of the leaf have other shapes. Figure 13, *B* shows the usual leaflet shape found on common locust trees whose leaflets differ from the shipmast locust type. This leaflet is elliptical, with a mucroemarginate apex and a well-developed stipel. Although leaflet shape is not a constant diagnostic character, it has proved useful for distinguishing some of the common locust trees from the shipmast locust group.

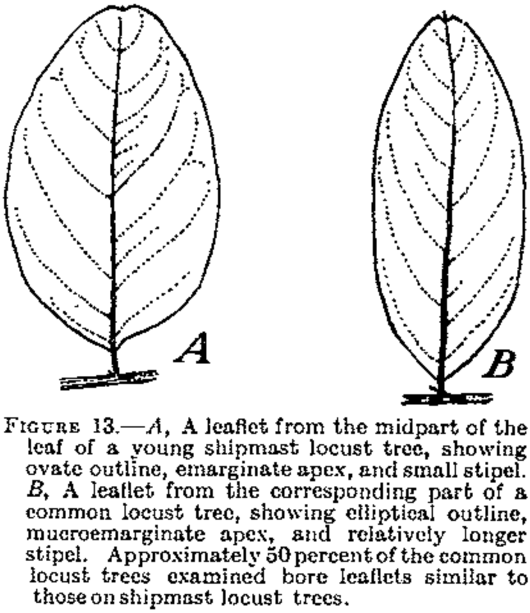

FIGURE 13.—*A*, A leaflet from the midpart of the leaf of a young shipmast locust tree, showing ovate outline, emarginate apex, and small stipel. *B*, A leaflet from the corresponding part of a common locust tree, showing elliptical outline, mucroemarginate apex, and relatively longer stipel. Approximately 50 percent of the common locust trees examined bore leaflets similar to those on shipmast locust trees.

DISCUSSION

The data given in this bulletin indicate that the shipmast form of black locust has definite and constant botanical characters. These characters differentiate shipmast locust from the common form of black locust under a variety of site conditions throughout the range of shipmast locust on Long Island. Outside Long Island, black locust trees that are similar in shape to shipmast locust trees have been found over an extensive area in the Northeastern States. Measurement of the bark of these trees and examination of their spines and leaves reveal that they possess the same distinguishing botanical characters as the shipmast locust trees on Long Island. Since the differences between the two forms over a wide geographical range are apparently not associated with site, these differences seem to be hereditary and not environmental. This evidence, therefore, substantiates the proposition that shipmast locust is a distinct botanical variant of black locust. Shipmast locust can be identified by four associated characteristics (bark, calyx, leaf, and stipular spine) in the manner described in this bulletin, regardless of variations in shape and growth rate that may be induced by environmental factors.

In ascertaining the phylogenetic relationship of the shipmast variant to the species of black locust as a whole, the spine and leaf characters described in this bulletin are significant. Spine and leaf shapes have been found to be clonal characters for black locust. This was determined from experimental plantings established by the Soil Conservation Service in which shipmast locust and other selections of black locust were grown in adjoining rows. In these plantings, clones established by vegetative propagation from individual trees were found to possess uniform spine and leaf characters, whereas marked differences were found in the shape of spines and leaves between different clones and between trees grown from seed. This observation explains the diversity in these characters among the common locust trees on Long Island, in which the production of seed permits the exchange of genetic factors. Shipmast locust trees, on the contrary, have been found to possess a uniform type of spine and leaf, except for the trees in the stand at Wyandanch, N. Y. Aside, therefore, from this one stand of trees, all the shipmast locust trees observed in this study appear to comprise a single clone.

Further evidence bearing on the phylogenetic status of shipmast locust is provided by its cultural history. According to available historical information, all the shipmast locust trees on Long Island have been grown from a single introduction (*3*). Shipmast locust trees fail to produce seed in any notable quantity; hence they could have been propagated only by vegetative methods (*12*). It would seem very likely, therefore, that the many thousands of shipmast locust trees on Long Island are in fact but one clone.

