
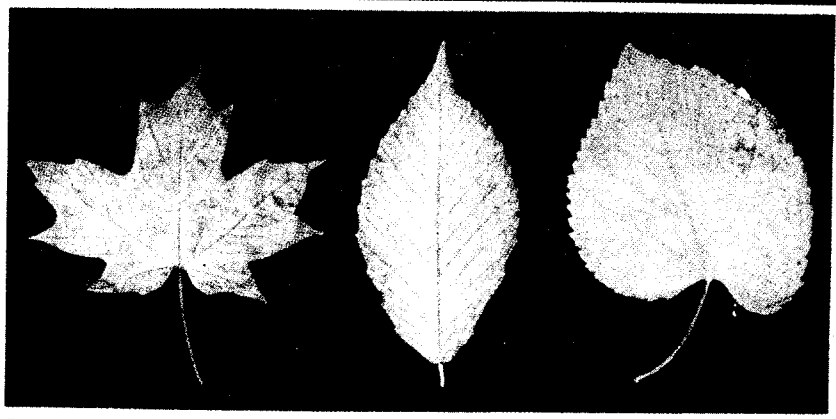


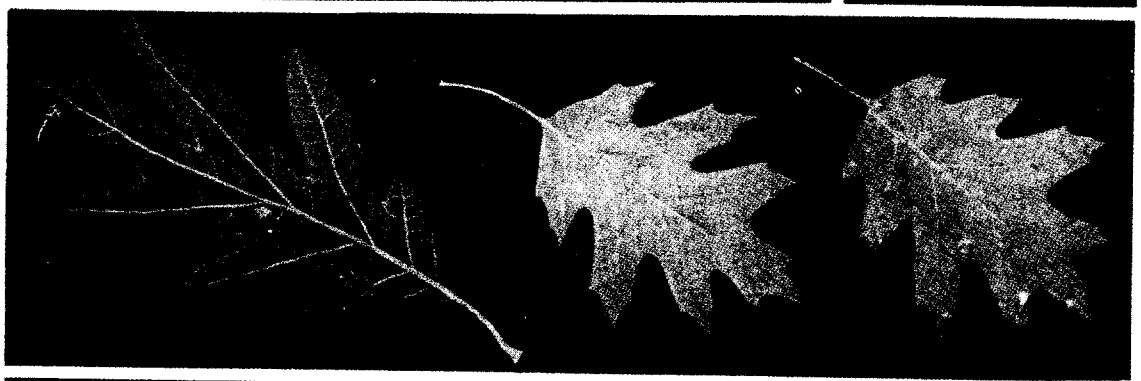
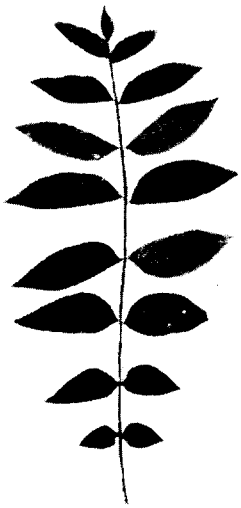
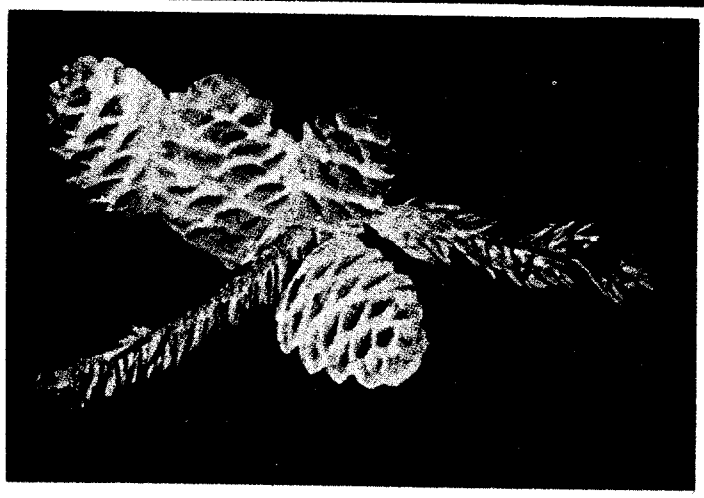
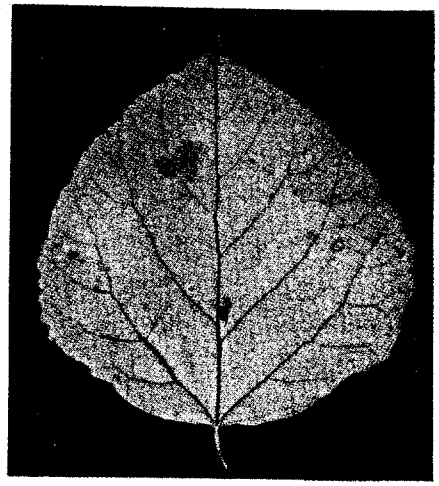

manager's handbook for

BLACK WALNUT

GENERAL TECHNICAL REPORT NC-38

NORTH CENTRAL FOREST EXPERIMENT STATION FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

Other Manager's Handbooks are:

Jack pine – GTR-NC-32
Red pine – GTR-NC-33
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Northern white-cedar – GTR-NC-35
Aspen – GTR-NC-36
Oaks – GTR-NC-37
Northern hardwoods – GTR-NC-39

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1977

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FOREWORD

This is one of a series of manager's handbooks for important forest types or species in the north-central States. The purpose of this series is to present the resource manager with the latest and best information available on handling these types. Timber production is dealt with more than other forest values because it is usually a major management objective and more is generally known about it. However, ways to modify management practices to maintain or enhance other values are included where sound information is available.

The authors have, in certain instances, drawn freely on unpublished information provided by scientists and managers outside their specialties. They are also grateful to the several technical reviewers in the region who made many helpful comments.

The handbooks have a similar format, highlighted by a "Key to Recommendations". Here the manager can find in logical sequence the management practices recommended for various stand conditions. These practices are based on research, experience, and a general silvical knowledge of the predominant tree species.

All stand conditions, of course, cannot be included in the handbook. Therefore, the manager must use technical skill and sound judgment in selecting the appropriate practice to achieve the desired objectives. The manager should also apply new research findings as they become available so that the culture of these important forest types can be continually improved.

CONTENTS

BLACK WALNUT

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KEY TO RECOMMENDATIONS

The following key is intended to facilitate quick access to recommendations covering any site or stand likely to be encountered in walnut management. It is important that the management objectives be clearly in mind before entering the key (Management Objectives, below).

1. **Poor or questionable walnut site** . . . . . CONSIDER OTHER SPECIES (see p. 3)
1. **Good walnut site (site index 40 or more)** 2
2. **No walnut trees** . . . . . PLANT OR SEED (see p. 6)
2. **Walnut trees present** 3
3. **Trees less than 10 feet (3m) tall** . . . . . CONTROL WEEDS AND IMPROVE FORM IF NEEDED (see p. 9)
3. **Trees taller than 10 feet (3m)** 4
4. **Scattered walnut trees in natural stands, pastures, or fence rows** . . MANAGE INDIVIDUAL TREES (see p. 14)
4. **Walnut plantations or pure natural stands** 5
5. **Product goals attained** . . . . . HARVEST AND REGENERATE (see p. 15)
5. **Product goals not attained** . . . . . THIN, PRUNE, AND/OR FERTILIZE AS NEEDED (see p. 12)

GENERAL CONSIDERATIONS

The decision to grow and manage black walnut should be based upon the following questions. First, are the soils and climate in the management area suitable for walnut; that is, is it biologically possible to grow walnut? Second, are the resources available to invest in management; that is, is it economically feasible? And, finally, what are the interests of, and the other management options available to, the landowner; that is, is it desirable to manage walnut? This handbook will address primarily the biological question.

Management Objectives

In the following tabulation, likely management options are indicated by an "X"; those marked with a question mark would be feasible only in special situations.

