BLACK LOCUST

Black locust, one of the heaviest woods grown commercially in the United States, is rated high in durability, strength, shock resistance, hardness, and nail-holding ability. The wood turns well in a lathe but is difficult to work with hand tools. Its durability under conditions favorable to decay makes black locust ideal for fence posts. It has further but limited use as mine timbers, insulator pins, and treenails for ship construction.

U.S. Department of Agriculture Forest Service
American Woods—FS-244 Revised January 1971

BLACK LOCUST

(*Robinia pseudoacacia* L.)

R. H. McAlister [1]

DISTRIBUTION

Black locust is native to the Appalachian Mountains from Pennsylvainiato northern Georgia and Alabama and to the Ozark Mountains of southern Missouri, Arkansas, and eastern Oklahoma. It is also found in southern Illinois and Indiana (fig. 1).

Cover: F–310010

This species has been extensively naturalized in the eastern half of the United States—west and south from Maine–and in southern Canada. In Oregon and other far western states, where it was introduced for use as fence posts, it has escaped from cultivation.

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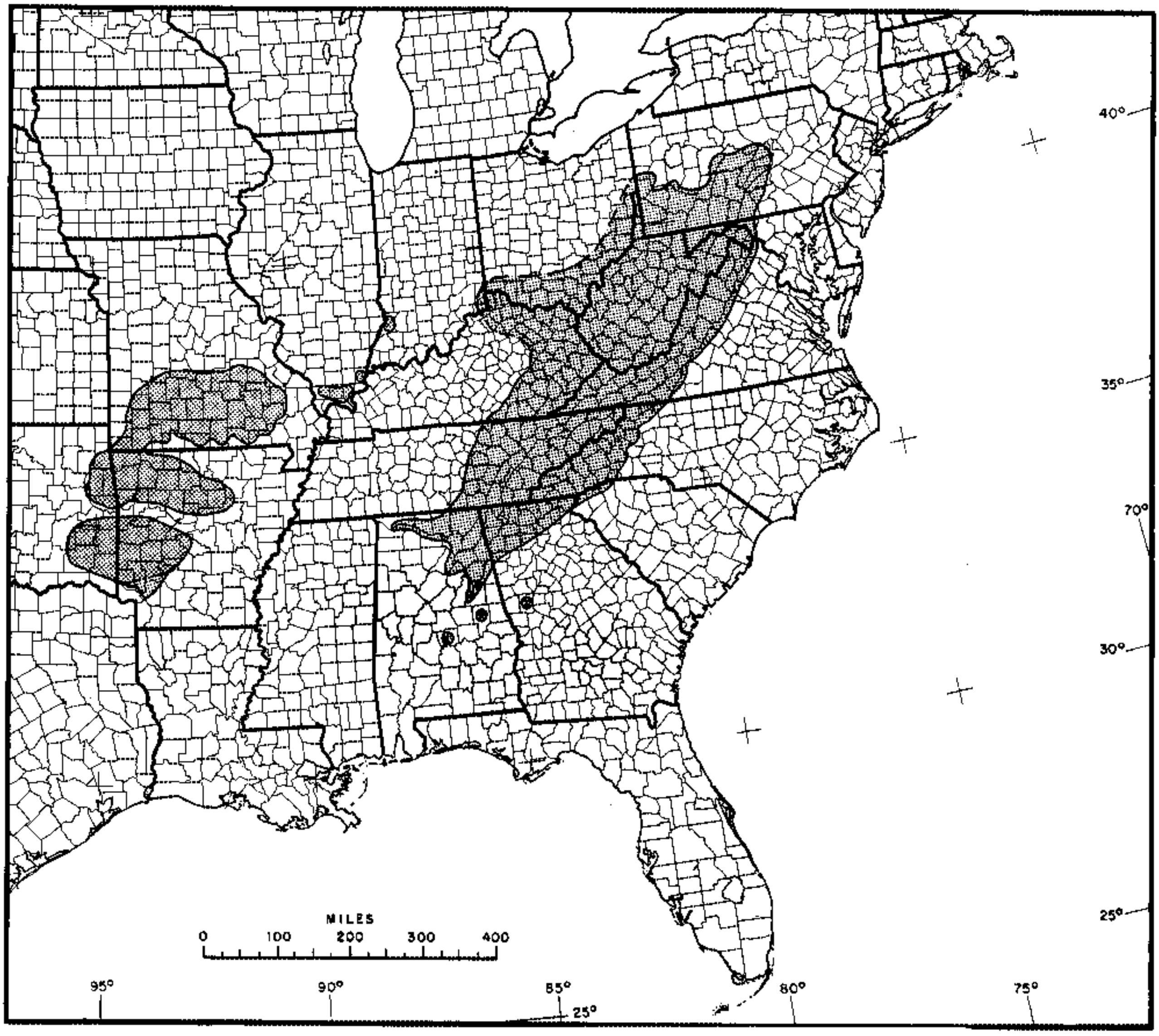

Figure 1.–The range of black locust, *Robinia pseudoacacia* L.

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Within its original natural range, black locust generally occurs below 3,500 feet elevation in association with black oak, red oak, chestnut oak, pignut hickory, yellow-poplar, and maple. Along streams it is found with ash, maple, and black walnut. In the western part of the Appalachian Mountains it grows in association with the various hard pines such as pitch pine, shortleaf pine, Table-Mountain pine, and Virginia pine. The species shows its best development in West Virginia.

DESCRIPTION AND GROWTH

Black locust grows to a height of 40 to 100 feet and a diameter of 1 to 3 feet. The stem is generally straight and clear in a forest stand, but in the open it is likely to fork and become limby (see cover).

Black locust is characterized by the paired sharp spines or stipules about one-half inch long that develop at the base of each leaf. Leaves are compound-pinnate, 8 to 14 inches long, with seven to 23 leaflets. The oval leaflets are 1 to 2 inches long and end in a minute sharp point. The white to pink flower clusters, 4 to 5 inches long, appear in the spring and have a heavy fragrance that is quite pleasant (fig. 2). The flat brown seed pods, a half-inch wide and 2 to 4 inches long, mature in the fall. Bark of the mature tree is brownish-gray, thick, and deeply furrowed into forked ridges (fig. 3).

Black locust attains best growth on sites without a pronounced subsoil. Limestone base soils are especially favorable. The tree is intolerant of shade and is seldom found in dense forests except as a dominant tree. When it has room to become established, its rapid growth enables it to compete successfully with the more tolerant species.

Black locust stands encroach on farmlands and burned-over areas by root suckering. These suckers appear in the fourth or fifth year of growth. Heavy crops of seed are produced, normally at 2-year intervals, but natural reproduction is primarily by root suckers because the heavy, impermeable seed coat restricts germination. Injury to the parent plant or disturbing the root system increases both the number and vigor of suckers. Sprouts can be controlled effectively by herbicides.

One variety has been recognized; namely, shipmast locust *(Robinia pseudoacacia* var. *rectissima* Raber), originally discovered on Long Island, N.Y., in the midthirties and since found throughout New England. This variety is a poor seed producer and propagates almost entirely by vegetative means. It differs from the typical species in having a straighter stem, greater resistance to attack by borers, and greater resistance to decay. Plantations of shipmast locust grown in the Central States do not have the desirable characteristics of the species grown in New England.

COMMON NAMES

Black locust is the name commonly used, but the species is also called yellow locust, locust, post locust, and shipmast locust.

RELATED COMMERCIAL SPECIES

The other species of *Robinia* which occur in the United States are not commercially important. The only other arborescent is clammy locust *(Robinia viscosa* Vent.). Clammy locust is widely planted a3 an ornamental. The wood is not distinguishable in trade from that of black locust.

SUPPLY

The total supply available in the forest inventory seems adequate to meet future demands. Inventory of the supply of black locust in 21 States, made between 1953 and 1965, totaled 495.6 million cubic feet. North Carolina, Virginia, Pennsylvania, and Kentucky were leading producers and collectively provided approximately 70 percent of the indicated supply. Tennessee and Maryland accounted for an additional 17.5 percent.

PRODUCTION

Generally black locust should be cut at an early age (20 to 30 years) since trees mature early. The locust borer *(Megacyllene robiniae)* often attacks the tree; this weakens the tree and makes it unfit for most commercial uses. A secondary attack by heart rot *(Fomes rimosus)* is usually fatal to trees already weakened by borer attack.

Production of black locust fluctuates considerably, but the general trend is decreasing because many uses of the wood are being lost to competing materials. In 1960 about 2.3 million board feet of black locust was used in all manufacturing industries. This was approximately one-half of the amount used in 1940 and about one-fourth of that used in 1928.

Use of black locust lumber in manufacturing in 1960 was mainly in two categories: lumber and wood products (including hardwood dimension and flooring), about 70 percent; and household furniture, about 30 percent.

Most black locust produced today is used for fence posts. Since most of the harvesting and marketing of these posts is done by small operators who sell directly to consumers, figures for production are only rough estimates. Production of fence posts in nine states where this industry is important was estimated in the years 1961 through 1965. West Virginia led, with 1,315,000; Kentucky was second with 1,100,000; all others combined totaled 1,290,000.

CHARACTERISTICS AND PROPERTIES

The outstanding characteristic of black locust is the durability of its heartwood when used under conditions favorable to decay. The wood is quite heavy; density at 15-percent moisture content is 49 pounds per cubic foot. Despite its high density, the wood has moderately small shrinkage and stays in place well. It is exceedingly strong in bending; its modulus of elasticity is more than two million p.s.i. It is one of the

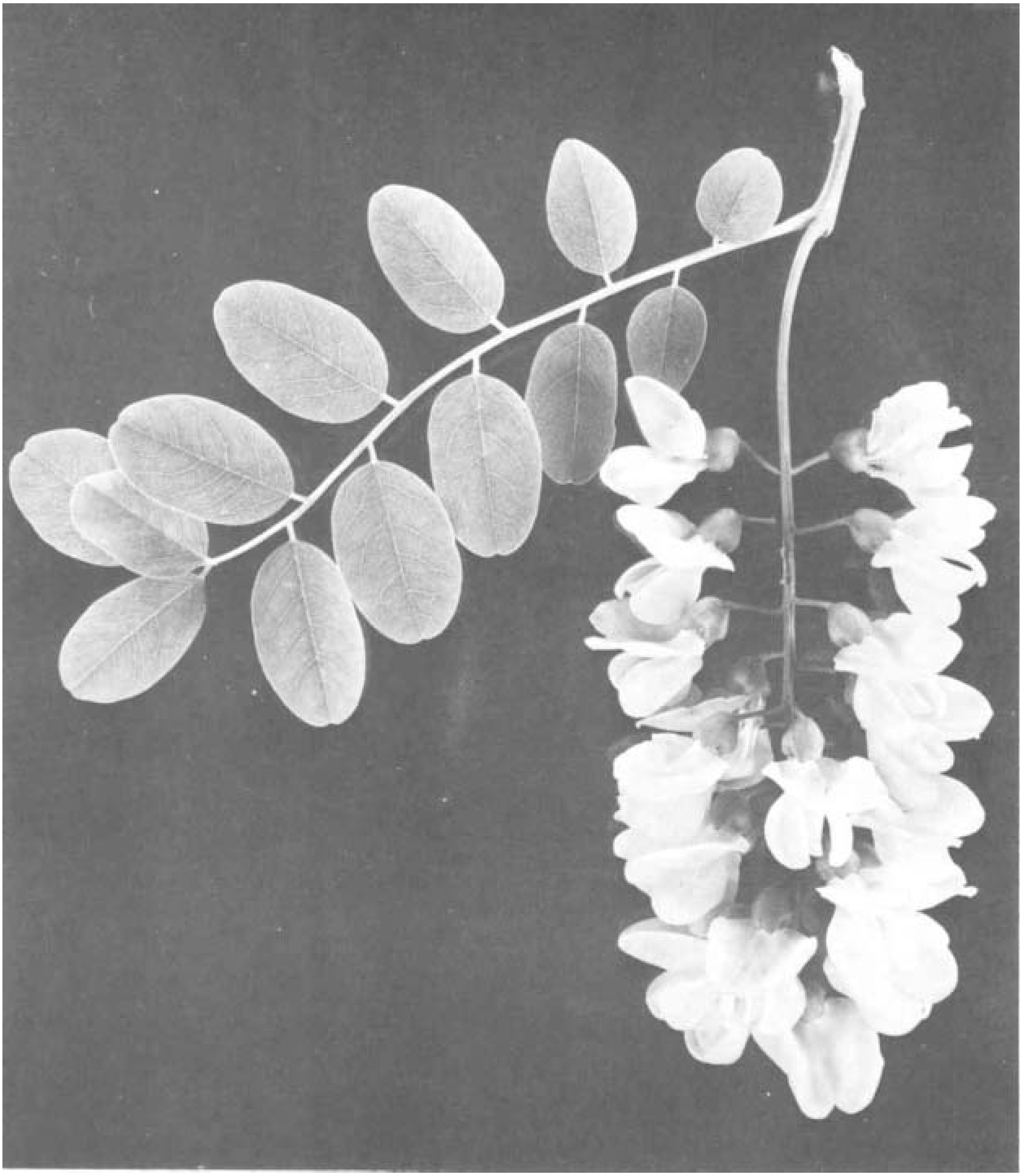

Figure 2.–Leaves and flowers of black locust. F-490937

hardest American woods. Its shock resistance is quite high but does not equal that of the true hickories.

The heartwood of black locust, when freshly cut, varies in color from greenish-yellow to dark brown. It turns to a dark russet brown after exposure to air. The narrow sapwood is a creamy white. The wood is often confused with that of Osage-orange *(Maclura pomifera).* However, shavings of Osage-orange placed in water leach a yellow dye but black locust shavings do not. Another positive means of separation is the presence of vestured intervessel pits, which do not occur in Osage-orange.

Figure 3.–Bark of black locust. F–236611

The wood turns well in a lathe but is rather difficult to work with hand tools. It holds nails well, and it has no distinct taste or odor.

Large, clear, straight-grained pieces are not common since the trees are frequently limby and crooked. The wood usually contains holes made by borers, as well as knots and cross-grain. Bird pecks cause discoloration of the wood but do not affect it otherwise.

PRINCIPAL USES

Black locust trees have been planted extensively on land strip-mined for coal because they survive better on the acid spoil banks than any native species. The extensive root system and the nitrogen-fixing capability of this member of the *Leguminosae* aid in reclaiming the land and in preventing erosion. In addition, black locust has been rated superior in developing wildlife habitat on wasteland.

Black locust wood can be used wherever durability, strength, and dimensional stability are important. It is a preferred wood for farm fencing because of its natural durability and nail-holding ability. In recent years, though, much of this market has been captured by dependable supplies of treated pine posts.