Of the two principal characters by which mature shipmast and common locust trees can be distinguished, the bark is the more suitable for diagnostic purposes since it can be easily measured in all seasons of the year, whereas the calyces can be examined during only a few days in the spring and are difficult to observe on tall trees. None of the mature common locust trees observed in this study have the distinctive, heavily furrowed bark that is characteristic of shipmast locust. However, the bark index alone is not sufficient for the identification of shipmast locust, since black locust trees can be found, especially within the native range of the species, that have thick bark but belong to other clones. It is important to determine the clonal identity of individual thick-barked black locust trees inasmuch as the superior economic qualities of shipmast locust are not as yet known to be associated with any other clone. Whether or not black locust trees that have the shipmast locust bark index belong to the shipmast locust clone would be indicated by a comparison of their spine and leaf characters with those described in this bulletin for the shipmast locust trees on Long Island.

Although spine and leaf shape can be used to determine whether mature thick-barked locust trees belong to the shipmast locust clone, their use for identifying young plants, for which the bark index cannot be determined, is not entirely satisfactory; for the spine and leaf shapes associated with shipmast locust are occasionally found also on common locust trees. Hence, the character of neither the spines nor the leaves is genetically linked to tree shape. These characters are useful, however, in permitting one to recognize by rapid inspection any young trees that definitely are not shipmast locust. Further studies are being made to establish methods, based on internal structural characters, for differentiating shipmast locust more accurately in the juvenile stage.

STANDARDIZED PROCEDURE FOR DETERMINING BARK TYPE

The identification of shipmast locust and common locust bark by the method described in this bulletin is a relatively simple procedure that can be followed without involved mathematical computation. The procedure consists in making 10 measurements of each of 4 bark characters on the sample tree and plotting the average of these values on a chart. The position of the derived point indicates whether the bark is characteristic of the shipmast or the common locust group.

When the bark is measured, care must be taken to obtain a representative sample of the bark characters. This is accomplished by measuring 10 consecutive segments and furrows around the circumference of the stem, beginning with any segment selected at random and breaking the sequence only to avoid branches and prominent bark wounds.

A diameter tape is placed around the tree at breast height, and only segments and furrows intercepted somewhere within their length by the tape are measured, in the following standardized manner (fig. 4):

Length of Furrows.—The mean of 10 measurements, made with a scale graduated in tenths of a foot, is obtained for each tree. The distance measured is the vertical extent of the furrows, which are formed by transverse separation of the bark tissues.

Width of Segments.—The mean of 10 measurements, made with a scale graduated in tenths of an inch, is obtained for each tree. The distance measured is the horizontal, tangential extent of each segment, from the deepest point in one furrow to the deepest point in the adjoining furrow. Measurements are made at about the midpoint of the length of the furrows, not at the apices of the furrows, where adjoining segments fuse.

Depth of Furrows.—The mean of 10 measurements, made with a scale graduated in tenths of an inch, is obtained for each tree. A thin, narrow scale, which can be inserted to the deepest point of the furrow, is employed. The depth of each furrow is estimated by holding the scale in a horizontal, radial position with the zero mark of the scale in the deepest part of the furrow. The scale is read at the point where it is intercepted by a line extending across the furrow from the crests of the adjoining segments. The location of this line is facilitated by drawing the diameter tape tightly around the tree so that it touches the crest of each segment.

Width of Flat Crests of Segments.—The mean of 10 measurements, made with a scale graduated in tenths of an inch, is obtained for each tree. The distance measured is the horizontal, tangential extent of the flat surface on the crest of each segment. The measurements are made at approximately the midpoint of the length of the furrows, not at the apices of the furrows, where segments adjoin.

Stem Diameter.—Measurements are made in inches and tenths of an inch at breast height with a steel diameter tape.