	Timber	Timber & Nuts	Multi-cropping
"Bare" land	X	X	X
Newly established plantation	X	X	?
Previously unmanaged plantation	X	X	?
Young natural stand			
—many walnut	X	X	?
—few walnut	X	–	–
Older natural stand			
—many walnut	X	X	–
—few walnut	X	–	–

Habitat Conditions

The frost-free season within the range of black walnut (fig. 1) varies from 140 days in the north to 280 days in

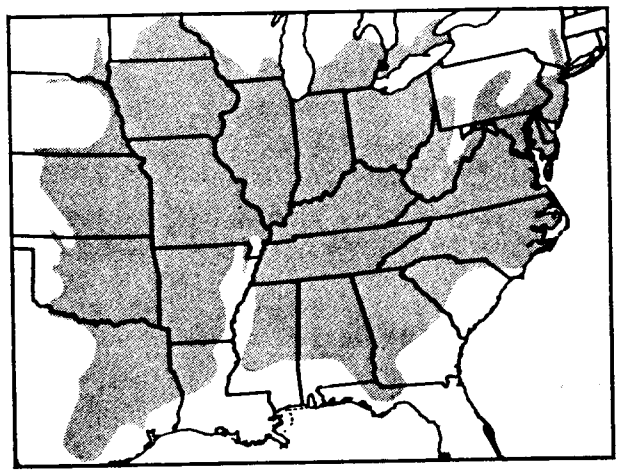

Figure 1. – *Natural range for black walnut,* Juglans nigra.

western Florida. Annual precipitation in this region varies from less than 25 inches (64 cm) in northern Nebraska to 70 inches (178 cm) or more in the Appalachians of Tennessee and North Carolina. Temperatures as low as -45°F (-43°C) have occurred where walnut grows.

Associated Trees and Shrubs

Black walnut grows in many of the mixed mesophytic forests but is seldom abundant. It generally is found scattered among other trees; pure stands are of limited extent, usually found on the edge of the forest. Chief associates include yellow-poplar (see Appendix, p. 19, for list of scientific names), white ash, black cherry, basswood, beech, sugar maple, oaks, and hickories. The eastern redcedar-hardwood type of Kentucky and central Tennessee often contains a relatively high percentage of black walnut. Near the western limits of the tree's range, it may be confined to floodplains and occur either with American elm, hackberry, green ash, and boxelder, or with basswood and red oak on lower slopes and other favorable sites.

No universal plant indicator of a good black walnut site is known, but the presence of Kentucky coffeetree seems to indicate a suitable site for walnut. In general, where yellow-poplar or white ash grow well, black walnut also thrives.

An antagonism between black walnut and many other plants growing within its root zone has been recognized and is attributed to a toxic substance, juglone, which is present in black walnut leaves and especially in roots and nut hulls. Plants known to be affected include tomatoes, alfalfa, and many coniferous species.

Reproduction and Early Growth

Flowering and Seed Production

Depending somewhat on latitude, black walnut flowers generally appear between mid-April and mid-June. The large, edible fruit ripens in September or October of the same year, usually dropping shortly after the leaves fall.

Seed crops are produced most commonly in an alternate-year cycle, but some trees bear annually, others in 1 or 2 years out of each 3, and many with no regular pattern at all. Although open-grown trees produce some seed as early as 4 years after planting, the minimum seed-bearing age for commercial quantities of seed is about 12 years. Best seed production begins when the trees are about 30 years old and continues for another 100 years.

The large, distinctively flavored nuts furnish food for squirrels and make up as much as 10 percent of the diet of eastern fox squirrels. Many nuts buried by squirrels are not recovered, and some sprout and establish additional trees, particularly on the fringes of existing stands.

Seedling Development

Many black walnut seedlings germinate from nuts buried by squirrels in the fall. Normal freezing and thawing usually will cause the seeds to break dormancy the following spring, but germination may be delayed, sometimes until the second year.

Most seedlings emerge between late April and early June of the first or second spring after seeding. Although black walnut does not make as rapid height growth as yellow-poplar and white ash on good sites, it generally surpasses the oaks. In eastern Nebraska, near the western limits of its range, walnut made much better height growth than oaks and basswood on a prairie site. It developed an excellent root system and was several times the height of the other trees.

Height growth begins rather slowly in the spring, reaches a peak rate in May or early June, and is essentially complete by the middle of July or the first of August. Diameter growth peaks in July and continues into mid-August; root growth ends in mid-September. In general, black walnut loses its leaves somewhat earlier than other trees and over its range has a growth period of 90 to 135 days.

Vegetative Reproduction

If small black walnut trees up to age 20 or 30 are cut or killed back by fire, the stumps usually sprout freely; sprouting is more erratic from stumps or trees from age 30 to 40. Stumps usually sprout at or about ground level.

Sapling Stage to Maturity

Trees 130 feet (40 m) tall and over 8 feet (2.5 m) in diameter at age 250 have been reported in Wisconsin. In Indiana, black walnut trees were 150 feet (46 m) in height and 6 feet (1.8 m) in diameter on the most favorable sites.

Reaction to Competition

Black walnut is an intolerant tree. In mixed forest stands, it must be in a dominant or codominant position to maintain itself, although it has survived and grown in the relatively light shade of black locust. Near the western limits of its range, black walnut may be part of the elm-ash-hackberry type that succeeds pioneer trees including willow, eastern cottonwood, and boxelder on bottomlands.

Open-grown trees tend to retain their lower branches indefinitely. Heavy artificial pruning is impractical because of sprouting from dormant buds. Sprouting is directly related to the amount of light reaching the bole; more branches may be removed from trees in dense stands than from open-grown trees. Dominant trees sprout less than intermediates. Trees that are drastically released from competition may develop epicormic branches.

Site Evaluation

Black walnut is sensitive to soil conditions, developing best on deep, well-drained, nearly neutral soils which are generally moist and fertile. This species is common on limestone soils and grows especially well on deep loams, loess soils, and fertile, well-drained alluvial deposits.

Failure to consider site quality is a common and serious mistake in walnut management. A thorough soil examination by a soils specialist is the best procedure. A less accurate, but generally useful, method is to determine site quality from index curves (fig. 2), if there are walnut trees 15 years of age or older on the area. Do not manage for walnut if the site index is less than 40.

If there are no walnuts of sufficient age for site index determination, analyze the topography and soil to assess site quality. In strongly rolling and mountainous areas, landscape position and slope aspect, as well as soil characteristics, are important in site selection. The better growing areas are typically located on the lower north- and east-facing slopes, stream terraces, and floodplains. Avoid steep, south- and west-facing slopes and narrow ridgetops.

In smooth and gently rolling areas, soil characteristics are more important than landscape position. The three most important soil factors for walnut are texture, depth, and drainage. Either use a soil auger or dig a soil pit to check soil characteristics to a depth of 3 feet (1 meter) (see Appendix, p. 19, for metric conversions). The topsoil should be a sandy loam, loam, or silt loam, while the subsoil should be one of the above or a sandy clay loam or clay loam. Soils derived from limestone with silt loam over clayey subsoils are good planting sites. Soils with acid clayey subsoils should be avoided, as should soils with coarse sand or gravel layers or bedrock within 2.5 feet (0.8 meters) of the surface.

A uniform brown, yellowish-, or reddish-brown color to 3 feet or more indicates satisfactory drainage. Avoid soils with evidence of mottling within 2.5 feet of the surface. A soil with red, yellow, or gray spots (mottles) or a uniform gray color generally indicates slow to very slow internal drainage.

Nutrient Requirements and Fertilization

If walnut trees are growing on the proposed site, their foliage can be checked for any serious deficiency symptoms (table 1). Chemical analysis of foliage can diagnose less extreme nutrient deficiencies that have no visible symptoms and also suggest if the trees will respond to fertilization (table 2). Not much is yet known about fertilization. Field fertilization research has been conducted only with the macro-nutrients (N, P, K, Ca), with variable response. It is not possible to make specific recommendations for specific soils at the present time, but, in general, nitrogen fertilization appears to be most promising. Fertilization of pole-size trees is likely to provide the best economic returns. It may be necessary to refertilize every 5 years or so in order to maintain growth stimulation. Fertilization should be considered a supplement to other cultural practices, and cannot be expected to compensate for other limiting soil factors such as poor moisture conditions.