Great quantities were formerly used in manufacturing insulator pins, but increasing use of underground cable and the development of a suitable steel insulator pin have greatly reduced this market.

Black locust is used in manufacturing some domestic furniture, but this use is limited by lack of dependable supplies of high grade material, the weight of the wood, and the difficulty of working it with hand tools. It has limited use for mine timbers and for treenails in ship construction.

REFERENCES

Betts, H. S.
1969 (rev.). Black locust. USDA Forest Serv. Forest Products Laboratory. 4 p.

Brown, Harry P., Panshin, A. J., and Forsaith, C. C.
1949. Textbook of wood technology. Vol. I. 652 p., illus. New York: McGraw-Hill Company.

Gill, Thomas G., and Phelps, Robert B.
1969. Wood uses in manufacturing industries, 1965. USDA Forest Serv. Sta. Bull. 440, 101 p., illus.

Harlow, William M., and Harrar, Ellwood S.
1968. Textbook of dendrology. 5th ed. 512 p., illus. New York: McGraw-Hill Company.

Little, Elbert L., Jr.
1953. Checklist of native and naturalized trees of the United States (including Alaska). U.S. Dep. Agr., Agr. Handb. 41. 472 p.

Record, S. J., and Hess, R. W.
1943. Timbers of the new world. 640 p., illus. New Haven: Yale Univ. Press.

Roddis Plywood Corporation.
1956. Characteristics of modern woods. 64 p., illus.

Sargent, Charles Sprague.
1962 (rev.). Manual of the trees of North America. Vol. II, 910 p., illus. Magnolia, Mass.: Peter Smith, Inc.

U.S. Department of Agriculture.
1949. Trees: the yearbook of agriculture, 1949. 944 p., illus.

USDA Forest Products Laboratory.
1955. Wood handbook. USDA Forest Serv. Agr. Handb. 72, 528 p., illus.

USDA Forest Service.
1958. Timber resources for America's future. U.S. Dep. Agr. Forest Res. Rep. 14. 713 p., illus.

———
1965a. Silvics of forest trees of the United States. U.S. Dep. Agr., Agr. Handb. 271. 762 p., illus.

———
1965b. Timber trends in the United States. U.S. Dep. Agr. Forest Res. Rep. 17. 235 p., illus.

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Robinia pseudoacacia

Family: Leguminosae

Black Locust

Robinia is a genus of about 10 species native to eastern North America and Mexico. The genus *Robinia* is named for Jean Robin (1550-1629) and his son Vespasian Robin (1579-1662), herbalists to kings of France and first to cultivate locust in Europe.

Robinia kelseyi-**Kelsey Locust**

Robinia neomexicana-Locust, Mexican Locust, New Mexican Locust, New Mexican Robinia, **New Mexico Locust**, Southwestern Locust, Thorny Locust, Western Locust

*Robinia pseudoacacia**- Acacia, Bastard Locust, Black Laurel, **Black Locust**, Common Locust, Common

Robinia, False Acacia, False Black Locust, Green Locust, Honey Locust, Locust, Peaflower Locust, Post Locust, Red Locust, Robinia, Shipmast Locust, White Locust, White Honey-flower, Yellow Locust

Robinia viscosa-Black Locust, Clammy-bark Locust, **Clammy Locust**, False Acacia, Honey Locust, Red Locust, Red-flowering Locust, Rose Acacia, Rose-flowering Locust

* commercial species

Distribution

Black Locust is native to the Appalachian Mountains from Pennsylvania to northern Georgia and Alabama and to the Ozark Mountains of southern Missouri, Arkansas and eastern Oklahoma. Also in southern Illinois and Indiana. It has been extensively naturalized in the United States and Canada.

The Tree

Black Locust reaches heights of 100 feet, with a diameter of 3 feet.

The Wood

General

The sapwood of Black Locust is a creamy white, while the heartwood varies from a greenish yellow to dark brown. It turns a reddish brown when exposed to the air. The wood is often confused with Osage Orange (*Maclura pomifera*). It has a high density and decay resistance. It shows slight shrinkage and stays in place well. It is very strong in bending and is one of the hardest woods in America. It's shock resistance is almost that of Hickory (*Carya* spp.).

Mechanical Properties (2-inch standard)

				Compression				
	Specific gravity	MOE $\times 10^6$ lbf/in^2	MOR lbf/in^2	Parallel lbf/in^2	Perpendicular lbf/in^2	WML[a] in-lbf/in^3	Hardness lbf	Shear lbf/in^2
Green	0.66	1.85	13,800	6,800	1,160	15.4	1,570	1,760
Dry	0.69	2.05	19,400	10,200	1,830	18.4	1,700	2,480

[a]WML = Work to maximum load.

Reference (98).

Drying and Shrinkage

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	7.2	5.8	2.4
Radial	4.6	3.7	1.5
Volumetric	10.2	8.2	3.4

References: 0% MC (98),
6% and 20% MC (90).

Kiln Drying Schedules[a]

	Stock				
Condition	4/4, 5/4, 6/4	8/4	10/4	12/4	16/4
Standard	T6-A3	T3-A1	—	—	—

[a]References (6, 86).

Working Properties: It is difficult to work with hand tools, but turns well on a lathe and nails well. It has no distinctive odor or taste.

Durability: It is extremely durable.

Preservation: No information available at this time.

Uses: Fencing, insulator pins, furniture, mine timbers, treenails for ships. The trees are used in strip mine reclamation, due to their ability to survive the acid conditions and for their nitrogen fixing roots.

Toxicity: The bark is poisonous, and there are reports of dermatitis from the wood. (40, 64, & 105)

Additional Reading and References Cited (in parentheses)

6. Boone, R.S., C.J. Kozlik, P.J. Bois & E.M. Wengert. 1988. Dry kiln schedules for ?commercial woods - temperate and tropical. USDA Forest Service, FPL ?General Technical Report FPL-GTR-57.

20. Cuno, J.B. 1930. Utilization of black locust. USDA Circular No. 131.

3. Elias, T.S. 1980. The complete trees of North America, field guide and natural history. ?Van Nostrand Reinhold Co., New York, 948 pp.

40. Hausen, B. M. 1981. Wood Injurious to Human Health: A Manual. Walter deGruyter ?& Co., Berlin, Germany; New York, NY.

41. Hopp, H. 1942. Mystery among the locusts. American Forests. Jan.:27-30.

55. Little, Jr., E.L. 1979. Checklist of United States trees (native and naturalized). USDA ?Forest Service, Ag. Handbook No. 541, USGPO, Washington, DC.

59. Markwardt, L.J. and T.R.C. Wilson. 1935. Strength and related properties of woods ?grown in the United States. USDA Forest Service, Tech. Bull. No. 479. USGPO, ?Washington, DC.

60. McAlister, R.H. 1971. Black locust. USDA Forest Service, American Woods - FS-244.

64. Mitchell, J.; Rook, A. 1979. Botanical Dermatology: Plants and Plant Products ?Injurious to the Skin. Greenglass Ltd., 691 W. 28th Ave., Vancouver, British ?Columbia, Canada V5H 2H4.

68. Panshin, A.J. and C. de Zeeuw. 1980. Textbook of Wood Technology, 4th Ed., ?McGraw-Hill Book Co., New York, 722 pp.

74. Record, S.J. and R.W. Hess. 1943. Timbers of the new world. Yale University Press, ?New Haven, 640 pp.

82. Scheffer, T.C. 1949. Decay resistance of black locust heartwood. USDA Technical ?Bulletin No. 984.

86. Simpson, W.T. 1991. Dry kiln operator's manual. USDA Forest Service, FPL Ag. ?Handbook 188.

90. Summitt, R. and A. Sliker. 1980. CRC handbook of materials science. Volume 4, ?wood. CRC Press, Inc., Boca Raton, FL. 459 pp.

98. USDA Forest Service, FPL. 1974. Wood handbook: wood as an engineering material. ?Ag. Handbook 72.

104. Wollerman, E.H. 1962. The locust borer. USDA Forest Service, Forest Pest Leaflet ?71.

105. Woods, B.; Calnan, C. D. 1976. Toxic Woods. British Journal of Dermatology; ?95(13):1-97 Published by Blackwell Scientific Publications, Oxford, England OX2 ?OEL.

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Decay Resistance of Black Locust Heartwood[1]

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CONTENTS

INTRODUCTION

Black locust (*Robinia pseudoacacia* L.) is one of the most decay-resistant native woods. Few, if any, other North American timber species surpass it for average length of service in contact with the ground. Because of this quality, early settlers transplanted the species in large numbers from its original limited locale, the southern Appalachians and the Ozarks of Arkansas (*1*),[4] so that they ultimately might have at hand a supply of durable wood for fence posts. Today

[1] Submitted for publication January 19, 1949.

[2] In cooperation with Forest Products Laboratory, maintained by the Forest Service, United States Department of Agriculture, at Madison, Wis., in cooperation with the University of Wisconsin.

[3] The authors are indebted to Eugene W. Manis for valuable assistance in conducting the tests and to Newell A. Norton for aid in a preliminary summarizing of the data.

[4] Italic numbers in parentheses refer to Literature Cited, p. 36.

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black locust fence posts are still prized and usually bring premium prices. They are a common forest commodity within the native range and are often sold locally as a farm product in areas where the species has been introduced.

Black locust also possesses outstanding soil-building qualities and has been extensively planted for soil protection. It has been successfully established throughout much of the humid section of the United States and in many foreign countries. In the subhumid sections of the United States it is being grown under irrigation. On erodible sites it has done well where planted in soils of fairly loose structure, although it is now quite generally recognized that it is not adapted for erosion control on sites having shallow impervious subsoil.

Although the decay resistance of black locust wood is outstanding for the most part, there are differences of practical significance. It is now recognized that strain differences of sufficient prominence exist within the species to warrant special efforts to procure and use superior planting stock (*10, 11*). The present study of decay resistance was undertaken as one phase in a larger program of investigation toward this objective. Posts of the shipmast variety, for example, have been reported with reasonable reliability to last from 50 to 100 years and those of the so-called common locust from 10 to 30 years (*5, 14*). A difference in durability has also been indicated by limited laboratory tests (*9*). Thus, for highly durable post wood, shipmast locust would be more desirable than the general run of common strains. It is felt that additional strains of outstanding merit should be had to meet the requirements of different sites and climatic conditions.

One purpose of the study was to learn how to test the decay resistance of black locust wood from individual trees so that the influence on the results of any factors other than genetic would be held to a practicable minimum. For example, if the decay resistance of wood from a 6-inch tree is to be compared with that from a 14-inch tree, it is necessary to know how much to correct the findings for the difference in size before the difference in inherent resistance can be judged. The work, therefore, was quite basic and a prerequisite to any further search for strains of superior durability. Factors especially considered for their possible relation to decay resistance were site, tree size and age, average annual diameter increment of the trunk section, number of growth rings per inch in the test sample, specific gravity of the wood, and the location of the wood in the trunk. It was found that some of these factors must be taken into account in arriving at suitable evaluations of inherent decay resistance.

Another objective was to ascertain whether a particular level of decay resistance is likely to be retained under propagation. It was possible to answer this question with respect to vegetatively propagated locust stock without waiting for the development of successive generations of progeny. Two of the groups selected for study bear practically no seed; hence, both are essentially clones (*10*). The third bears seed and is of heterogeneous origin. The variation in decay resistance found in these groups thus gave an excellent indication of the genetic stability of decay resistance to be expected with black locust under vegetative as compared with seed propagation.

Consideration of these various points led to a comprehensive study of the decay resistance in this single species of wood. Some of the relations indicated have been found to occur in other species. Although the order of relationships may differ, the results obtained with black locust point to some of the most prominent factors with which differences in decay resistance may be associated in numerous species.

PROCEDURES

Selection of Material

Forty-two trees, cut during February on Long Island, N. Y., were used for the major comparisons. Thirty of these were representatives of 2 strains that propagate almost entirely vegetatively. They were, therefore, presumed to be largely clonal in character. One of these strains was the shipmast locust (*10, 11*), and the other was an undescribed variant designated as Flowerfield locust. Locally, both strains were reputed to have highly durable wood and were designated as yellow locust. The other 12 trees were of a heterogeneous nature, grouped under the general name common locust. These were seed-bearing types and showed marked differences in growth form. Several variants were probably represented in this group.

Five stands were sampled for each of the three groups. Sites were selected that represented a range of growth rates, based on a site index chart previously published (*12*). In each of the five Flowerfield stands, three trees of about the same diameter at breast height (d. b. h.) of approximately 10 inches were selected. In the shipmast and common locust stands, three trees, of 5-, 10-, and 15-inch d. b. h. class, respectively, were chosen at each site, in order to cover a range of tree sizes.

In addition to the winter-cut trees, six trees were taken from some of the same sources in the month of May. Collections were made during the growing as well as the dormant season in order to have some evidence as to whether the decay resistance varied with the season of felling.

The average age, height, and sapwood thickness of the winter-cut trees in the different selection groups are listed in table 1. Additional information about the trees, and information about the test material obtained from them, is given in table 2.

Table 1.—*Average age, height, and sapwood thickness of the sampled trees cut in February*

Selection group	Diameter class	Age	Height	Sapwood thickness
	Inches	*Years*	*Feet*	*Inch*
Shipmast	5	25	37	0.27
	10	47	59	.26
	15	62	75	.20
Flowerfield	10	49	65	.26
Common	5	23	40	.52
	10	39	54	.49
	15	47	66	.39

TABLE 2.—*Characteristics of trees and classification of 1-foot trunk sections used in the decay tests*

Stand	Average site index	Age of section at 7–8 foot height	D. b. h. class	D. b. h. actual	Height in tree (feet) [1]									
					1–2	3–4	5–6	7–8	15–16	23–24	31–32	39–40	47–48	55–56
SHIPMAST STRAIN														
		Years	*Inches*	*Inches*										
		22	5	6.7				W	W	W	W			
B-6	55	38	10	10.6				W	W	W	W	W		
		72	15	14.9				W	W	W	W	W	W	
		22	5	6.6				W						
B-7	63	57	10	10.0				W						
		63	15	15.0				W						
		11	5	4.8				W						
B-4	64	43	10	10.2				W						
		42	15	12.3				W						
		24	5	4.9				W						
B-9	65	37	10	9.1				W						
		47	15	14.7				W						
		10	5	4.9		W		W						
B-10	67	27	10	10.3		W		W						
		59	15	14.6		W		W						
		16	5	4.8	S	S		S						
B-10	67	28	10	9.9	S	S	S	S	S	S				
		61	15	15.9	S	S	S	S	S	S	S	S	S	
FLOWERFIELD STRAIN														
		48	10	11.5				W						
C-42	53	48	10	9.1				W						
		49	10	9.4				W						
		42	10	9.9				W						
B-42	64	44	10	12.2				W						
		44	10	12.9				W						
		41	10	12.6				W						
B-45	69	51	10	12.3				W						
		43	10	11.9				W						
		45	10	9.9				W	W	W	W	W	W	
B-46	70	49	10	12.7				W	W	W	W	W	W	W
		48	10	11.7				W	W	W	W	W	W	
		35	10	10.1				W						
A-19	72	32	10	10.2				W						
		35	10	10.8				W						
COMMON LOCUST—VARIOUS UNTYPED STRAINS														
		24	5	5.4				(3)						
B-53	(2)	18	10	9.7				W						
		24	15	11.8				W						
		38	5	6.3				(3)						
B-54	(2)	34	10	10.3				W						
		68	15	17.8				W						
		10	5	5.3				(3)						
C-56	(2)	21	10	9.0				W	W	W	W			
		22	15	14.9				W		W	W			
		12	5	5.5				W						
B-56	(2)	39	10	10.0				W						
		48	15	12.6				W						
		15	5	5.1		W		W						
A-54	(2)	50	10	10.7		W		W						
		50	15	14.2		W		W						
		19	5	5.7	S	S	S	S	S					
A-54	(2)	53	10	10.2	S	S	S	S	S	S	S	S		
		61	15	15.6	S	S	S	S	S	S	S	S		S

[1] W=Trees cut in winter; S=trees cut in spring.
[2] It was not possible to test the effect of site on the decay resistance of common locust because each site may be represented by genetically different trees.
[3] Sections discarded because of excessive damage by locust borers.