The data obtained from the sample tree are plotted on the nomograph in figure 9 in the following manner:

(1) The value for length of furrows is located on axis *A*, and a line is drawn from this point to the value for width of segments on axis *B*, thus locating a point *ab* on the reference axis *I*.

(2) A line is then drawn from point *ab* to the value for depth of furrows on axis *C*, thus locating a point *abc* on reference axis *II*.

(3) In like manner, a line is drawn between *abc* and the value for width of flat crests of segments on axis *D*, thus locating a point *abcd* on reference axis *III*.

(4) From point *abcd* a line is projected through the value for stem diameter on axis *E* to intersect axis *Q*, thus locating the value for bark index.

(5) The computed value for the bark index is then projected horizontally on the rectangular diagram to the intersection with the independent ordinate for stem diameter. The position of the derived point in relation to the regression lines for shipmast locust and common locust indicates the affinity of the bark specimen. The arrows indicate the variation for the 1-percent limit of probability.

To illustrate the procedure, the identification of a shipmast locust and a common locust tree is worked out on the chart. The measurements are given in table 6. The data from tree No. A 3-2 yield a *Q*-value of 0.183, which, when projected on the perpendicular scales to the stem diameter of the tree, 14.3, proves to be within the probable range of shipmast locust and outside the probable range of common locust. The data from tree No. A 54-5 yield a *Q*-value of −0.019, which is within the probable range of common locust and outside the probable range of shipmast locust at 8.5 inches d. b. h.

This procedure for the identification of the two types of bark is an objective method that can be used readily after a little practice. By this means it is possible to combine measurements of four bark characters into one value that differentiates a greater percentage of trees than does the measurement of any one character when used by itself.

TABLE 6.—*Field measurements of a shipmast locust and a common locust tree, and the bark index computed from these measurements on the nomograph in figure 9*

Group	Tree No.	Measurements of —					Computed bark index, *Q*
		Length of furrows	Width of segments	Depth of furrows	Width of flat crests of segments	Stem diameter	
		Feet	*Inches*	*Inches*	*Inch*	*Inches*	
Shipmast	A 3-2	1.27	1.83	1.06	0.23	14.3	0.183
Common	A 54-5	0.36	0.70	0.31	0.27	8.5	−0.019

SUMMARY

External differences between the common form of black locust and an erect form known as shipmast locust are described. Because of its superior economic qualities, shipmast locust appears to be a promising form for farm planting.

The data given indicate that shipmast locust, which occurs on Long Island, N. Y., is a distinct taxonomic variant of black locust. Shipmast locust possesses definite morphological characters regardless of the site on which it grows.

In the juvenile stage, the character of the leaves and stipular spines is the only external means of differentiating trees of the two groups. Shipmast locust plants have uniformly a double-recurved ventral margin on the stipular spines and ovate leaflets with emarginate apices and poorly developed stipels. Young trees cannot always be identified with certainty, however, since some common locust plants have spine or leaf characters like those of shipmast locust. These characters are variable in common locust trees, but the greater

number have spine or leaf shapes different from those of the shipmast locust group. A study now in progress promises to furnish a method, based on internal structural characters, for differentiating small trees of the two groups.

Individual trees of the two groups can be differentiated with greater certainty in the mature stage. Trees over 4 inches d. b. h. are distinguishable by means of the bark index, a compound numerical expression that differentiates the heavy, thick-ridged bark of shipmast locust from the thinner bark of common locust. Whereas it is often difficult, without considerable previous experience, to judge this difference qualitatively, the bark index permits objective determination of even small differences between the bark of sampled trees. In order to facilitate classification of the bark type in the field without mathematical computation, a simple linear nomograph is used. This nomograph differentiates approximately 50 percent of trees 6 inches d. b. h. and 99 percent of trees 16 inches d. b. h.

Other characters for differentiating mature trees of the two groups in the field are calyx pigmentation, width of sapwood, and width of inner bark. The first character is classified according to a pigmentation scale, and the other two characters are described by formulas.

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