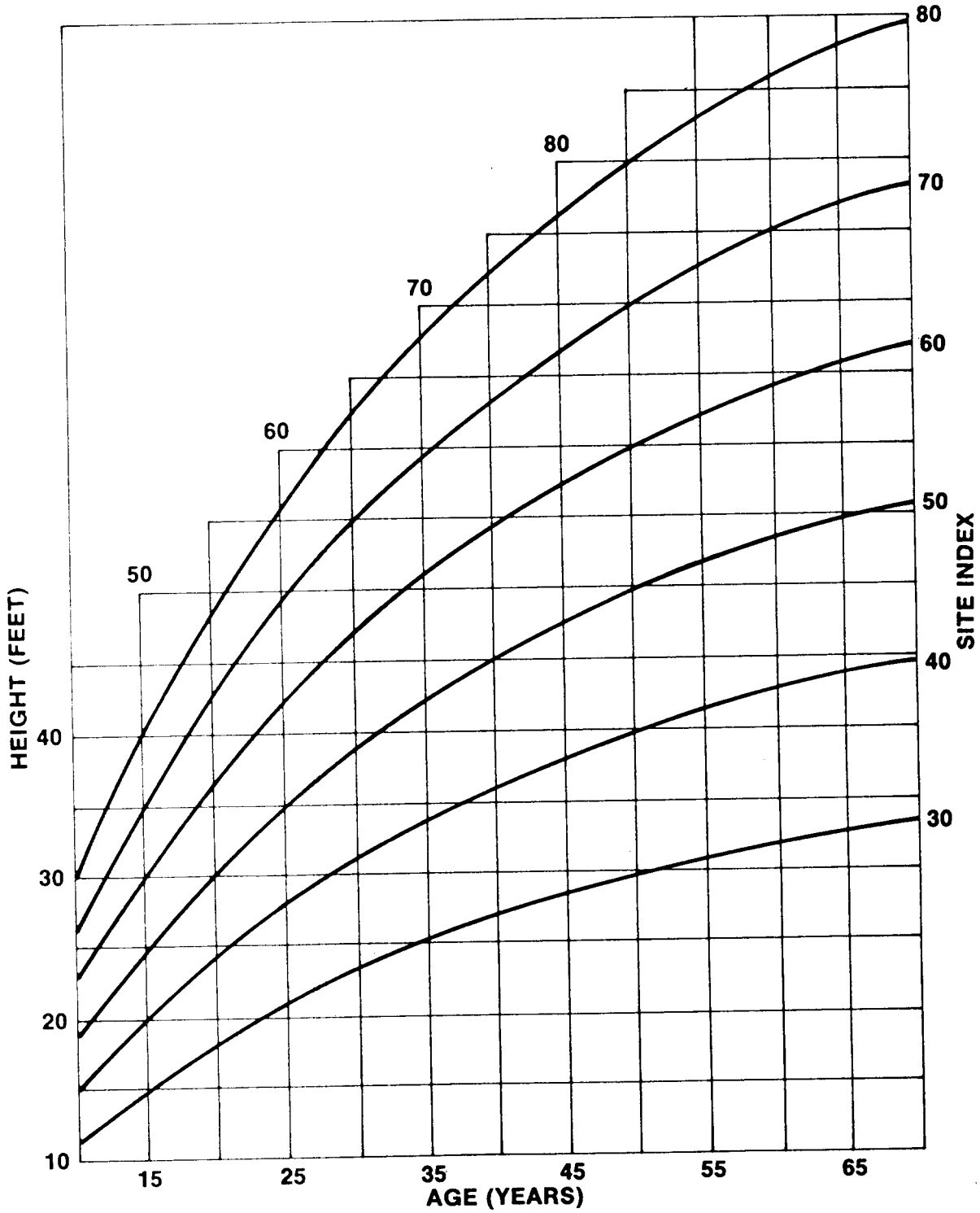

Figure 2. – *Black walnut site index curves.*

Protection from Damaging Agents

Although older black walnut trees are quite windfirm and not easily damaged by ice or windstorms, young trees are susceptible to top breakage during early summer storms while the new growth is still succulent.

Numerous insects and diseases attack black walnut, but the "big three" for the grower are the walnut caterpillar, the bud borers and casebearers, and anthracnose. The black walnut caterpillar is a defoliator. Damage varies from year to year, but repeated defoliation can lead to the death of the tree. Bud borers and

Table 1. – *Deficiency symptoms for various nutrients in leaves of black walnut seedlings*[1]

Nutrient	Most apparent deficiency symptoms
N	Leaflets and rachis small. Leaflets yellow to yellow-green, veins yellow. Leaflets have a crinkly appearance. Number of leaflets reduced.
P	Leaflets and rachis small. Yellowish rachis. Chlorotic areas on the leaflets between veins. Lateral leaflets exhibit bronzing. Number of leaflets reduced.
K	Leaflets light yellowish green with marginal yellowing, especially at tips. Rachis yellow-green to yellow. Leaves small. Number of leaflets reduced.
Ca	Leaves very small. Leaflets have chlorotic areas and patches of light green to yellow. Terminal leaflet has tip burn. In extreme case, leaf loses practically all green coloring and appears bleached and whitish. Number of leaflets reduced.
Mg	Leaf size about normal. Some small chlorotic areas. Leaflets yellow-green to light green. Veins remain green. Number of leaflets normal.
S	Leaves small. Leaflet color pale green to almost bleached white. Veins near base of leaflet darker green than other leaflet tissue. Rachis green to purplish. Number of leaflets normal.
Fe	Similar to sulfur except less reduction in leaflet size and veins remain green especially adjacent to the mid-vein. Leaflet surface smooth. Number of leaflets normal.
Mn	Leaf size about normal. Rachis is brownish, basal leaflets show bleaching along margins, and overall leaf color is yellow-green. Number of leaflets normal.

[1]Hacskaylo, Finn, and Vimmerstedt, 1969.

Table 2. – *Tentative critical foliar nutrient levels*[1] *for diagnosing nutrient deficiencies in black walnut trees*

Nutrient	Deficient (will probably respond to fertilization)	Intermediate (may or may not respond to fertilization)	Adequate (will probably not respond to fertilization)
	Percent		
N	below 2.00	2.00 - 2.60	over 2.60
P	" .10	.10 - .25	" .25
K	" .75	.75 - 1.30	" 1.30
Ca	" .50	.50 - 1.10	" 1.10
Mg	" .15	.15 - .45	" .45
S	" .05	.05 - .25	" .25
	Parts per million		
Fe	" 40	40 - 100	" 100
Mn	" 30	30 - 80	" 80
B	" 20	20 - 50	" 50
Zn	" 15	15 - 50	" 50
Cu	" 5	5 - 10	" 10
Mo	" .05	.05 - .10	" .10

[1]Based on analyses of mature leaves collected about mid-August (Phares and Finn 1971).

casebearers are particularly important during the early years of plantation establishment, boring into the buds and causing forking of the main stem. Anthracnose is a leaf spot disease that may cause premature leaf drop and loss of growth, and may induce the degrade of nut quality known as 'ambers'.

Adults of the walnut caterpillar are present during the spring and summer. They are stout-bodied moths, have wingspreads of about 2 inches, and are dull brown to chestnut brown in color. Egg-laying begins in June, the eggs being deposited in masses on the underside of leaves. The larvae feed in colonies. Full-grown larvae are up to 2 inches long, black with longitudinal, yellowish stripes, and covered with long white or dirty gray hairs. Insect parasites and birds control them naturally to a limited extent. The least expensive direct control measure is to destroy the colonies of larvae by removing them from the tree and burning or squashing them.

Several species of bud borers and casebearers have been found on black walnut. Although at some stage in their life cycle they feed on the leaves, the major damage is to the buds and developing shoots, and can be mistaken for frost injury. In either case, killing of the terminal bud or shoot often results in the development of more than one lateral bud. Control measures have not yet been developed. Ways to improve the form of affected trees are discussed on page 9.