The parts of the trees to be tested were shipped in the form of 1-foot trunk sections (table 2). Differences in decay resistance between trees, stands, and strains were ascertained largely on sections from the 7- to 8-foot height in the winter-cut trees. The relations of decay resistance to radial position in the trunk were ascertained for these same sections. Sections from different heights in the trees were used for evidence of vertical trends in decay resistance also as part of the evidence on the effect of season felling.

Preparation of Test Specimens

Test blocks, ½ by 2 by ¼ inch, were sawed out of the trunk sections, as illustrated in figure 1. Only heartwood was used. The blocks were inspected in ultraviolet light, under which locust sap-

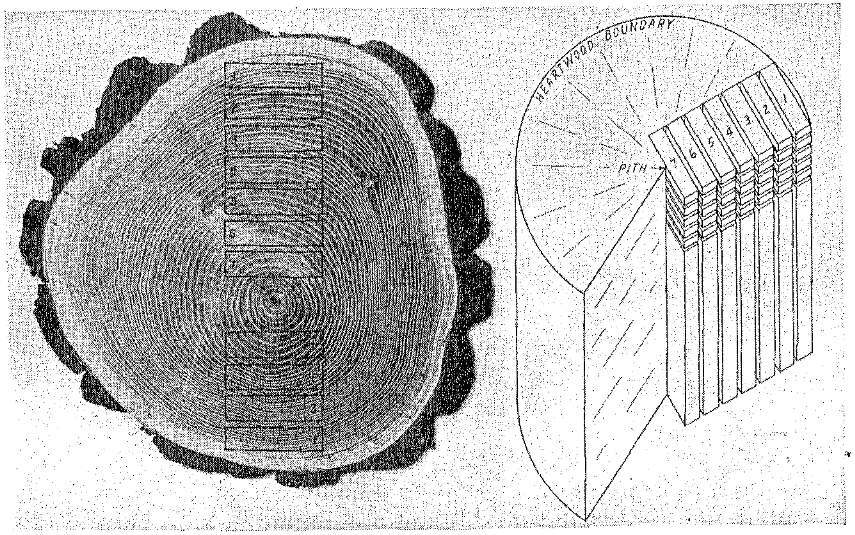

FIGURE 1.—Representative original arrangement of the test specimens in each trunk section.

wood has a pronounced purplish-blue color. Any containing sapwood were discarded. The blocks were taken in a continuous series along each of two radii, one long and the other short. The purpose in testing both long and short radii in each section was to determine the effect of different growth rates within the same tree.

The blocks were numbered consecutively as to their location with reference to both the pith and the sapwood. Each numbered position represented the width of specimen, 0.5 inch, plus the saw kerf, 0.15 inch, making a total of 0.65 inch on a radius. Five replicate blocks were taken in vertical alinement at each position. Four were used for the decay tests, and the fifth was used for moisture-content determination. Inasmuch as all five were adjacent and in the same annual rings, they matched closely.

Preliminary to testing, the specimens were dried to equilibrium weight at 80° F. and 30-percent relative humidity.

Decay Tests

The decay tests were made by exposing the blocks to pure cultures of each of two wood-rotting fungi. All tests were in duplicate. The method, except for comparatively minor details, is widely used for accelerated laboratory testing of decay resistance. It does not show the actual service life to be expected, but it indicates with reasonable reliability the relative order and general magnitudes of decay resistance. Much depends on the selection of test fungi.

For this work the two fungi were *Poria incrassata* (Berk. and Curt.) Burt (Madison 563), which in previous tests had been found to cause rapid decay in a variety of woods, and *Fomes rimosus* (Berk.) Cke. (Madison 696), which was isolated from a zone of advanced decay in a locust fence post. *F. rimosus* is known to be one of the most serious heart rotters in locust trees; hence information derived from it should be applicable to living trees as well as posts. Other unidentified wood rotters were obtained from locust posts, but in preliminary trials caused less decay than *F. rimosus* and for this reason were considered inadequate for test purposes.

After the blocks had been brought to equilibrium moisture content, they were given a mild sterilization treatment by steaming them in closed containers for 20 minutes at 212° F. They were then transferred under aseptic conditions to 6-ounce sterilized wide-mouth bottles of the French square type, having screw tops from which the paper lining had been removed. Each bottle contained 25 ml. of malt-agar medium [5] that had hardened while the bottles were in a horizontal position. The specimens were laid, one in a bottle, on a 3-mm., V-shaped glass rod resting on the hardened medium, and the medium was promptly inoculated with a pure culture of the test fungus. The bottles thus prepared were stored for 4 months in a room with a maintained temperature of 80° and relative humidity of 80 percent (fig. 2). At the end of the incubation period the blocks were wiped free of any loose surface growth of the fungus, oven-dried at 222°, and again weighed. The extent of decay was measured by the percentage loss in the oven-dry weight of the wood. The test blocks were not oven-dried at the start, but their initial oven-dry weights were estimated from moisture content determinations made on one of the similarly conditioned replicate blocks from each position.

PATTERN OF DECAY RESISTANCE IN BLACK LOCUST TREES

Before any of the results are examined, it would be well to consider certain general points regarding their interpretation. All comparisons of decay resistance are based on the weight losses occurring in the test samples; thus it is necessary to keep clearly in mind that the larger the weight loss the lower the decay resistance represented, and vice versa.

It will also be noted that the range of weight losses dealt with for the most part, particularly where caused by *Fomes rimosus*, is com-

[5] 2½ percent of Trommer's plain diastasic malt extract and 1½ percent of bacto-agar in distilled water.

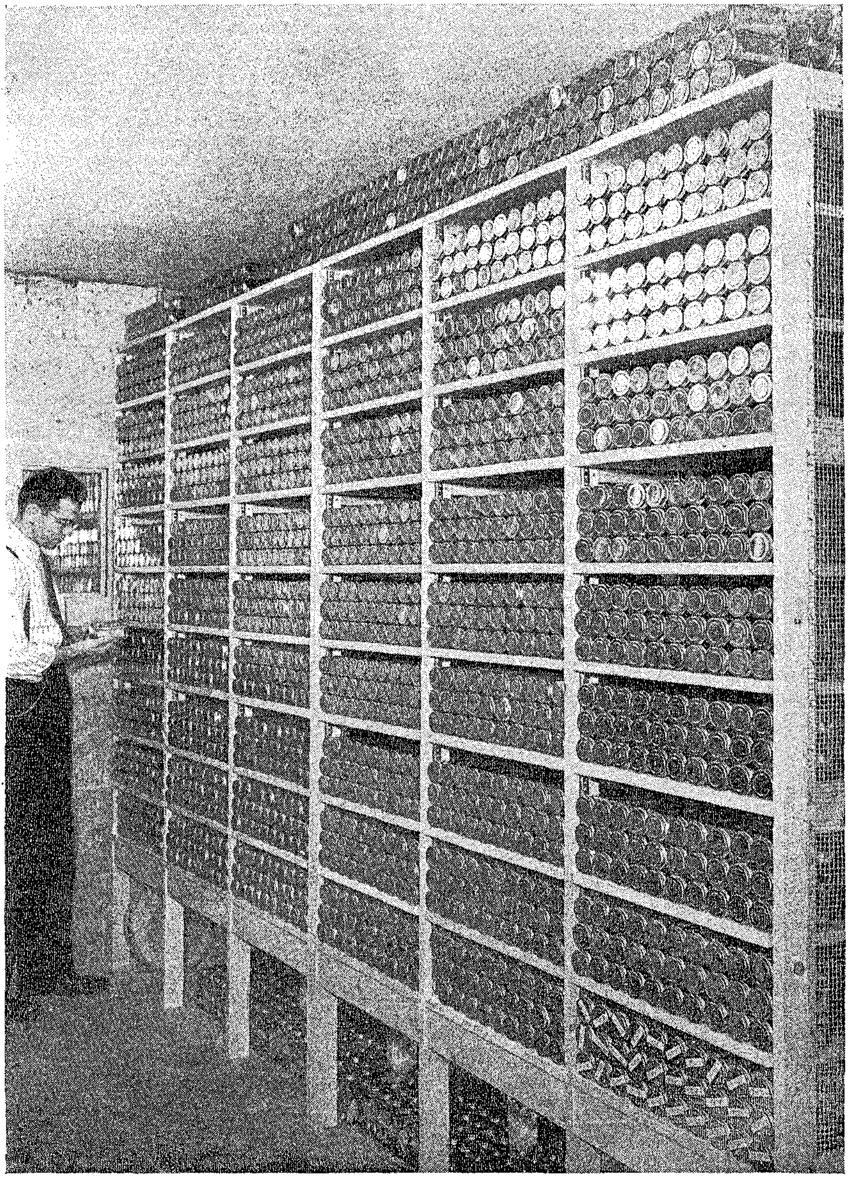

FIGURE 2.—A part of the test in progress in the controlled incubation room.

paratively small. This should not be interpreted as indicative of small differences in durability. Although average differences in weight loss between the wood of shipmast and common locust trees were small, the relative differences were substantial. Many years' difference in potential service life probably are represented (see p. 2).

Another point that should be clarified at the outset relates to the way in which the means were calculated from the individual block values. For most of the study, the means were obtained simply by averaging the percentage weight losses for the blocks. In a part of the study, however, it was desired to estimate the average decay loss for an entire cross section. To do this, the decay loss for each block was weighted by a multiplying factor, which was the proportion of the area of the entire cross section occupied by the ring in which the block was located. Averages derived in this manner represent approximately the loss that might be expected had the entire cross section actually been tested. Where there is a possibility of confusion, these weighted averages will be so designated.

Data furnished by both fungi are given in the following section. Results obtained mainly with *F. rimosus* are dealt with in subsequent sections because of the similarity in the evidence of chief practical significance given by both fungi and because *F. rimosus* is considerably the more important of the two as a destroyer of locust wood. Moreover, the experimental error (as measured by differences in weight loss between the duplicate test blocks) of results obtained with *Poria incrassata* was relatively greater than that with *F. rimosus*, making certain of the more detailed relations more difficult to establish with the former fungus. The ratio of the standard deviation to the mean result (coefficient of variation) is a commonly used measure of relative variation. In this study the relative variation in weight loss between duplicate test blocks decayed by *F. rimosus* and by *P. incrassata* is indicated in table 3.

TABLE 3.—*Coefficient of variation in weight loss between duplicate test blocks decayed by Fomes rimosus and Poria incrassata*

Range of weight loss considered in determining standard deviation (percent)	Decay by—					
	Fomes rimosus			*Poria incrassata*		
	Observations represented	Mean weight loss	Coefficient of variation	Observations represented	Mean weight loss	Coefficient of variation
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0 to 1	42	1. 1	33	35	0. 7	58
2 to 5	53	2. 7	20	25	2. 9	46
6 to 10	5	6. 5	14	6	7. 6	55
11 to 25				14	16. 5	75
26 and higher				20	33. 4	9

Variation in Resistance With Radial Position in the Tree

One of the most uniform findings of the study was that the decay resistance was progressively less, often markedly so, with increasing proximity to the pith. Radial trends of this sort in the 15-inch d. b. h. trees of shipmast and common locust are shown in figures 3 and 4, respectively. With respect to the outer one-half to two-thirds of the radius length, representing the major volume of wood in the trunk sections, the general trends evidenced by the two fungi were essentially alike. Nearer the pith, the radial differences in decay by *Fomes rimosus* tended to be relatively more pronounced than those by *Poria incrassata*. This tendency was largely absent in the 10-inch trees, however.

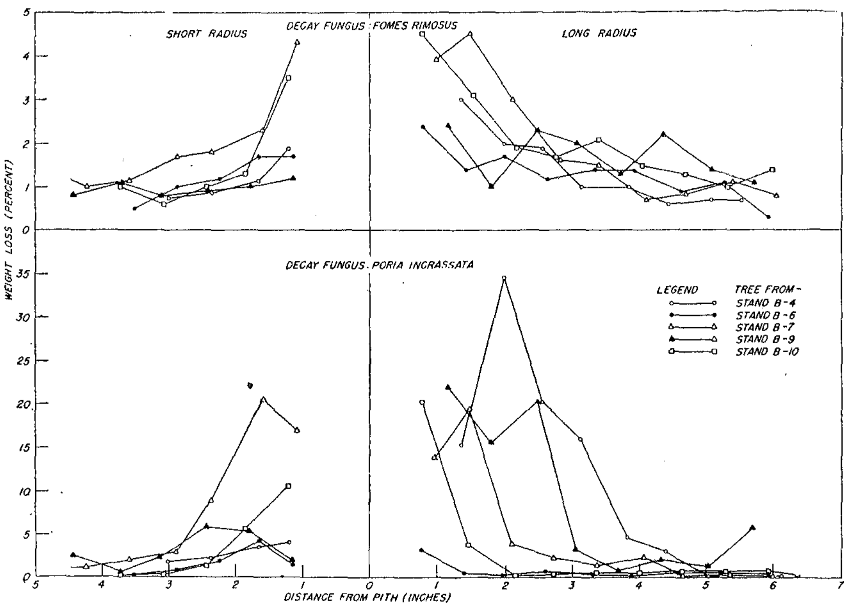

Figure 3.—Weight losses in test blocks from different radial positions in the heartwood of shipmast locust trees of the 15-inch d. b. h. class. (Winter-cut trees, sampled at a height of 7 to 8 feet.)

The irregularity of trend at places in some of the trees raises the question of whether this was a result of testing variability or that it might be a fairly representative situation. Although both explanations undoubtedly are needed, testing variability seems to apply in larger degree. Based on the standard errors of weight-loss determination,[6] the smallest differences between values in figures 3 and 4 that might be regarded as true ones, when considered without reference to associated data, are indicated in table 4.

[6] Computed from differences in results obtained between the duplicate test blocks.

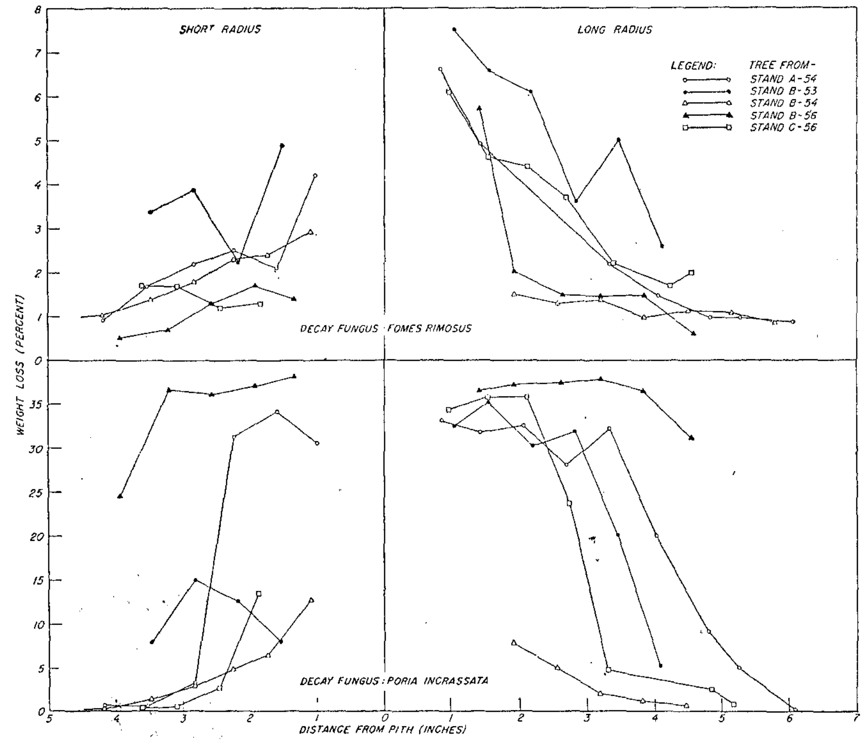

Figure 4.—Weight losses in test blocks from different radial positions in the heartwood of common locust trees of the 15-inch d. b. h. class. (Winter-cut trees, sampled at a height of 7 to 8 feet.)

Table 4.—*Least significant difference*[1] *between percentage weight losses shown in figures 3 and 4*

Range of weight loss in which the difference lies (percent)	Least significant difference for decay by— *Fomes rimosus*	Least significant difference for decay by— *Poria incrassata*
0 to 1	0.7	0.7
2 to 5	1.1	2.6
6 to 10	1.8	8.2
11 to 25	----	24.2
26 and higher	----	5.9

[1] At the 5-percent level of significance.

Trends of decreasing decay resistance from the outer to the inner heartwood have previously been reported for black locust[7] and for several other species (*2*, *3*, *16*, *18*). Some species do not show this trend; in fact, a reverse trend was found by the senior author (*15*) in certain tropical hardwoods, but in these cases there was no visible differentiation between heartwood and sapwood; hence it is not certain that true heartwood was dealt with.

The order of diameter-class and selection-group differences indicated by both fungi was the same. This can be more readily observed in figures 5 and 6, which summarize the trends just observed and, in addition, include curves for the 10-inch trees of all three selection groups. The point values in these figures were obtained by averaging the weight losses of all the test blocks in each radial position. The trend lines for the radii were then averaged to give the mean trend for each diameter class. Although each of the figure curves represents the average shape of the trend line for that diameter class, the trend lines for each tree would be higher or lower. In general, the trend lines for the smaller trees were higher than this average, while for the larger trees the trend lines were lower.

From this graphic evidence it is apparent that heartwood at similar depths in the shipmast and common locust trees is appreciably more decay resistant in the trees of the 15-inch d. b. h. class than in trees of the 10-inch class. Also, by comparing weight losses in samples at equal depths in the heartwood it will be seen that the shipmast wood is more resistant on the average to both test fungi than the common locust wood and that the Flowerfield is more resistant than the shipmast. The difference between common and selected locust is more pronounced with decay by *P. incrassata* than with decay by the locust-specialized *F. rimosus*, a circumstance possibly indicative of what might be expected generally with locust posts attacked by nonspecialized fungi.

It is pertinent to note here that a part of the differences in weight loss observed in figures 5 and 6 among the selection groups may be attributable to differences in the average size of the trees sampled. The average actual diameter at breast height of trees in the 10-inch diameter class was 11.1 inches for Flowerfield, 10.0 inches for shipmast, and 9.9 for the common locust; there was no noteworthy difference in diameter at breast height between the shipmast and common locust trees of the 15-inch class.

Variation in Resistance With Vertical Position in the Tree

The vertical distribution of decay resistance in shipmast locust heartwood, like the radial, followed a definite pattern (fig. 7). The resistance of the heartwood at equal distances from the sapwood decreased as the height above the ground was greater. The resistance of the innermost heartwood, on the other hand, increased with height. As a result, the most resistant heartwood occurred in the outer basal

[7] Hopp, H., and Hirt, R. R. Experiments on the relative decay resistance of black locust selections. U. S. Soil Conserv. Serv., Div. Hillculture Res., in cooperation with the N. Y. State Col. Forestry, Syracuse Univ. 1939. [Typewritten report.]

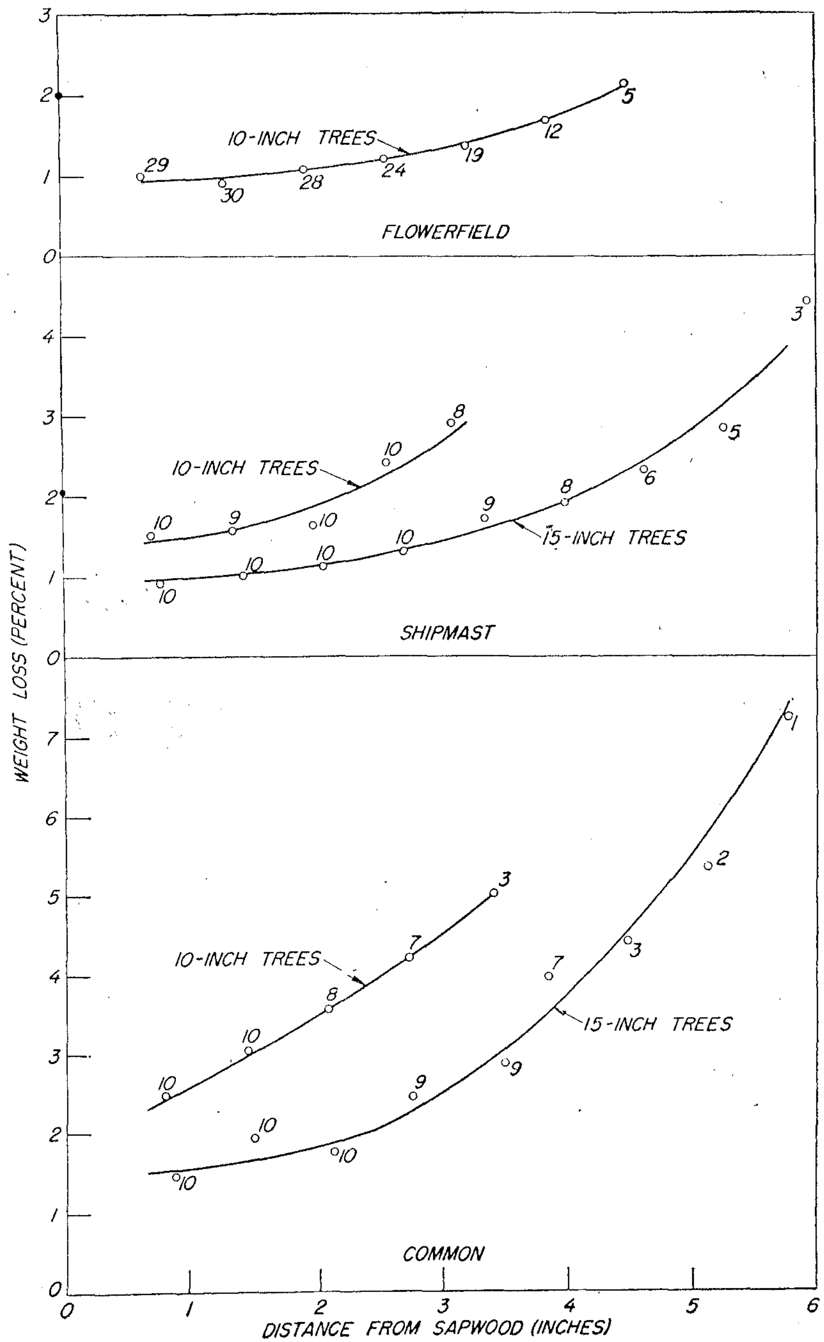

Figure 5.—Relative average weight losses caused by *Fomes rimosus* in test blocks from different radial positions in the heartwood of trees of the 10- and 15-inch d. b. h. classes of the three selection groups. (Numerals at the plotted points denote the number of radii sampled at the position represented.)

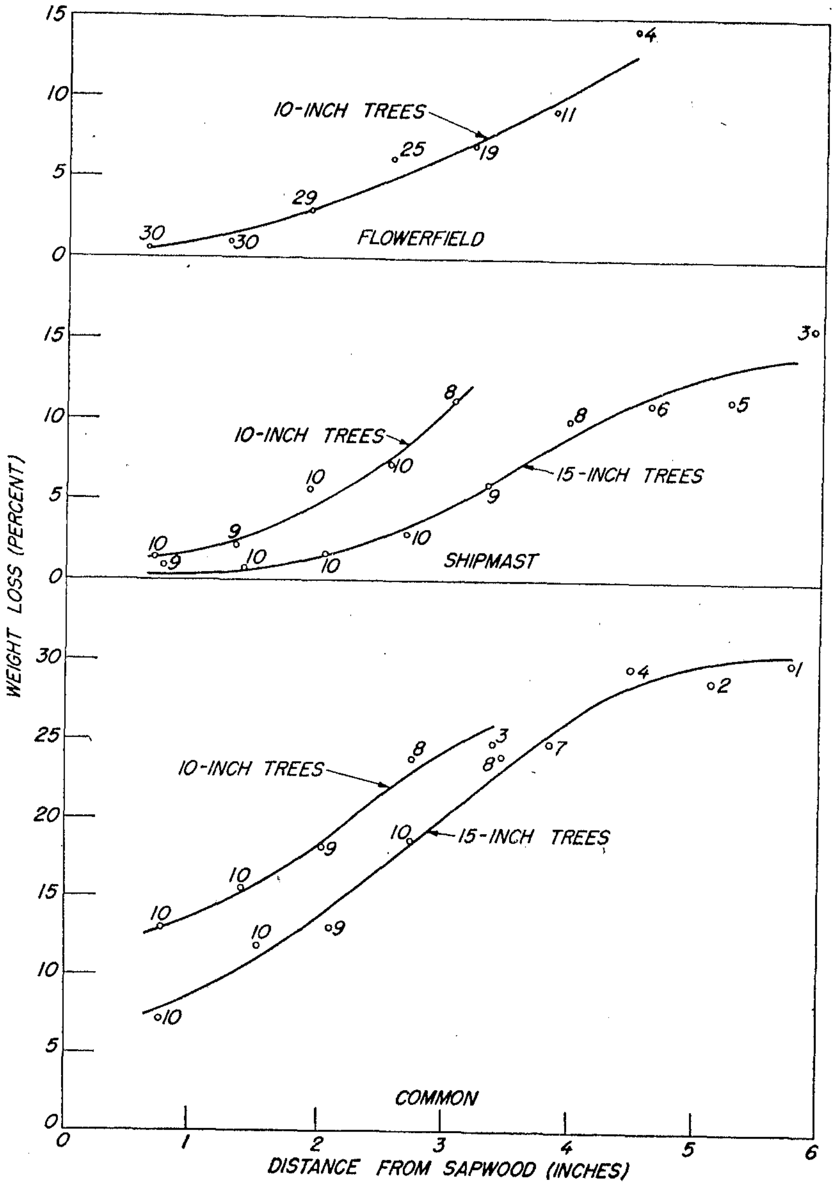

Figure 6.—Relative average weight losses caused by *Poria incrassata* in test blocks from different radial positions in the heartwood of trees of the 10- and 15-inch d. b. h. classes of the three selection groups. (Numerals at the plotted points denote the number of radii sampled at the position represented.)

part of the trunk and the least resistant in the inner basal part. Higher in the trunk, intermediate degrees of resistance occurred, with a progressively decreasing difference between inner and outer heartwood.

When the weight losses shown in figure 7 are plotted on a chart to represent a longitudinal section through the center of a tree, lines of equal decay resistance appear, as shown in figure 8. The radius lengths indicated for the different heights are averages for the three trees on which the data are based. (See table 1.)

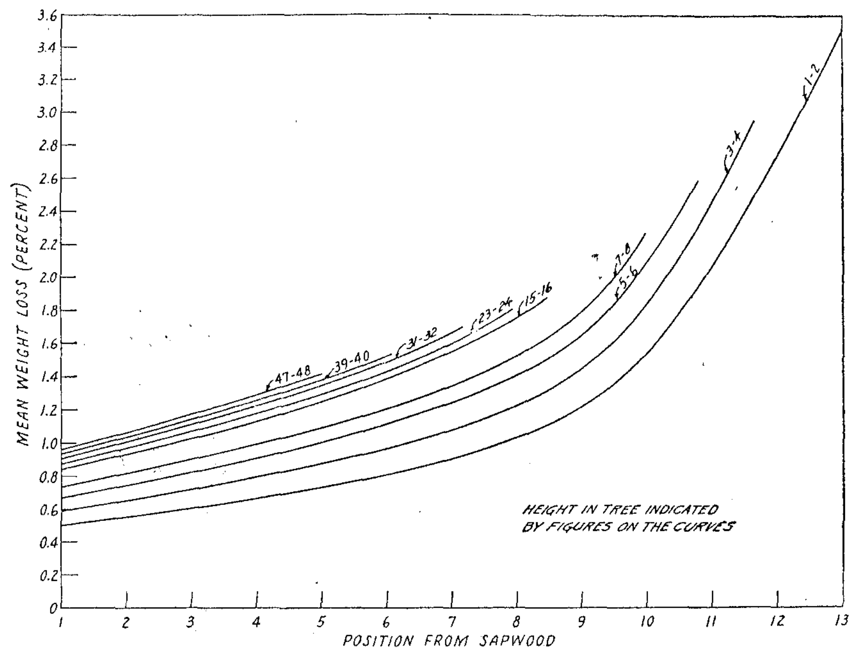

Figure 7.—Relative average weight loss in test blocks from different heights above the ground in spring- and winter-cut shipmast locust trees of the 15-inch d. b. h. class. (Based on long radii only.)