Anthracnose leaf spot appears as irregular circular dark spots scattered over the leaflets early in the summer. The spread of anthracnose is more rapid during wet weather. Infection can be heavy enough to blight most of the leaf and cause it to drop prematurely. How much it affects tree growth has not been determined. It is believed that nut crop failures in some cases may be directly attributable to anthracnose, and control may be necessary for the production of nuts. Control is possible through the application of fungicides, such as Cyprex which is presently registered, or Benlate (registered only for use on nonbearing trees).[1]

Fire is another threat to black walnut. Although the evidence of damage following a ground fire is not immediately apparent, the living tissue directly beneath the bark can be killed by the high temperatures. The bark itself may remain in place over the dead wood for several years, but the wound to the valuable first log has already occurred. Where the danger of fire exists, fuel buildup in young plantations can be controlled by mowing grasses and weeds in the fall.

PLANTING

Intensive culture of black walnut is most feasible (and most necessary) in pure stands, but these are rarely encountered in nature. A major portion of this handbook is thus devoted to planting and to plantations where intensive culture can be practiced. Before actual planting, spacing, site preparation, plant material, and planting method must all be considered.

Spacing

To a considerable extent, appropriate spacing in walnut plantations is dictated by management objectives. We will consider plantations intended to produce timber alone, timber and nuts, and those with multiple-use objectives.

Objective: Timber

For plantations intended solely for timber production plant trees approximately 10 x 10 feet (3 x 3 meters) apart. Plantations established at such an initial spacing can be reduced from 436 to 23 trees per acre (1,077 to 57 trees/hectare) through a sequence of five thinnings (see example, Appendix, p. 17). The final thinning to 23 trees/acre at an average spacing of 44 x 44 feet (13.3 meters) will allow the trees to reach an average d.b.h. of 23.4 inches (59 cm) at harvest. This average diameter can be achieved only through selecting the faster growing trees to retain at each thinning. If the original planting comprises only 23 trees to be grown to final harvest, average d.b.h. for the same period of time is estimated to be only 19.6 inches (50 cm). Retaining only trees with above average growth rates results in a stand averaging 3.8 inches (9 cm) larger in d.b.h. at harvest and containing 50 percent more merchantable volume.

Relatively close initial spacing (10 x 10) can also be expected to result in improved tree form, through both the training effect of adjacent trees and the greater

[1] *See Pesticide Precautionary Statement, p. 20.*

number from which to select better formed individuals. A final reason for close spacing is that trees removed in later thinnings should yield merchantable products (see Maintaining Quality and Growth, p. 12). The disadvantages of close spacing are obvious: increased costs for planting stock and weed control, and extra labor required for planting, tending, and removing the additional trees. On balance, we recommend spacing plantations for timber at about 10 x 10 feet (3 x 3 meters); somewhat irregular spacings such as 8 x 12 feet (2.5 x 3.5 meters) may be preferable in some situations to allow use of machinery through the wider dimension.

Objective: Timber and Nuts

Stocking in plantations intended to produce both timber and nuts should be maintained at lower levels than for timber production alone. An initial spacing of 15 x 15 feet (4.5 x 4.5 meters) is recommended. At this spacing, the first thinning will not be needed until average stand d.b.h. is 5.6 inches (14 cm). Regular nut production should have begun on trees of this size and trees to be retained after the first thinning can be evaluated on the basis of nut yield and quality as well as for timber traits.

Objective: Intercropping

In walnut plantations intended for multiple use to produce forage, hay, sod, or row crops, spacing will probably have to be unusually wide in at least one direction. Wide spacing will allow efficient use of fencing to prevent livestock from damaging young trees and will allow turning room for large farm equipment. However, spacing within rows should be close to allow the selection of desirable individuals as in pure plantations. Spacings such as 5 x 30 or 5 x 40 feet (1.5 x 9 or 1.5 x 12 meters) should be considered, but the actual arrangement of the planting will of course be dictated by the specific crops to be grown and the equipment to be used.

Site Preparation

Walnuts can be planted successfully on a variety of sites, but intensive follow-up culture is usually necessary if the plantations are to become satisfactorily established. Thorough site preparation, in addition to its traditional benefits, greatly expedites subsequent cultural practices.

Cutover Sites

Selection or shelterwood systems for regenerating forest stands are not effective for establishing walnut plantations on forested sites. Although some walnut seedlings will survive for a few years under partial cover, they grow satisfactorily only following complete overstory removal. All woody vegetation larger than 1/2 inch (1.3 cm) d.b.h. should be cut; stumps 8 inches (20 cm) or less in diameter should be treated immediately with a low-volatile ester formulation of 2,4,5-T[1] to inhibit sprout competition. Site preparation on clearcut sites need not include removal of all slash, since it is unlikely that power equipment such as tractor-hitched mowers or sprayers can be operated among the stumps. It is important for planted rows to be sufficiently clear so that planted trees can be readily located, weeds controlled around them, and corrective pruning accomplished as necessary.

Brushy Fields

Walnuts may be interplanted in brushy fields if the site is good. Such sites justify removal of brush for planting at regular spacing, use of power equipment, and intensive culture; on marginal brushy sites other species requiring little or no tending after planting should be considered instead of walnut. Cut stumps should be treated with herbicide to minimize sprouting.

Weeds and Grasses

It is neither necessary nor desirable to destroy all standing herbaceous vegetation in an old field prior to planting walnuts. Erosion is likely to be accelerated on completely cleared sites, even though they may appear to be almost level. Strips mowed at the same spacing as the intended planting may expedite the subsequent planting job. This practice works well in fields covered with a heavy stand of dead annual weeds; the intervening strips of weeds that remain will provide desirable protection from winds.

It is feasible and sometimes convenient to apply herbicides in strips or spots to kill grass sod prior to planting. If the herbicides are applied in the early spring before planting, the dead grass will mark the planting spots. Combinations of simazine and dalapon and simazine and paraquat have proved effective for this sort of advance weed control, but at the time of writing, simazine is not registered for use on walnut plantations during the first year (see Establishment and Ensuring Good Form, page 9).

Although plowing and discing prior to planting are not necessary for successful plantation establishment, trees planted in plots plowed and disced before applying

herbicide will eventually outgrow those planted in sod. One obvious effect of plowing grassy fields before planting is the conversion of the ground vegetation to predominantly broadleaf weeds. Simazine works effectively on germinating weed seeds, so weed control with simazine is more complete on areas prepared by plowing than on established sod. On the other hand, plowing may encourage the development of deep-rooted perennial weeds such as trumpetcreeper.

Plant Material

Seed Source

Black walnut occurs naturally over a broad range, extending into 33 States and Ontario. Studies have shown that walnut trees originating south of the planting site grow for a longer period during the growing season than those of local or northern origin. In several test plantings, trees originating well to the south consistently outgrew those of local provenance. At present we recommend using seed from sources up to 200 miles (320 km) south of the intended planting site; seed from more than 50 miles (80 km) north of the planting area should not be used unless it is collected from tested and proved trees or stands.

From the standpoint of just timber production, growing walnut for veneer offers by far the greatest profit potential. Intermediate products such as firewood, fence posts, small dimension parts, and even sawtimber are much less valuable. To insure that sufficient numbers of trees will reach veneer size, we need genetic diversity in walnut plantations. Over the several decades required to produce veneer timber, the plantations will be subject to attack by an assortment of disease and insect pests, including some that are probably not important at this time. Various "unusual" climatic conditions will occur and reoccur. It is unreasonable to expect seedling progeny of any single parent tree, even a "superior" one that is pollinated by another selected parent, to be satisfactorily resistant to all possible adverse situations. The only protection lies in establishing a sufficiently broad genetic base in each plantation. Do not plant seed or seedlings derived from one or only a few trees, no matter how beautiful the parent trees look or how well the seedlings grow in the nursery. Planting an assortment of seedlings (ideally derived from seed orchards containing many tested-and-proved parents) provides cheap and effective insurance against disaster that might strike just as the trees are increasing most in value.