The average decay resistance of the entire heartwood cross section[8] was calculated for the various heights in a number of trees. The resulting trends are shown in figure 9. It is apparent that there was a general tendency for the mean cross-sectional decay resistance to decrease with increasing height of the wood in the trees, and more so in the smaller trees than in the larger ones. This tendency was not exhibited by the 15-inch shipmast trees, and it was negligible for practical considerations through most of the merchantable trunks of the 15-inch common and the 10-inch shipmast and Flowerfield trees. Reliable evidence of pronounced vertical trends in the mean cross-sectional decay resistance is had only in the 5-inch shipmast and common locusts and in the 10-inch common trees.

[8] Determined as described on p. 9.

Variation in Resistance With Size of Tree

Differences in decay resistance in relation to tree size are indicated by the radial trends shown in figures 5 and 6. A more comprehensive analysis of the relation in this respect is offered in the harmonized[9] curves of figure 10, which show the variation in weight loss with length of heartwood radius. Long and short radii within the same cross

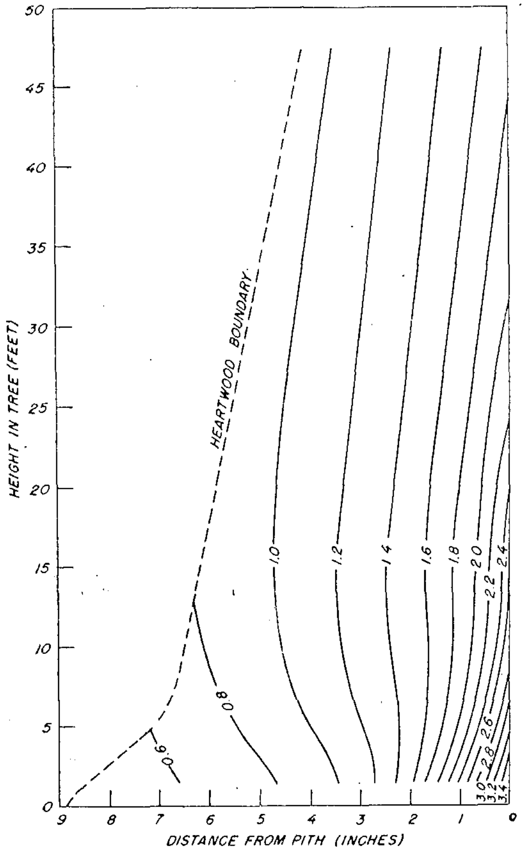

Figure 8.—Contours of percentage of weight loss in shipmast locust trees of the 15-inch d. b. h. class. (Based on figure 7.)

section usually exhibited the decay-resistant characteristics of large and small trees, respectively.

In general the curves show that the longer the radius the greater was the resistance of wood at any specified distance inward from the sapwood and the greater was the difference in resistance between the inner and outer heartwood. Moreover, although the longer radii had the most resistant wood found, they also had the least resistant.

[9] Any two of the harmonized curves differ in level from each other by the same percentage at all common radial positions. Curves of this type appeared to give a truer representation of the general relations than did curves independently established on segments of the data.

Similar relations were found with the common locust, but the trees of this strain were less consistent, probably because of complications introduced by genetic differences in this group.

As an additional aspect of the relation of decay resistance to size of tree, figure 11, *A*, shows the mean weight losses for the outer, middle,

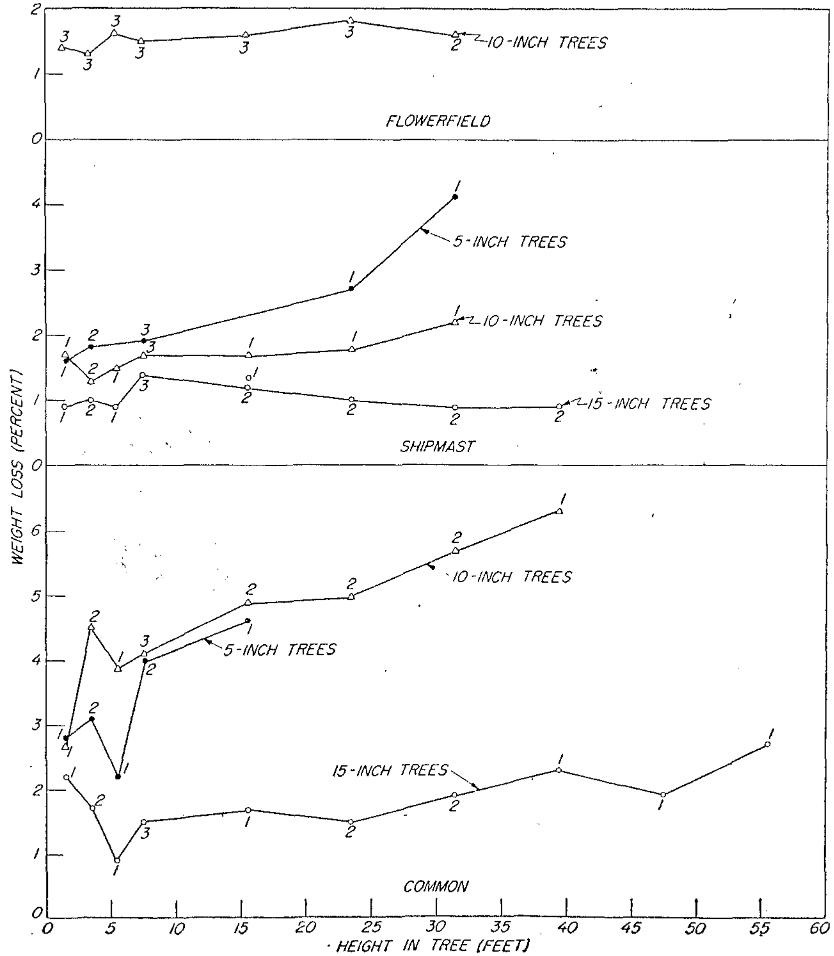

Figure 9.—Relative average weight losses indicated for the entire heartwood cross section at different heights above the ground in locust trees of the 5-, 10-, and 15-inch d. b. h. classes. (Numerals at the plotted points give the number of trees sampled at the height represented.)

and inner thirds of heartwood radii of different lengths. With increasing length of radius, increases in decay resistance occurred, on the average, only in the outer two-thirds of the radius and the most pronounced increases occurred in the outermost one-third. Wood from the inner one-third of the radius, on the other hand, exhibited a marked decrease in resistance as the radius was longer.

The average decay resistance of the entire heartwood cross section, derived as described on page 9, increased as the radius was longer (fig. 11, *B*). This was true, despite the pronounced opposite trend for the inner heartwood alone, because of the relatively small proportion of the total cross section represented by the inner third of the radius (11.1 percent). The differences were not large, however, and there is a marked suggestion in the curve that the over-all resistance of shipmast heartwood 7 to 8 feet high in the tree may change very little after a radius length of 4 or 5 inches has been attained. As a matter of fact, if only the larger trees are considered, a further generalization might be made that the average resistance of the heartwood cross section commonly may not vary greatly with the size of trunk, either among different shipmast trees or at different elevations (fig. 9) in the same trees.

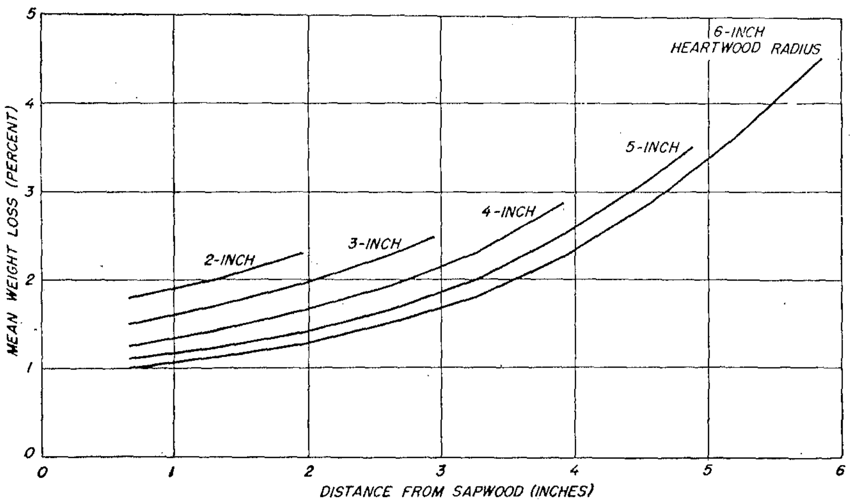

FIGURE 10.—Relative average weight loss in test blocks from radii of different lengths in the heartwood of shipmast trees. (Winter-cut trees, sampled at a height of 7 to 8 feet.)

FACTORS ASSOCIATED WITH VARIABILITY IN DECAY RESISTANCE

The observations discussed up to this point show that black locust wood varies widely in decay resistance. This condition can be of economic importance in the selection and production of durable wood. An attempt was made, therefore, to determine the associated factors that might best index the decay resistance.

ANNUAL-RING AND LINEAR POSITION OF THE WOOD

The radial position of the wood in the trunk was the factor that most closely indexed its relative decay resistance. The efficiency of four different methods of specifying the location of the wood was examined graphically, using the data for wood taken from a height of 7 to 8 feet in the winter-cut trees. These were (1) distance from the pith, (2) number of annual rings from the pith, (3) distance from the sapwood, and (4) number of annual rings from the sapwood. The averages and ranges of values dealt with in considering these factors are given in table 5.

The table shows that the material sampled covered a rather wide range in all of the characters observed. The closeness of the relation between the decay resistance and each factor was then ascertained from the within-tree variability in weight loss that was not accounted for by the respective regressions. This variability, expressed as the adjusted mean square of estimate (also known as the mean square error of estimate), is listed in table 6.

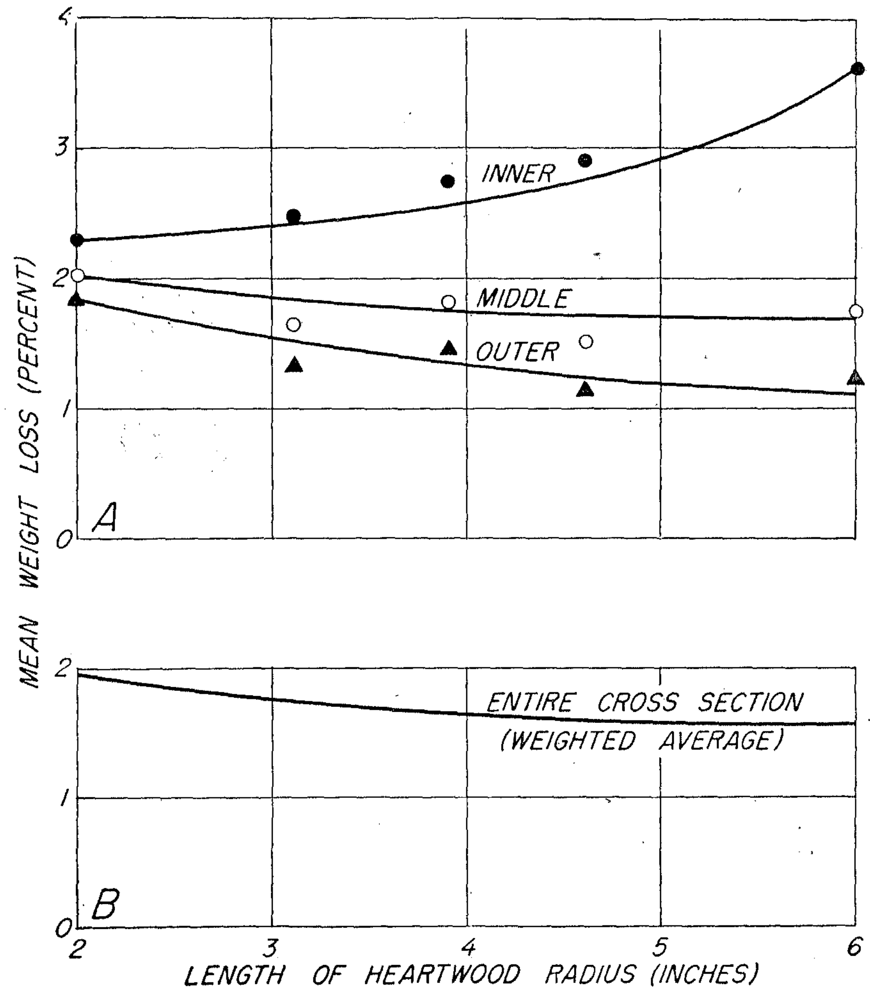

FIGURE 11.—*A*, Weight loss of the inner, middle, and outer thirds of radii of different lengths in shipmast locust. (Spring- and winter-cut trees, sampled at a height of 7 to 8 feet. The curves are based on figure 10; the point values, which were included to confirm the representativeness of the curves, are averages of the original data.) *B*, Weight loss indicated for the entire heartwood cross sections of different diameters. (Calculated from the data in *A*, with weighting according to area represented; see p. 9.)

TABLE 5.—*Averages and ranges of weight loss and of the principal observed characters of the blocks[1] tested for decay resistance*

Observation	Average	Range
Weight loss (percent)	1. 92	0.1 to 10.7
Inches from pith	2. 3	.3 to 6.4
Inches from sapwood	2. 0	.3 to 6.4
Rings from pith	18	2 to 59
Rings from sapwood	26	3 to 60
Rings per inch	10	2 to 34
Specific gravity	. 71	.56 to .82

[1] From winter-cut trees, sampled at a height of 7 to 8 feet.

TABLE 6.—*Relative effectiveness of four factors in explaining the variability[1] in decay resistance among the test blocks[2] within the respective radii (fig. 1) of the heartwood cross sections*

Selection group	Unadjusted mean square	Mean square adjusted for—			
		Distance from pith	Rings from pith	Distance from sapwood	Rings from sapwood
Shipmast	20. 6	10. 1	7. 7	6. 6	8. 9
Flowerfield	7. 5	5. 3	4. 1	4. 0	4. 4
Common	52. 2	21. 4	20. 7	16. 0	43. 2
All groups	24. 0	11. 3	9. 8	8. 1	16. 3

[1] The variability is here expressed by the mean square of weight-loss deviations from the regression line of weight loss on radial location of test block. The mean squares were calculated from percentage deviations. Transformation of the deviations into percentages was necessary to make the deviations less correlated with the means.
[2] Winter-cut trees, sampled at a height of 7 to 8 feet.

The decrease in weight-loss variability by adjusting for these factors shows that the weight loss was correlated with both ring count and distance, whether measured from either the pith or the sapwood. With all three selections, however, the best correlation was with distance from sapwood (adjusted mean square, 8.1 percent), and the next best was with ring count from pith (adjusted mean square, 9.8 percent).[10] These data suggest that variability in decay resistance is associated with the location of the wood in relation partly to the sapwood and partly to the pith. The two best of the individual factors, ring count from pith and distance from sapwood, were therefore tried in combination.

The relation between weight loss and these two factors, for the wood 7 to 8 feet high in the shipmast and common trees, is shown in figures 12 and 13. Similar curves were not established for the Flowerfield locust.[11]

[10] The ring count from pith designates the age of the tree at that height when the wood was formed.

Three primary generalizations are suggested by these figures: (1) The decay resistance at a given distance from the sapwood is pro-

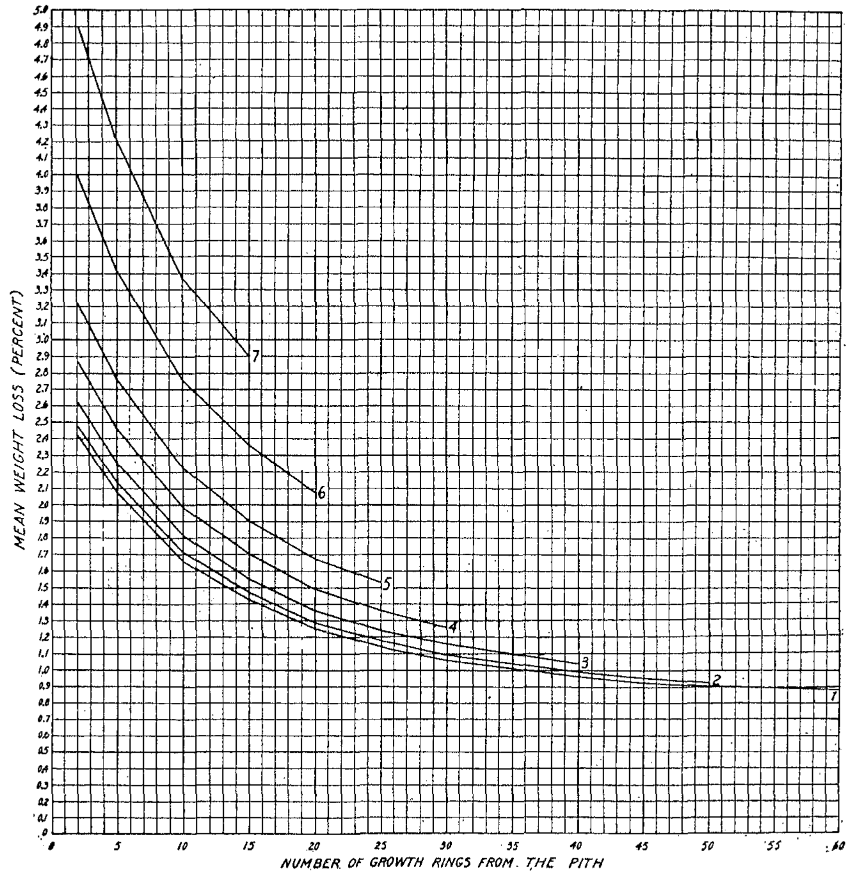

FIGURE 12.—Relation of weight loss to the distance of the wood from the sapwood and to the number of growth rings between the wood and the pith in shipmast locust. The number of the curves denotes the distance in inches from the sapwood. (Winter-cut trees, sampled at a height of 7 to 8 feet.)

[11] All the trees of the Flowerfield strain were selected from the same diameter class; as a consequence, the factors of distance from sapwood and ring count from pith were negatively correlated to such an extent that the association of weight loss with each factor separately was not apparent. Also, variability in weight loss within the Flowerfield trees was less than in the shipmast and common trees. For this reason, the derivation of a set of curves based on the two factors was not of so great importance as in shipmast and common locusts. Only a single regression, weight loss on ring count from pith, therefore, was derived for the Flowerfield locust. This regression is not shown, but the curve occupies nearly the same position as the one for the outer inch of shipmast heartwood in figure 12, being slightly lower in the first 25 growth rings from the pith and slightly higher farther out.

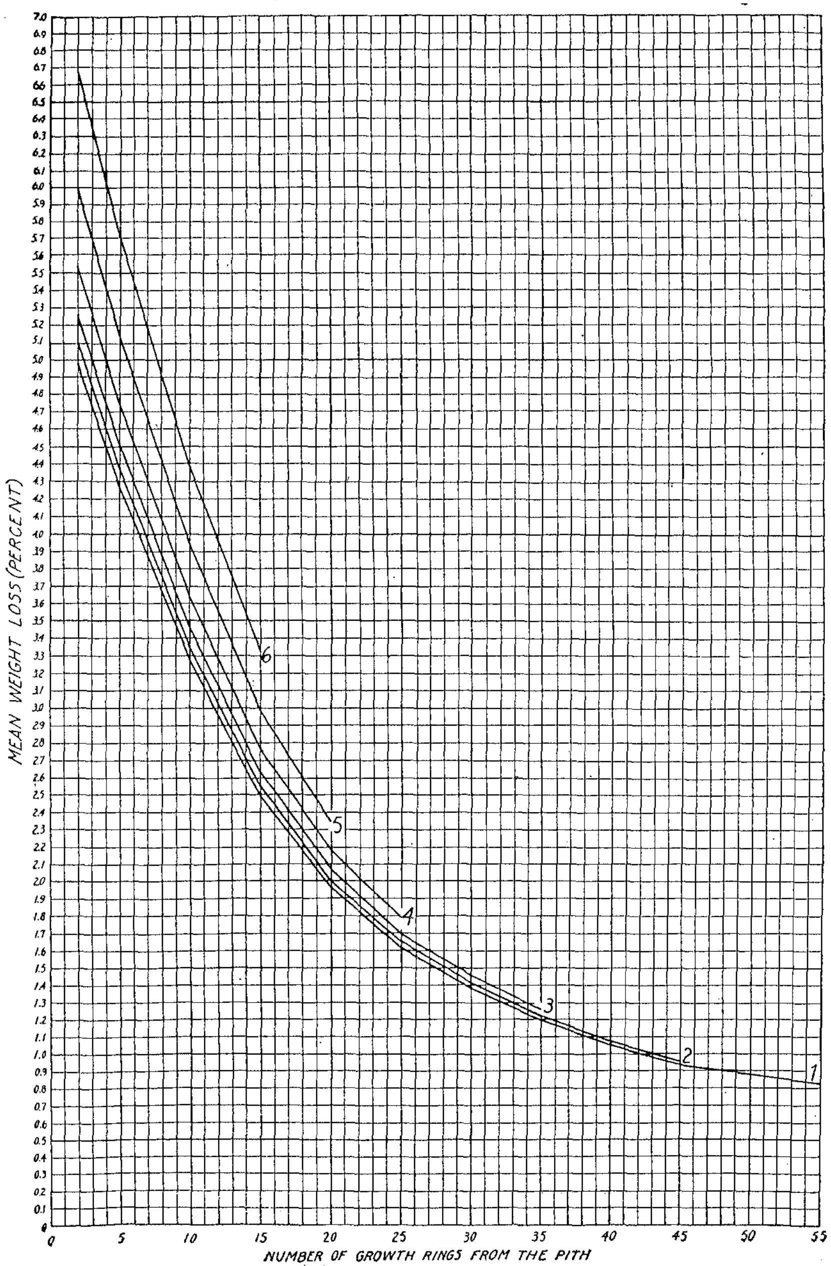

FIGURE 13.—Relation of weight loss to the distance of the wood from the sapwood and to the number of growth rings between the wood and the pith in the common locust. The number of the curve denotes the distance in inches from the sapwood. (Winter-cut trees, sampled at a height of 7 to 8 feet.)

gressively greater with an increasing number of growth rings to the pith; (2) the decay resistance at a given number of growth rings from the pith is progressively less with increasing distance from the sapwood; (3) the decay resistance of the heartwood is greatest at the time the heartwood is formed; thereafter it does not remain constant but gradually becomes less.

It follows from observations (1) and (2) that in locust trees of equal growth rate and genetic constitution, wood at the same distance inside the sapwood is generally more resistant in older than in younger trees and that wood formed at the same age of the trunk is generally less resistant in larger than in smaller trees. Considered even more broadly, it might be expected from these observations that the resistance of at least the major part of the heartwood would be greater in slow-grown than in fast-grown trees of about the same age and particularly of the same heartwood diameter.

The latter expectation is supported by comparisons of the average ages of shipmast and Flowerfield trees that incurred, respectively, greater and less weight loss than the average for the diameter at breast height that each represented. The average weight loss for the respective diameters was determined from the relation of weight loss to diameter at breast height established graphically on the 15 trees in each collection group. The weight loss used for each tree was the cross-sectional average (p. 9). Among the 15 shipmast trees, those with less than the indicated average resistance to *Fomes rimosus* had an average age of 35 years, whereas those with more than the average resistance had an average age of 41 years (thus were slower grown). Corresponding ages with decay by *Poria incrassata* were 34 and 42 years. Among the Flowerfield trees the corresponding ages were 41 and 44 years with decay by *F. rimosus* and 41 and 45 years with decay by *P. incrassata.*

Supporting field evidence has been reported (*13*) for durability tests made on black locust fence posts in the Mississippi Delta. Posts from Delta-grown trees were compared with others from hill-grown trees having about the same size and percentage of heartwood, but which were nearly twice the age of the Delta locust. After 5 years, 91 percent of the hill-grown posts were rated as still serviceable as contrasted with 73 percent for the faster grown posts from the Delta. Similar observations have been reported from Ohio (*4*). Genetic differences, of course, may have been a factor as well as the differences in growth rate.

Comparisons of figures 12 and 13 show that the average weight losses in the common locust wood were generally greater than those in the shipmast from the same positions in the trees. Only where the number of annual rings between the wood sampled and the pith was large (that is, usually in the outer heartwood of the largest trees) were the differences in weight loss between these two groups slight or absent.[12] The general relations of weight loss to distance from sap-

[12] The advantage previously shown for shipmast in the outermost as well as in the inner heartwood (figs. 5 and 6) is due to the inclusion of the younger trees in the average trends; in the younger trees, as shown in figs. 12 and 13, the shipmast had an advantage over common in all parts of the heartwood. This average advantage is accentuated in figs. 5 and 6 by the fact that the shipmast grows more slowly than the common, so that the shipmast trees sampled were older than the common locust in the same diameter class.

wood and to rings from pith were essentially the same for both locust groups. Consequently, these relations furnish a basis for comparing the resistance of selections and individual trees and for appraising the influence of external factors on decay resistance despite differences in size, age, and part of the trees sampled. This aspect of the study is dealt with later.

Inasmuch as the curves of figures 12 and 13 were based on blocks taken entirely from a height of 7 to 8 feet, these relationships were tested further on blocks taken at other heights. The position of these latter blocks in terms of rings from pith and distance from sapwood was used to determine the expected weight loss from figures 12 and 13. These expected weight losses were then compared with the actual weight losses by a correlation analysis. The results are shown in table 7.

The correlation coefficients were all highly significant (beyond the 1-percent level). Those for the common locust, however, were consistently smaller than those for the shipmast, probably because of the greater genetic variability among the trees of the former group. The analysis indicates that a significant part of the variability in weight loss among blocks at different heights was explainable by the age and position relationships derived from blocks taken at the 7- to 8-foot height. Moreover, the three coefficients for each selection were not significantly different statistically, indicating that figures 12 and 13 may apply uniformly well to wood from all heights in trees of the respective selections.

TABLE 7.—*Correlation between the regression values of figures 12 and 13 and the corresponding observed weight losses in test blocks obtained from different heights in the trees*

Height in tree	Trees tested	Blocks tested	Correlation coefficient
	Number	*Number*	
Shipmast locust:			
1 to 6 feet	6	96	0. 66
7 to 8 feet	9	78	. 63
15 to 48 feet	5	148	. 60
Common locust:			
1 to 6 feet	6	105	. 38
7 to 8 feet	8	73	. 50
15 to 56 feet	5	92	. 47

RELATION OF DECAY RESISTANCE TO SPECIFIC GRAVITY AND TO NUMBER OF GROWTH RINGS PER INCH

The specific gravity of the test blocks ranged from 0.56 to 0.82, and the number of rings per inch from 2 to 34, as shown in table 5. Within individual trees, the decay resistance generally tended to be greater as the specific gravity was lower and as the number of rings per inch was greater. In other words, decay resistance was greater in the outer heartwood, where the growth rate was generally slower and the specific gravity generally lower. Also, as brought

out in the preceding section, the resistance of the heartwood tended to be greater in slower grown than in faster grown (therefore with generally denser wood) trees. However, ring count from pith and distance from sapwood indexed the decay resistance much more closely than did either specific gravity or the number of rings per inch in the wood. Neither specific gravity nor the number of rings per inch appeared to be correlated with the deviations of individual weight losses from the average curves shown in figures 12 and 13; their association with weight loss was therefore apparently the result of their relation to size of tree and position in tree.

The assumption sometimes made that denser wood is more decay resistant than lighter wood of the same species is probably more or less correct for coniferous woods. With conifers the rapidly grown wood near the center of a tree is generally less dense than the wood grown at a moderate rate further out. With hardwoods, the opposite is true; the wood near the center tends to be the most dense. As the highest decay resistance (as measured by percentage loss in weight) of most woods studied occurs in the outer heartwood (*2*, *3*, *15*, *16*, *18*), a positive association between decay resistance and specific gravity might be expected in conifers, but just the opposite association might be expected in hardwoods, as was found in this study.

It must be recognized, of course, that high density has some direct effect on the serviceability of decayed wood; dense posts, for example, may continue serviceable after a percentage weight loss that would make posts of low or moderate density too weak for further use.

COLOR OF LOCUST WOOD AS AN INDEX OF ITS DECAY RESISTANCE

There is a widespread belief among users of black locust wood that the yellower its color the greater its decay resistance is apt to be. Some justification for this belief was found in the material tested. By daylight, the samples ranged in color from a light greenish yellow to a light chocolate brown, and by ultraviolet light from a deep lemon yellow to a light straw yellow. The first-mentioned color in each case was associated with the highest decay resistance. The association of decay resistance with these colors was much too variable, however, to be relied on as a basis for selection.