Seedling Quality

Large black walnut seedlings outgrow small ones on a variety of sites, and seedlings 1/4-inch (6 mm) or larger in caliper are recommended for planting. Seedlings showing signs of root rot or that have stems black and apparently dead (as might be caused by freezing in the nursery) should be discarded.

Care of Seed and Seedlings

Nuts to be direct-seeded in the spring can be stratified in outdoor pits or in plastic bags in cold-storage rooms. Pit-stored seed usually germinates somewhat better and can be held for as long as 4 years without serious loss of viability. Unless properly dried, seed held in plastic bags in cold storage will begin to germinate in the bags about 7 to 10 months after collection and must be promptly sowed before it is lost.

Walnut seedlings properly packed at the nursery can be held in cold storage overwinter, at least as long as 6 months. Seedlings received in the spring should not be allowed to freeze or overheat. Seedlings can be stored under shade – such as in an unheated warehouse – up to 2 weeks before planting. If they have been properly packed, no more than one drenching of the seedling roots should be necessary to keep them in good condition. If planting must be delayed more than a couple of weeks, seedlings should be heeled in or kept in refrigerated storage.

Planting Method

Direct Seeding

Pilferage by squirrels and other rodents severely limits successful direct seeding of walnuts. Loss can be minimized by using mechanical barriers made of hardware cloth or punctured cans, but these devices are expensive to prepare and put in place. Several chemical treatments have been devised in attempts to repel rodents or to conceal planted nuts, but none have proved effective.

Several factors, including luck, may combine to allow successful direct seeding. First, in seasons with heavy natural mast crops, rodents will be less ambitious about digging up planted seed. Further, squirrels are reluctant to travel more than 330 feet (100 meters) across open country so planting sites located at such a distance from standing timber can be safely seeded. Finally, rodents will pilfer walnuts at any season, but sowing late in the spring, and using seed that have already begun to

germinate, will reduce the period of vulnerability. When planting germinating seeds, care must be taken to protect the emerging radicle from breaking.

Planting of Seedlings

Walnut seedlings may be successfully planted by any customary machine or hand method. The only necessary requirements are that the seedlings be planted upright and the entire root system buried without distortion. Reasonable root pruning, top pruning, or both (roots should not be pruned to less than 8 inches (20 cm) long) are acceptable but not essential. Deep planting is not advantageous and may be detrimental. Because of the need to control potential competing vegetation around the seedlings, spring planting is recommended; in areas where all weeds have been killed, fall planted trees are susceptible to frost-heaving over the ensuing winter.

ESTABLISHMENT AND ENSURING GOOD FORM

Intensive culture is essential in walnut plantations until they are successfully established and the trees are at least 9 to 10 feet (3 meters) in height. The emphasis during this period should be on growing a stem that is straight, free of defects, and can be converted into a veneer log of at least minimum dimensions. This objective can be met by using cultural techniques that correct defects through direct action and also by maintaining optimum environmental conditions that stimulate trees to overgrow defects before they become serious. Most recommended practices are appropriate for use in young naturally regenerating walnut stands as well as in plantations.

Weed Control

Control of competing grasses and forbs is especially important in plantations being established in fields previously used for agriculture. Complete weed control is neither necessary nor desirable since it aggravates erosion problems.

On sites suitable for intensive walnut culture, control of competing weeds for the first 3 years after planting should ensure that the trees will grow well during the crucial period when form is determined. One or 2 years of weed control are usually sufficient to ensure satisfactory establishment, but the third year stimulates height growth equivalent to at least an extra year's increment. Weed control for more than 3 years, especially on a larger area around each tree, will continue to stimulate growth, but costs may not justify it.

Planted walnut trees grow faster when weeds are controlled by herbicides than by either mulching or cultivation. Simazine is the preferred chemical for controlling germinating seeds and has been used effectively with dalapon (for standing grasses), 2,4-D (for broadleaved weeds), or both. At the time of writing, only simazine among these chemicals is registered for use with black walnut, and then only in plantations that have been established for a year or more; expanded pesticide labels have been proposed that will allow use of other herbicides in walnut plantings.[1] Simazine should be applied at the rate of 4 pounds active ingredient per acre of area treated (4.5 kg/ha) on sandy loam soils and 5 pounds per acre (5.6 kg/ha) on clay loam soils. Paraquat is a registered and effective herbicide that kills standing weeds but must be used with care because of high toxicity to mammals.

Depending on terrain and available equipment, herbicides may be applied in strips along rows of trees, or to circular areas surrounding the trees. Spot diameter and strip width need not be wider than 4 feet (1.2 meters) for the first 2 years. During the third year, some additional tree growth may be gained by increasing spot diameter to 5 or 6 feet (about 2 meters).

In plantings established on cleared forest sites, competition from herbaceous weeds is likely to be much more critical than that from woody vegetation. Weed control methods used in other planting situations should be adequate for use in forest openings.

Maintaining Stem Form

During the first season after planting, walnut seedlings may die back from the tip and subsequently sprout from lateral buds. Dieback related to planting shock is relatively widespread, especially on less-than-ideal sites or when the summer after transplanting is unusually dry. Damage to leader tips in subsequent years can also be caused by deer browsing, late spring frosts, and especially by insect attack (see Protection from Damaging Agents, p. 4).

When lateral branches sprout following dieback of terminals, some young trees produce a relatively straight new leader, others develop a strong fork, and many exhibit some intermediate type of form – a moderate crook or a weak fork. Because of the premium value of straight veneer logs, it is tempting to take immediate action to shape up potentially crooked trees, but it isn't always necessary.

Some trees are obvious candidates for corrective pruning, those with evenly balanced "slingshot" forks, for instance. Most of these forks can be straightened at an early age using masking tape, pruning shears, and Bey's "new twist" technique (fig. 3). The procedure goes as follows:

1. Select the strongest, most promising shoot – one with a healthy terminal bud.
2. Bend it so that the tip is as close as possible to being over the central axis of the main stem.
3. Select another shoot (or two, if necessary) that will hold the terminal in position.
4. Secure the terminal in position by wrapping 1-inch wide masking tape around both the terminal and the supporting lateral. Branches larger than 3/4 inch in diameter and branches with angles wider than 45° exert more pressure and may require additional wraps of tape. Most will be secured near the top of the terminal.
5. Cut off the tip of the supporting lateral branch to eliminate potentially competing new growth. This may mean cutting off only the terminal bud or perhaps many inches of the lateral branch.

The procedure can be used shortly before or soon after growth begins in the spring. New leaves interfere with taping, and therefore it can be done more rapidly before growth begins.

At the beginning of the third or fourth growing season after planting, trees with potentially poor form are usually obvious and still small enough to correctively prune. Not all poorly formed trees need to be corrected; they can safely be neglected if they are surrounded by trees with good form in sufficient number to make a stand after thinning.

Trees without a potential strong leader should be coppiced if they seem likely to be needed beyond the first thinning; after they sprout from the root collar, the sprout clumps should be thinned to the single best stem. Coppicing should be done in the spring before the beginning of the third or fourth growing season for two reasons: first, regrowth of the new sprout never quite catches up to that of the original stem, but cutting at this relatively early age minimizes the increment loss; second, if trees older than 5 years are coppiced, the sprouts will grow so fast that they may not stand upright.