EFFECT OF SEASON OF FELLING ON DECAY RESISTANCE

It is often said of black locust and certain other timber species that wood from trees felled in spring and early summer is less durable than that from trees felled in winter during the dormant period. There is no experimental support for such an opinion for black locust, although Crumley (*4*) found some evidence in an examination of posts under practical use to indicate that it is better not to cut posts in spring just as the tree begins to grow. Differences in the durability of wood cut at different seasons of the year were reported by Gäumann for spruce and fir (*6*), and lesser differences for beech (*7*); but in no case were the differences of practical magnitude in wood that had been seasoned.

In connection with the present study, the decay resistance of spring- and winter-cut wood was compared for six trees each in a shipmast locust stand and a common locust stand. In each stand, three of the trees were cut in February and three in May. The three trees were of approximately 5, 10, and 15 inches d. b. h., respectively (see table 2). The wood blocks for the decay tests were taken at two heights in the trees—3 to 4 feet and 7 to 8 feet. As with all the other blocks, they were air-dried prior to testing.

The average decay losses for the winter- and spring-cut wood are shown in table 8. The shipmast locust wood cut in spring was more resistant than that cut in winter, whereas the reverse was true for the common locust. The differences in decay resistance are partly but not entirely attributable to differences among the trees as regards the ring count and distance from the sapwood of the wood sampled.

TABLE 8.—*Average weight losses in wood from winter- and spring-cut locust trees*

Season of cutting	Weight loss	
	Shipmast locust	Common locust
	Percent	*Percent*
Winter	1. 86	3. 20
Spring	1. 52	3. 59
Difference	. 34	—. 39
Adjustment for radial location of samples (figs. 12 and 13)	. 18	. 08
Adjusted difference	[1] . 16	—. 31

[1] Significant at the 5-percent level.

Inasmuch as the testing was limited to 12 trees, differences attributable to season of cutting could be apparent only if they were marked. The indication from the present results is that any superiority of winter-cut locust wood over spring-cut is doubtful or at most of small practical consequence if the wood is first seasoned.

SITE

The influence of site on decay resistance was determined from an examination of the data for the 7- to 8-foot level in winter-cut shipmast and Flowerfield trees. These two strains were used for studying site effects because the trees of each strain are probably clonal. This assumption is based on the fact that the trees bear very few seeds and are propagated vegetatively. Further evidence to support this assumption has been obtained from a study of their vegetative characteristics (*10*). In that study, the homogeneity in the leaves and spines on shipmast locust contrasted sharply with the heterogeneity of these characters on common locust, which produces seed.

Since the five stands of the shipmast and Flowerfield strains were similar genetically and the trees in each case were of about the same average size, any marked differences between the stands in average durability might reasonably be attributed to site effects. The site indices of the shipmast and Flowerfield stands and average weight losses in all three selection groups by diameter class and stand are given in table 9. With respect to decay by either *Fomes rimosus* or by *Poria incrassata*, weight losses for the five shipmast stands were comparatively small and indicated about the same class of decay resistance. The same is true for the Flowerfield stands.

The differences bore no significant relation to the site index of the stands. This uniformity of results also indicates that the decay resistance of the vegetatively propagated stock is of very stable character in the Long Island area. Both this genetic stability and the absence of a material site influence obviously would be of advantage in widespread cultivation of strains selected for superior decay resistance of the wood.

The variability in weight loss among the common locust stands, on the other hand, contrasted sharply with the consistency in the two vegetatively propagated strains for the same general area. Further evidence on this point was obtained by appraising the stand differences by analysis of variance in weight loss caused by *F. rimosus*, after adjusting the individual weight losses for differences related to size and age of the trees in the stands according to the graphically expressed relations of figures 12 and 13. This indicated that the observed differences among the shipmast and Flowerfield locust stands, respectively, were no greater than might very commonly be had among groups of genetically similar trees in a single stand. In marked contrast, differences as large as those found among the common locust stands would not be expected oftener than about once in 20 times, simply as a result of random sampling of similar trees. The comparison serves to emphasize again the genetic heterogeneity of the stands that arose from seed-propagated stock.

The preceding information does not, of course, exclude the possibility that decay resistance might be affected by differences in site or climate larger than those studied.

GENETICS

Genetic influences on decay resistance were apparent in the differences among the three groups as well as among the stands of the common locust group (table 9). Part of these differences, however, were associated with the annual-ring and radial positions of the test blocks representing the different groups. Relative to the trees of the 10-inch d. b. h. class, for example, the higher resistance of the Flowerfield as compared with that of the shipmast was partly attributable to the fact that the average diameter at breast height of the Flowerfield trees was about 1 inch greater than that of the shipmast trees and the average age of the sampled cross sections was about 5 years greater. In order to correct for these two factors, therefore, the weight

TABLE 9.—*Mean*[1] *weight loss in test blocks, by selection groups, stands, and diameter-at-breast-height classes*[2]

Shipmast						Flowerfield			Common				
Stand	Site index	Average weight loss of—				Stand	Site index	Average weight loss, 10-inch class	Stand	Average weight loss of—			
		5-inch class	10-inch class	15-inch class	All trees[3]					5-inch class	10-inch class	15-inch class	All trees[3]
DECAY BY FOMES RIMOSUS													
	Percent	Percent	Percent	Percent	Percent			Percent		Percent	Percent	Percent	Percent
B-6	55	1.8	2.5	1.3	1.8	C-42	53	1.3	B-53		6.3	4.6	5.3
B-7	63	1.1	1.6	2.0	1.7	B-42	64	1.3	B-54		1.6	1.5	1.5
B-4	64	2.7	1.0	1.3	1.3	B-45	69	1.3	C-56		2.5	2.8	2.7
B-9	65	.7	2.4	1.4	1.7	B-46	70	1.4	B-56	2.7	1.8	1.7	1.8
B-10	67	2.2	2.5	1.8	2.1	A-19	72	1.5	A-54	4.6	4.3	2.4	3.5
All stands		1.7	2.0	1.6	1.7	All stands		1.4	All stands	3.9	3.4	2.5	2.9
DECAY BY PORIA INCRASSATA													
B-6	55	1.6	2.9	1.0	1.8	C-42	53	0.9	B-53		32.4	18.8	24.4
B-7	63	1.9	1.1	6.1	3.7	B-42	64	5.5	B-54		18.4	3.2	9.2
B-4	64	8.7	2.5	8.8	6.5	B-45	69	6.1	C-56		15.8	14.0	14.5
B-9	65	1.3	9.8	6.4	7.2	B-46	70	3.1	B-56	31.9	26.6	35.4	31.7
B-10	67	8.1	9.9	2.9	5.9	A-19	72	5.6	A-54	2.1	.3	19.3	10.0
All stands		3.6	5.3	4.9	4.9	All stands		4.2	All stands	14.0	16.8	17.4	17.0

[1] Each value is the average of the percentage weight losses obtained from the individual samples; the larger trees supplied more samples and thus had more influence on the "all trees" and "all stands" values.
[2] Winter-cut trees, sampled at a height of 7 to 8 feet.
[3] Mean actual diameter at breast height of all trees represented was 10 inches for shipmast, 11.2 inches for Flowerfield, and 11 inches for common locust.

losses on which the averages in table 9 were based were adjusted by means of the following multiple regression formula:

$$\sqrt{\text{Weight loss (percent)}}=0.68+0.0128X+0.3408Y-0.0074XY,$$

in which X=rings from pith and Y=distance from sapwood in inches.

This formula consists of the same two independent variables that were indicated by graphic analyses (table 6) to explain best the variability in decay resistance on a cross section. The square-root transformation of the percentage weight losses was used in this case in order to get an essentially linear expression of the relations and thereby permit the following analysis of the variability in weight loss on an entirely mathematical basis.

It should also be pointed out that the data for all selection groups were pooled in deriving the formula. Hence, the relationships expressed by the formula, although concerning the same variables, apply to all selections as a whole rather than specifically to selection groups, as in the cases of the graphically derived figures 12 and 13. Both the formula and the curves, however, led to the same conclusions as regards general trends, and the standard errors were similar for both methods of calculation.[13]

The application of this formula in an analysis of variance (*19*), table 10, serves to point out the variability in decay resistance that was not attributable merely to the selection of the wood blocks. The adjustment of the data gives an estimate of the decay losses that could be expected if all the blocks had been taken at the same radial distance from the sapwood and the same number of annual rings away from the pith.

The first column of table 10 lists the sources of variation. The error refers to the variability in weight loss between the duplicate test blocks. The other lines refer to the variability in mean weight loss among individual radii, trees, stands, and groups. The mean square associated with each source of variation in the original data is shown in column 2. The differences in extent of decay increased progressively the less the material was related. Thus the duplicate blocks varied least (mean square=0.0158), whereas the groups varied the most (mean square=7.0208).

That part of each mean square in column 2 that was not accounted for by the relation of weight loss to the radial location of the wood as given in the preceding formula is shown in column 3. The mean square between duplicate blocks was not changed by adjustment for the annual-ring and linear-position relationship, inasmuch as the two blocks of each pair were alike in respect to these factors. The mean square among blocks in the same radius was largely accounted for by these factors, as evidenced by the reduction from 0.0821 to 0.0375; the remainder (0.0375), however, was still significantly greater than the

[13] Another point that should probably be mentioned is the use of XY, which is entered as a third factor in the formula. By using XY, the curves are given the proper convergence at higher values of X and Y. Also, within the range of the major part of the data, the net effect of X becomes negative, which is also in conformity with the graphic analysis. These points apply only within the range of the data used in the study.

TABLE 10.—*Analysis of variance of weight losses*[1] *adjusted for annual-ring and radial positions of the test samples.* (*Based on winter-cut trees of all selections and on samples taken from a height of 7 to 8 feet in the tree*)

(1) Source of variation	(2) Unadjusted losses		(3) Losses adjusted for ring count from pith and distance from sapwood, according to regression formula on p. 29	
	Degrees of freedom	Mean square	Degrees of freedom	Mean square
Duplicate blocks within radial positions (error)	357	0. 0158	357	0. 0158
Positions within radii	306	. 0821	303	. 0375
Radii within trees	40	. 1079	40	. 0871
Trees within stands	27	. 3873	27	. 3562
Stands within groups	12	1. 2073	12	1. 2165
Groups	2	7. 0208	2	6. 5443

[1] The mean squares in this analysis were computed on the square roots of the percentage weight losses; see text, p. 29.

error (0.0158). The reduction in mean square for the other sources of variation, on the other hand, was small, indicating that a considerable part of the variability in decay resistance in these cases was attributable to factors other than radial position and annual-ring location of the specimens.

As shown in table 9, wood of common locust decayed the most, that of shipmast locust less, and that of Flowerfield locust the least. The mean square among the three groups is of particular interest, for it greatly exceeds that associated with all other sources of variation. The differences in average weight loss among these groups are represented by the mean square of 7.0208, and only a small part of this (7.0208 − 6.5443, or 0.4765) is explained by the fact that the wood blocks for the three groups were not all from a similar average location in the trees. The residual mean square, 6.5443, is highly significant statistically, as compared with that among stands within the groups, 1.2165. This indicates that the variability in decay resistance among the groups is definitely greater than can be accounted for by a random selection of stands of the same group.

The ratio of the residual mean squares (6.5443/1.2165, or 5.4) is far greater than that required for significance, indicating that group differences as large as those between the common locust and the selected strains probably could be reliably ascertained on a much smaller sampling basis than was used. This, of course, would be a marked advantage in any extensive exploration for strains of superior decay resistance. To evaluate strains, all of which are above average in resistance, however, might still require considerable sampling.

The differences in decay resistance among stands within the same group were larger than could reasonably be explained by random selection of trees of the same stands. This is shown by the highly significant variance ratio (1.2165/0.3562, or 3.4).

This significant mean square among the stands was attributable entirely to the variability in the common locust group. The shipmast and Flowerfield strains showed no significant stand differences. (See p. 27.) The variability among the common locust trees was probably mainly due to genetic differences, inasmuch as the stands were of heterogeneous seed origin and site did not appear to be a factor of decay resistance.

One of the common locust stands, B–54, compared favorably with shipmast and Flowerfield locust for decay resistance (table 9). The measured resistance of wood of this stand was approximately three times that of the least resistant common locust stand, B–53. This observation indicates the further possibility in black locust of selecting decay-resistant local strains that can be reproduced by seed.

DISCUSSION

THE NATURE OF THE DECAY-RESISTANCE FACTOR

The results of this study raise some interesting questions as to the source of decay resistance in black locust wood. The decay resistance of wood in general appears to depend largely on natural chemical preservatives that retard or prevent fungus attack on the cellulose and lignin components. In black locust it has been known for some time that the water extractives, particularly those soluble in hot water, have a considerable bearing on the decay resistance (*8*).[14] The fungi used to get evidence on this point were *Poria incrassata* and Madison 517 (tentatively identified as *Polyporus tulipiferus* (Schw.) Overh.). The relation was examined further in the present study, but the results were given in an earlier report (*17*); hence only the substance of the findings need be considered here.

Toxicity of the hot-water extractives was readily demonstrated by a reduction in growth rate of the test fungus (*Fomes rimosus*) on a malt-agar nutrient medium to which the extractive was added. The reduction in growth rate produced by various dilutions of extractive from the same samples of wood was almost in straight-line relation to the quantity present in the medium, between concentrations of 0.3 and 1 percent.

It was also found that the concentration, by weight, of hot-water extractives in the wood accounted for much of the significant variability in decay resistance in different parts of the same tree. The concentration of extractive accounted very little, however, for variability in weight loss among blocks from different locust groups or

[14] See footnote 7, p. 12.

from different trees of the same group. This result suggested that the toxic composition of the extractives was comparatively uniform at different places within individual trees, but that among different groups and trees either the concentration or chemical character of the toxic principle in the extractives varied considerably.

In order to determine whether extractives from different groups and trees varied in toxicity, the inhibiting effect of *F. rimosus* on the total quantity of extractive obtained from equal weights of wood was tested in malt-agar medium. Despite the fact, however, that these tests thus took into account differences in both the quantity and the toxicity of the material present, it was found that the differences in decay resistance between groups and trees could be indexed in no better way than by simply determining the quantity of extractives present in the wood. It is concluded, therefore, that, although the hot-water extractives account in substantial measure for the sizable differences in decay resistance found within individual locust trees, an explanation of the differences between trees must be sought in an additional factor. From what has already been noted (p. 25), it seems unlikely that this factor is a physical one.