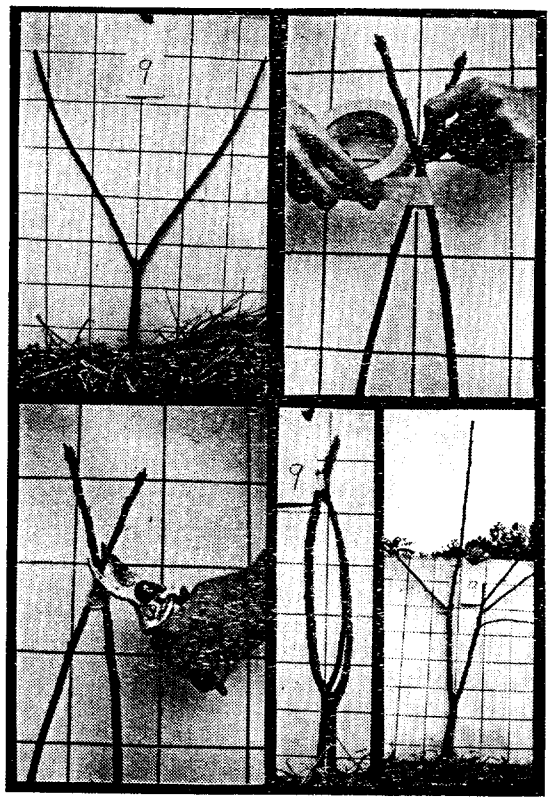

Figure 3. – *Masking tape and hand clippers are useful tools for developing straight boles on young black walnut trees.*

Corrective pruning should not be confused with lateral pruning (page 12) which is intended to promote development of knot-free wood. Lateral pruning is not appropriate when the tree is being cultured for good form except to remove some lower branches to prevent their being run over and torn out by vehicles being operated between plantation rows. Zealous attempts to minimize the size of the knotty core by early clear-length pruning sometimes have disastrous consequences (fig. 4).

Another good procedure that is recommended for "correcting" poor stem form is the exercise of patience. Despite the accidents that befall them, most black walnut trees in plantations have a strong natural tendency to grow upright. Crooks that appear to be potentially disastrous in a shoulder-high tree often turn

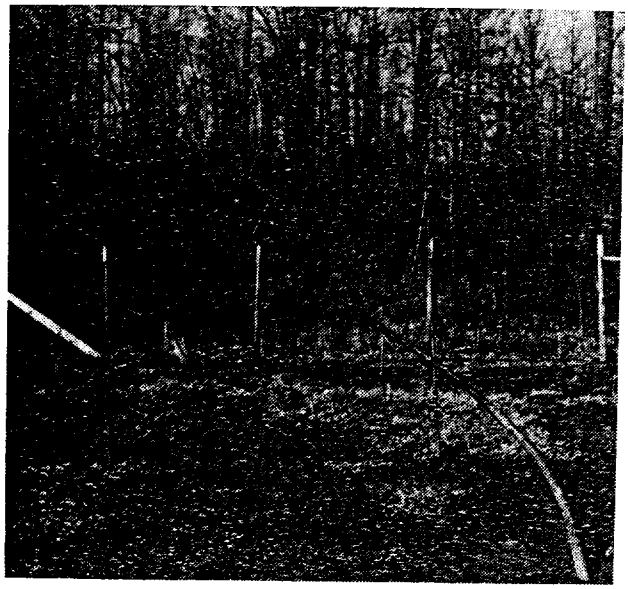

Figure 4. — *Branches were pruned from about 70 percent of the total height of this young walnut. It produced numerous bole sprouts and heavy foliage and toppled over during a summer windstorm.*

out to be innocuous after the tree has grown to be 3 or 4 meters tall. Crooked young trees make differential radial growth, adding more wood on the concave side of the crook than on the convex. Furthermore, they also straighten physically; the combination of the two processes can result in dramatic improvement in form (fig. 5).

Fertilization

As a general rule, fertilizing walnut plantations during the establishment years is a mistake. On the high quality sites suited to intensive culture, soil nutrients are usually not limiting to walnut growth, but fertilizer treatments may stimulate weed competition. On mediocre sites, tree growth may sometimes be increased through fertilization, but rotations are still likely to be lengthy because of other limiting soil factors such as inadequate moisture or poor aeration. On such sites, fertilization during the increment phase (see page 14) is probably a better bet, because the investment will not have to be carried for such a long time.

Intercropping

Walnut plantations interplanted with agronomic crops may require special cultural practices. For instance, livestock must not be allowed to browse young trees; a portable electric fence system may be arranged that permits rotational pasture grazing without damage to the walnuts (fig. 6).

If herbicides are used to control weeds competing with planted walnuts, each case must be considered separately since some chemicals are not registered for use with planned agricultural crops. In other cases, the herbicides may be registered and usage compatible, but scheduling of sowing, harvesting, or grazing may need to be modified to comply with label restrictions.

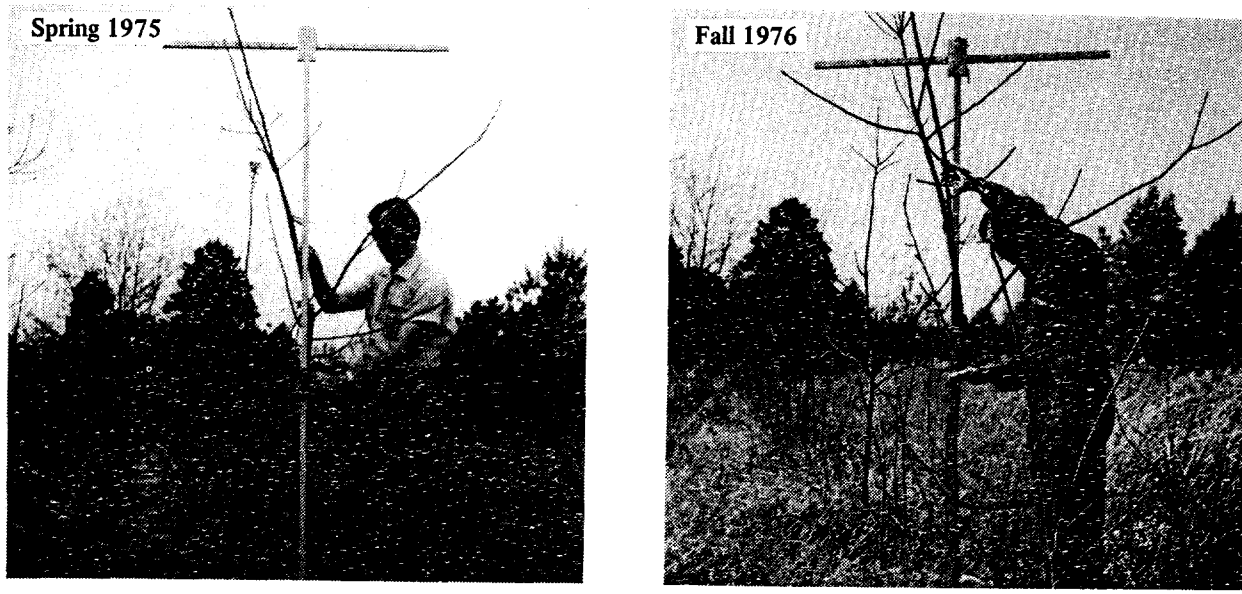

Figure 5. — *In two growing seasons, the stem of this tree has moved 9 inches closer to the vertical position.*

Figure 6. – *Closeup of a young black walnut interplanted with soybeans in Missouri. The spacing is 40 feet x 40 feet. (Photo courtesy of Gene Garrett, University of Missouri.)*

Maintaining good stem form may be more difficult in intercropped plantations in which the walnut trees are irregularly spaced. The trees are likely to be more exposed to environmental stress and also to damage by agricultural equipment. An extra year of corrective pruning is likely to be necessary. Some lateral pruning to avoid damage by equipment may also be appropriate.

Other trees or shrubs may also be interplanted with walnut for any of a number of reasons: for esthetic values, to provide wildlife cover or food, for an intermediate crop such as Christmas trees, to serve as trainers for the walnut trees, or, in the case of nitrogen-fixing species, to stimulate growth of the walnuts. Interplanting can thus be used as at least a partial substitute for corrective pruning and fertilization. Of the many species that have been used for interplanting, we suggest autumn-olive as worthy of further trial. Autumn-olive is an attractive shrub that bears bright red berries relished by songbirds and game birds. It fixes atmospheric nitrogen and adds it to the soil in a form available to other plants.