Some constituents that may not be especially toxic to decay fungi nevertheless may indirectly interfere with their attack, perhaps by limiting their capacity to produce enzymes needed to decompose lignin and cellulose. If some such constituent is present in the hot-water extractives of black locust, it would hardly be evident in a test of growth-rate retardation on an artificial medium. There is also the possibility, of course, that all the toxic material in the wood was not hot-water soluble or that the toxicity of some of the soluble material disappeared in the processes of extraction or in subsequent handling.

Whatever the nature of the chemical-resistance factors, they evidently varied in quantity or quality, or both, not only between strains, as a reflection of genetic differences, but also within the groups. The trend of variability within the groups (figs. 12 and 13) brought out the following two points: (1) The decay resistance of the newest formed heartwood, located at the sapwood border, is greater from year to year; and (2) the resistance of the heartwood at any particular point does not remain constant but decreases as the tree gets older and larger. This situation suggests either (1) that a greater quantity of the resistance factor is produced per unit of newly formed heartwood each year and that this resistance factor is not stable but subsequently deteriorates in effectiveness with age; or (2) that the quantity of the resistance factor produced for a unit of new heartwood is about the same from year to year, but is supplemented by a continuous outward diffusion or migration of previously formed resistance factor. Either explanation would account for the general features of the weight-loss trends shown in the preceding charts. Perhaps both are correct in some measure.

Selection of Wood for Maximum Durability

A number of conclusions with respect to the selection of black locust wood of greatest durability, particularly for use as posts, can be drawn from the data provided by this study. The most durable wood of a

particular strain is located in the outer heartwood in the basal part of large trees, and the least durable in the inner basal heartwood of the same trees. Consequently, split posts taken at different depths in the butt log of large trees may vary considerably in decay resistance. Some of the variation in service life of locust posts in a fence line is no doubt traceable to this factor. With strains having a relatively low average level of resistance, such as was exhibited by most of the common locust trees, the lesser resistance of posts from the inner heartwood would be particularly pronounced.

Posts from logs of small diameter generally would not be so durable as most posts from logs of large diameter. This difference would be more pronounced in strains having lower average resistance. In highly resistant strains, such as shipmast locust, the difference would not appear to be sufficient to warrant distinguishing between small and large logs from the viewpoint of their decay resistance. In less resistant strains, such as some of those in the common locust group, there might be some justification for such a distinction.[15]

The greatest durability advantages apparently may be had through the use of strains with superior average decay resistance. Not only might the average service life of the wood be expected to be greater accordingly, but the data also indicate that the service given by wood from trees of different sizes and from different parts of individual trees would be more uniform in such strains.

Selection of Superior Genetic Types

During the course of the studies on black locust strains referred to in the introduction, various other individual trees and stands having especially desirable growth features were noted. In considering the value of such selections as parent stock, the question of their inherent decay resistance should be taken into account. Tests to determine this attribute can be made in a relatively simple manner by making use of the findings in the present study.

The best comparisons are of course made between trees of the same age and size and with samples taken from the same position in the tree. The foregoing relations, however, indicate that it should be possible to sample trees of different sizes and ages and at different places in the trunk and still distinguish with rather high accuracy those that are hereditarily most resistant. For example, if trees of unknown resistance are sampled at a depth of 2 inches in the heartwood and the samples tested according to the methods of this study, the curve marked 2 in figure 13 might be followed. From this it appears that if the trees are alike genetically, samples located 40 annual rings from the pith should lose only about one-fourth as much weight in testing as samples located 6 or 7 rings from the pith in young trees. Similarly, if the samples are taken at a depth of 4 inches, those located 25 rings from the pith in an older tree should lose only about half as much weight as samples 10 rings from the

[15] The economics of selective use of locust wood from logs of different sizes or of growing the wood for round instead of split posts is, of course, a factor to be considered as well as the decay resistance. This, however, is outside the scope of the present study.

pith in a younger tree if the 2 trees deserve equal rating; and considerably less than that proportion should be lost if the older tree is to be rated as the superior one.

In the same way trees might also be rated individually with respect to their superiority or inferiority to common locust, as characterized by the values of figure 13. Or they might be compared with shipmast locust on the basis of figure 12, particularly if one were interested primarily in trees approaching the shipmast in resistance.

The base relations expressed in figures 12 and 13 would, of course, need to be modified somewhat in the event that a different fungus were used. It should be further noted that differences in decay resistance between individual trees would need to be established on results obtained with more than one fungus if the broadest application is desired. It has already been observed (p. 12) that the two fungi used in this study indicated a similar order of resistance among the tested selection groups and between trees of different diameter class in these groups. Certain differences, however, among the stands in resistance to the test fungi were evident. For example, as shown in figure 4 and table 9, trees of the common locust stand B–56 had relatively high resistance to *Fomes rimosus* but relatively low resistance to *Poria incrassata*.

In making use of the relations found in this study certain restrictions on the sampling apparently would substantially improve the reliability of determinations and therefore require fewer determinations per tree. It was noted (p. 23) in discussing figures 12 and 13 that samples taken from the outer heartwood of large trees having approximately the same growth rate frequently may not show sufficient differences in weight loss for reliable appraisal of genetic differences in decay resistance. Although the experimental error of determining decay resistance tends to be less as the average weight loss is lower, the part of the error caused by computing the initial weights of test specimens (p. 7) was not smaller at the lower levels of weight loss. Consequently, the error in determining small losses is not low enough to certify small differences of the magnitude indicated for the outer 2 inches of large trees. Therefore, in dealing with large locust trees, strain differences in decay resistance would appear to be most effectively ascertained on samples taken at least 3 inches deep in the heartwood.

With trees of small to intermediate size (e. g., no larger than 10 inches d. b. h.) no such need for restricting the location of the sampling seems necessary. This being the case and if standing trees are to be sampled, the outer heartwood of trees of this general size might be most conveniently tested. The smaller trees, of course, offer easier access to the inner heartwood for measurements of radial location and for ring counts.

In testing standing trees it would be desirable to obtain the samples in such manner as would not cause serious injury to the trees. A supplementary decay test on locust wood indicated that samples consisting of ordinary increment cores,[16] 1 or 2 inches in length, would serve very well. The cores required more precise weighing (to 0.001 gram) than did the blocks; also, from three to five replications of the cores were needed for the same reliability of determination as was provided by the duplicate blocks.

[16] Obtained with a Swedish increment borer having an inside diameter of 0.21 inch.

SUMMARY

This study was made to test the decay resistance of strains of black locust and to ascertain what factors of testing should be considered in order to separate true strain differences from differences in resistance that might be associated with other factors. Strains considered were shipmast, of reputed high durability; Flowerfield, another clonal variety not previously recognized; and several consisting of the common seed-reproduced locust. All were obtained on Long Island, N. Y. Forty-eight trees of various sizes, chosen from several stands that differed in growth rate, were sampled. The tests were made in the laboratory on small blocks of heartwood from different parts of the trees. The blocks were exposed to decay by *Fomes rimosus*, a heart-rot fungus commonly found in locust trees and which also occurs in locust posts, and by *Poria incrassata*, a fast-growing fungus that rots a variety of woods in use. The extent of decay was measured by the loss in weight.

On the average, the Flowerfield strain decayed the least, the shipmast somewhat more, and the common locust considerably more. The results with shipmast and common locust bore out the reputed difference in general durability of the two types. There was comparatively small variation in decay among the shipmast and Flowerfield stands, indicating stable resistance in vegetatively propagated stock. Variation in decay among the common locust stands was marked; being seed-propagated, the sampled trees of this group evidently were of several strains.

Radially in a tree, the decay resistance was progressively less from the outer heartwood to the pith. Vertically, the resistance of the outer heartwood was progressively less from the base of the tree to the upper trunk; the opposite trend occurred in the inner heartwood. For the tree as a whole, the outer heartwood at the base was the most resistant and the inner heartwood at the base the least. Higher in the trunk the wood was intermediate between these extremes. The average resistance of the entire heartwood cross section was generally less in the upper part of the trunk than in the lower: the difference was especially noticeable in the small trees, but was absent or doubtful in the 15-inch-diameter class.

The large trees were more resistant in the outer heartwood than the small ones, but in the inner heartwood the opposite was true. Because the outer heartwood makes up more of the trunk volume than the inner heartwood, large trees were superior to small ones in the average resistance of the entire heartwood cross section, but the difference was small. The differences between large and small trees in the lower part were much like those obtained between sections of large and small diameter at different heights in the same tree.

Decay resistance was influenced by the rate of diameter growth; with trees of equal diameter, the slower grown ones were slightly more resistant. The rate of height growth apparently did not influence decay resistance.

These variations in decay resistance were correlated in large degree with two measurable characteristics of the wood—the closer the sample was to the sapwood and the greater the number of annual rings from it to the pith the greater was its resistance to decay. Both graphic and mathematical expressions of the relation of weight loss to those two factors were used as a basis on which to compare samples taken from different positions in a tree or from trees of different diameters, ages, and growth rates.

Other ways of characterizing locust heartwood, such as by rings per inch, specific gravity, and color, proved to be rather unreliable for judging decay resistance. In general, however, wood having more rings per inch or lower specific gravity was more resistant and yellow-colored wood averaged somewhat more resistant than brown.

The belief that locust wood is more resistant when cut in the winter than the spring was not confirmed by this study. The common locust trees cut in the winter averaged slightly greater in resistance, but the opposite was found with the shipmast locust.

The decay resistance of locust wood was found to be partly associated with the extractives that could be dissolved in hot water. These extractives were toxic to fungi. Both the extractives and the decay resistance were greatest at the time the heartwood was first formed. Thereafter they decreased as new layers of heartwood were added to the outside. The measurable differences in extractives accounted for a large part of the differences in resistance within individual trees, but they did not explain the differences among trees or strains.

In comparing trees for genetic superiority in decay resistance, it was suggested that the test blocks be taken from the outer heartwood if the trees are not more than 10 inches in diameter. For larger trees, the blocks should be taken at least 3 inches deep in the heartwood. If the trees differ much in size or age or if the test samples are not taken from the same position in each tree, the results should be corrected for these differences in accordance with the relations reported here. The quantitative values in these relations would, of course, need to be modified on the basis of preliminary testing if the testing procedure differed materially from that used in this study.

LITERATURE CITED

(1) Betts, H. S.
1945. BLACK LOCUST. U. S. Dept. Agr. Amer. Woods Ser. 5 pp., illus.

(2) Cartwright, K. St. G.
1941. THE VARIABILITY IN RESISTANCE TO DECAY OF THE HEARTWOOD OF HOME-GROWN WESTERN RED CEDAR (THUJA PLICATA D. DON.) AND ITS RELATION TO POSITION IN THE LOG. Forestry 15: 65–75, illus.

(3) ———
1942. THE VARIABILITY IN RESISTANCE TO DECAY OF THE HEARTWOOD OF HOME-GROWN EUROPEAN LARCH, LARIX DECIDUA, MILL. (L. EUROPAEA), AND ITS RELATION TO POSITION IN THE LOG. Forestry 16: 49–51.

(4) Crumley, J. J.
1910. THE RELATIVE DURABILITY OF POST TIMBERS. Ohio Agr. Expt. Sta. Bul. 219, pp. 605–640, illus.

(5) Detwiler, S. B.
1937. THE HISTORY OF SHIPMAST LOCUST. Jour. Forestry 35: 709–712, illus.

(6) Gäumann, E.
1930. UNTERSUCHUNGEN ÜBER DEN EINFLUSS DER FÄLLUNGSZEIT AUF DIE EIGENSCHAFTEN DES FICHTEN– UND TANNENHOLZES. II. TEIL: DER EINFLUSS DER FÄLLUNGSZEIT AUF DIE DAUERHAFTIGKEIT DES FICHTEN– UND TANNENHOLZES. Schweiz. Ztschr. f. Forstw., Beih. 6, 155 pp., illus.

(7) ———
1936. DER EINFLUSS DER FÄLLUNGSZEIT AUF DIE DAUERHAFTIGEKIT DES BUCHENHOLZES. Schweiz. Anst. f. Forstl. Versuchsw. Mitt. 19: [382]–456, illus.

(8) Hawley, L. F., Fleck, L. C., and Richards, C. A.
1924. THE RELATION BETWEEN DURABILITY AND CHEMICAL COMPOSITION IN WOOD. Indus. and Engin. Chem. 16: 699–700.

(9) Hirt, R. R.
1938. A PROGRESS REPORT ON LABORATORY TESTS OF THE RELATIVE DURABILITY OF DIFFERENT VARIETIES OF BLACK LOCUST SUBJECTED TO CERTAIN WOOD DECAY FUNGI. Jour. Forestry 36: 53–55.

(10) Hopp, H.
1941. METHODS OF DISTINGUISHING BETWEEN THE SHIPMAST AND COMMON FORMS OF BLACK LOCUST ON LONG ISLAND, N. Y. U. S. Dept. Agr. Tech. Bul. 742, 24 pp., illus.

(11) ———
1941. GROWTH-FORM VARIATION IN BLACK LOCUST AND ITS IMPORTANCE IN FARM PLANTING. Jour. Forestry 39: 40–46, illus.

(12) ——— and Grober, S.
1947. EFFECT OF SITE ON THE GROWTH OF SHIPMAST LOCUST. Jour. Agr. Res. 74: 315–328, illus.

(13) Muntz, H. H.
1943. A FENCE POST SERVICE TEST IN THE MISSISSIPPI DELTA. Jour. Forestry 41: 524–526.

(14) Raber, O.
1936. SHIPMAST LOCUST, A VALUABLE UNDESCRIBED VARIETY OF ROBINIA PSEUDOACACIA. U. S. Dept. Agr. Cir. 379, 8 pp., illus.

(15) Scheffer, T. C. and Duncan, C. G.
1947. THE DECAY RESISTANCE OF CERTAIN CENTRAL AMERICAN AND ECUADORIAN WOODS. Yale Univ., School Forestry Trop. Woods 92: 1–24, illus.

(16) ——— Englerth, G. H., and Duncan, C. G.
1949. DECAY RESISTANCE OF SEVEN NATIVE OAKS. Jour. Agr. Res. 78: 129–152, illus.

(17) ——— Lachmund, H. G., and Hopp, H.
1944. RELATION BETWEEN HOT-WATER EXTRACTIVES AND DECAY RESISTANCE OF BLACK LOCUST WOOD. Jour. Agr. Res. 68: 415–426, illus.

(18) Sherrard, E. C., and Kurth, E. F.
1933. DISTRIBUTION OF EXTRACTIVE IN REDWOOD—ITS RELATION TO DURABILITY. Indus. and Engin. Chem. 25: 300–302, illus.

(19) Snedecor, G. W.
1946. STATISTICAL METHODS. Ed. 4, 485 pp., illus. Ames, Iowa.

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