Autumn-olive grows at a rate more like that of walnut than either black locust or European alder. These species also fix nitrogen but are likely to overtop walnut trees in only 4 or 5 years on most good sites. In five Midwestern plantations, autumn-olive grew at an average rate of about 2 feet (0.6 meters) per year for the first 7 years after planting and is expected to level off at about 15 feet (4.5 meters). Walnuts interplanted with these autumn-olive reached 15.1 feet (4.6 meters) at the same age, while solid walnut plantings were only 9.7 feet (3.0 meters) tall. Stem form and natural pruning of walnuts interplanted with autumn-olive were also superior to those in pure stands. Specific recommendations for spacing and thinning schedules remain to be worked out, but interplanting with autumn-olive is tentatively recommended.

MAINTAINING QUALITY AND GROWTH

Once walnut trees are taller than 10 feet (3 meters), techniques to maintain the growth of selected crop trees and improve the quality of the merchantable portion of the stem become paramount. Quality improvement can be achieved through lateral pruning, while maintaining growth involves thinning and fertilization.

Pruning

Pruning of lateral branches helps to produce knot-free wood under growing conditions (wide spacing) that would normally permit most of the lower branches to persist. Crowding sufficient to stimulate natural pruning would also decrease diameter growth. The objective of pruning is to produce a clear bole while minimizing damage to the tree and loss of growth. Normally, pruning should be done in several stages.

Branches should be pruned before they are 2 inches (5 cm) in diameter to minimize damage and promote rapid healing. A neat, clean cut should be made, preferably using a pruning saw. Pruning wounds made during the dormant season (early spring is best) tend to heal most rapidly and completely and sprouts from dormant buds near the wound are less likely to develop. If sprouts do develop, they should be promptly removed.

Start pruning as soon as the trees are taller than 10 feet (3 meters). Prune from 25 to 100 potential crop trees per acre (60 to 250 per hectare) and only trees less than 10 inches (25 cm) in diameter. No more than 25 percent of the live crown should be removed in a single year, and the live crown length ratio should be maintained at no less than 50 percent. Pruning should proceed in stages until at least the first 9 feet (2.7 meters) of the bole are clear. For veneer and timber production, the first 17 feet (5.2 meters) should be pruned. Costs increase rapidly for upper log pruning, while the returns from the smaller upper logs are less than for the first log.

Thinning

Periodic thinning provides the opportunity for selecting the better trees to retain as their superiority becomes apparent. If the plantation were not thinned, the faster-growing trees would eventually out-compete their neighbors, but at a considerable sacrifice in their own growth. The objectives of thinning are: (1) to maintain rapid growth of all potential crop trees while delaying the selection of the actual crop trees for as long as possible, and (2) if possible, to grow the trees to be removed to a size sufficient to yield salable intermediate products.

Crown competition factor (CCF) is a useful tool for deciding when to thin and how much to leave. Based on the size of an open-grown tree's crown, this measure of crowding provides an objective method for assessing plantation stocking. At CCF = 100, the sum of the tree crown areas equals the area of the plantation or stand. Given any two of four stand parameters (basal area per acre, number of trees per acre, average diameter, and CCF), the other two can be obtained from graphs (fig. 7); or the last three parameters can be obtained more precisely by using a table (see Appendix for table 3 and an example). CCF should not be used if spacing is highly irregular; e.g., if the distance between rows is more than twice the distance between trees within rows. Although optimum CCF levels for walnut management are not known, the following paragraphs discuss tentative recommendations and considerations.

Management objectives will dictate the appropriate upper limits for stocking levels. Nut production will require stocking levels of 90 CCF or less; the upper levels for timber and veneer production may be as high as 110 CCF. For optimum growth of individual trees, lower levels of stocking may be required on dry sites than on moist sites.

The first step in using CCF to guide thinning decisions is to select upper and lower CCF levels between which plantation stocking will be maintained. When the upper level is reached, the plantation should be thinned back to the lower level. The difference between the upper and lower levels will determine how often thinnings will be

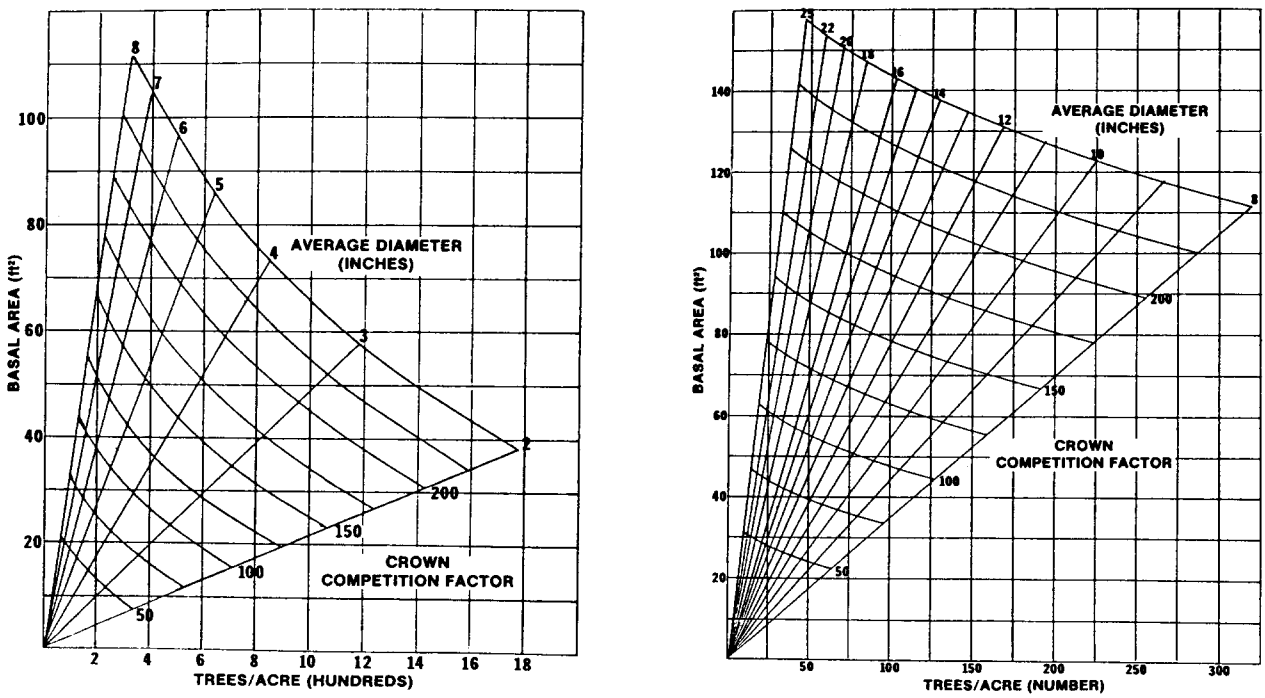

Figure 7. – *Stocking for trees (left) 2 to 8 inches in diameter, and (right) 8 to 25 inches in diameter.*

required. If the difference is small, frequent light thinnings will be needed. Thinning to reduce CCF by 40 will generally result in removing 40 to 60 percent of the trees (see example in Appendix).

Although the determination of when to thin and how many trees to leave can be arrived at objectively using CCF, the selection of the trees to leave must be a subjective, on-the-ground determination. Strictly mechanical spacing would defeat the purpose of having a population of trees to select from, but consideration of spacing in conjunction with crop tree selection is necessary. In general each crop tree should benefit from thinning by the removal of at least one competing neighbor. Generally if 50 percent of the trees are cut, most of the crop trees will have two or three nearest neighbors removed.

Until the trees to be removed are of sawtimber size, the markets for thinning products are rare. In certain situations markets for small furniture-type dimension material or other products may exist to help offset the cost of thinning, but in general thinnings must be considered a necessary investment for the production of high-quality timber products in the least amount of time. Once the trees reach sawtimber size, thinning should be profitable.

Plantations for which CCF is not appropriate because of irregular spacing should be thinned when the theoretical crown width is twice the distance between the trees in the rows. Theoretical crown width is calculated using the following formula: crown width (feet) = 1.993 times d.b.h. (inches) plus 4.783. After one or more thinnings, spacing will become more regular, and CCF can be used.

For mixed-species stands including walnut and for plantations in which stocking levels have reached CCF 160 or more, thinnings using the stocking-guide approach are not appropriate. Crop tree release following the guidelines for single tree culture (below) offers a better solution for the mixed stand and for the initial treatment in the overstocked stands. Reducing the stocking to the appropriate lower CCF level in one operation could result in epicormic branching. Following this first treatment, the plantations can be brought under the stocking guide procedure.

Fertilization

Foliage analysis currently provides the best diagnostic tool for deciding whether fertilization is needed or beneficial (see Nutrient Requirements and Fertilization, page 3). Fertilization cannot be considered in isolation from other cultural practices. If the trees are crowded, thinning or release should precede fertilization, and if a well-established understory is present, it may be necessary to control the understory in order to allow the added nutrients to reach the trees.

Intercropping

The walnut trees will increasingly occupy a higher proportion of the plantation area as they develop, decreasing the intercropping options. Most row crops require full sunlight for growth, so that once stocking levels of 50 CCF or more are reached, this option is no longer viable.

Pasturing can continue to be an intercropping option until the trees reach maturity. Once the walnut trees are stout enough (4 to 6 inches or 10 to 15 cm in diameter) and tall enough (a clear bole length of 9 feet or 3 meters) light, well-regulated grazing will cause little or no damage. Heavy grazing with its associated soil compaction and physical damage to the root systems can reduce sawtimber yields by as much as 20 percent.

SINGLE TREE CULTURE

Release

More than for any other American timber species, intensive culture of individual black walnut trees is economically justified. Furthermore, most walnuts respond well to culture whether they occur as scattered trees in a mixed forest or singly in a pasture or open grove.

Release is the first item to be considered for individual trees in a forest. Dominant and codominant trees can be expected to continue to grow more rapidly than those in intermediate or suppressed classes, but strong intermediates often respond most to release (in terms of relative increase in growth rate). Any walnut tree that is healthy, has a bole with potential to make a veneer or high-quality log, and is small enough that it can reasonably be left to grow for at least ten more years, should be considered a candidate for release.

To be effective, release must be thorough. One rule of thumb is that at least three-fourths of the crown of the

released tree should be at least 5 feet (1.5 meters) from the crowns of adjacent trees 60 to 100 percent as tall and at least 10 feet (3 meters) from the crowns of taller trees. After the walnuts have responded to release, the increased growth should be maintained at a uniform rate. The crowns of trees that have been released as well as surrounding trees can be expected to expand rapidly. When walnut crop trees are no longer free to grow, subsequent releases should be made, probably at intervals of about 6 to 10 years.

Some bole sprouting can be expected on forest-grown trees that are released for the first time. Most of the sprouts will occur above the butt log so little extra pruning will be required.

Pruning

By definition, open-grown trees need no release, but they, as well as many forest-grown trees, can almost always benefit from pruning of side branches. Ideally, pruning should start before branches are more than 2 inches (5 cm) in diameter at the butt; minimizing wound size minimizes the time until wound closure. Because of the characteristic rapid diameter growth of walnut trees in the open, somewhat larger pruning wounds can be tolerated than in trees in plantations or natural stands. As branches grow larger than 3 inches (8 cm) in closed stands, or 4 inches (10 cm) on open-grown trees, pruning should be suspended except for removal of dead branches.

Fertilization

Although results from a number of field fertilization trials are not completely consistent, they may be summarized as follows. Diameter growth is often increased as much or more by release than by fertilization. Nitrogen fertilization stimulates diameter growth more than does phosphorus or potassium treatment. All three elements – N, P, and K – may be effective in stimulating increased nut production, sometimes doubling or tripling the crop produced by released but unfertilized trees. Fertilization is not effective in stands 60 years of age or older.

At present we recommend fertilizing pole-sized trees managed for timber production with 10 pounds (4.5 kg) of urea spread around the tree over an area about 10 meters in diameter; for combined production of timber and nuts, 5 pounds (2.3 kg) of triple superphosphate, and 8 pounds (1.8 kg) of muriate of potash should be added. All fertilized trees should be free to grow or else released in advance; treatments can be repeated at 5-year intervals. To verify that fertilized trees are responding to treatment, several similar trees should be left as unfertilized "check trees".

HARVESTING

When to make the final harvest depends upon the project objective, market conditions, and the potential increase in value if harvesting is deferred. Also to be considered at harvest time is the question of whether or not to establish a new stand of walnut, and if so, how.

Product Specification

Most black walnut is grown to produce veneer and saw logs. There are no standardized specifications for veneer trees. Veneer buyers have their own systems for selecting and evaluating potential trees for their particular needs. The seller can obtain a fair market price for his timber through competitive bidding between two or more potential buyers, but there is presently no objective procedure for assessing the market value of walnut veneer trees.

Saw log trees can be evaluated more objectively using standard tree grades and current selling prices. The high value of walnut compared to other timber species results in greater dollar variation around the average selling prices. Thus, although a reasonable estimate of log value can be made, the actual market value may vary considerably from this estimate.

Growth and Yield

Intensive management of black walnut plantations is recent enough that no growth and yield information is available for managed plantations, and the limited information available from unmanaged plantations is considered too conservative for managed plantations. To indicate future growth and yield when it is most needed – during the final stage of growth just before harvest – use the past performance of the plantation. Standard form-class volume tables can be used in combination with projected diameter growth to estimate volume increment for the next 5- to 10-year period, with sufficient accuracy for planning purposes.

Regeneration

Once the decision to harvest has been made, the establishment of a future stand must be considered if the land is to remain in forest. If the walnut to be harvested is scattered as individuals in a mixed hardwood forest, the recommended regeneration methods for the specific forest type should be followed.

If the walnut to be harvested is in a pure stand or plantation, the surest way to regenerate it is by planting (see page 6). Not enough is known yet about regenerating a pure stand or plantation to assure success. If it is tried, the seeds need to be buried or pressed into the ground (to get moisture for germination) and seedlings must be released from shade after a few years. Indeed, the number of seedlings surviving decreases by about two-thirds each year. Discing or rolling the plantation area following a good seed year, then the prompt removal of the overstory once sufficient seedlings are present, is suggested.

APPENDIX

Stocking Guide Example

To use a measure of stocking to guide thinning decisions, you must select upper and lower CCF levels between which stocking will be maintained. When the upper level is reached, the plantation should be thinned back to the lower level. The difference between the upper and lower levels determines how often thinnings will be required. The larger the difference between the levels, the fewer thinnings will be required.

Besides determining the upper and lower levels, the following also must be known before decisions can be made as to when and how much to thin: (1) number of trees per acre, and (2) the average tree d.b.h. If any two of these three variables are known, the third can be determined by using the charts on page 13, or the conversion tables shown in table 3 in the Appendix and this formula: CCF = average crown area x number of trees per acre.

For example, thinning decisions for a plantation initially composed of 436 trees per acre could be derived as follows:

Select an upper CCF level of 110, appropriate for veneer production, and a lower CCF level of 70. The 110 level would be divided by 436, which would give the average crown area of 0.252. This corresponds to the average tree size of 3.5 inches shown in table 3 in the Appendix. Therefore, the first thinning on this plantation would be made when the average size of the trees had reached 3.5 inches.

To determine how much to thin, however, it is necessary to estimate the average tree size after thinning. Based on the limited data available at this time, the diameter after thinning can be calculated by multiplying 3.5 inches by 1.04 and then adding 0.4 inch. Therefore, the estimated average diameter of the crop trees would be 4.0 inches.

To determine the number of trees to leave, the lower CCF level, 70, would be divided by 0.298, which is the average crown area shown for a 4.0-inch tree in table 3 in the Appendix. This would show that 235 trees should be left.

Using the same procedure, a schedule for subsequent thinnings on this plantation could be set up as follows:

	BEFORE THINNING	
	Trees/acre (Number)	**Average d.b.h. (Inches)**
First thinning	436	3.5
Second thinning	235	5.6
Third thinning	131	8.4
Fourth thinning	73	12.1
Fifth thinning	41	16.9
Harvest	23	23.4

	AFTER THINNING	
	Trees/acre (Number)	**Average d.b.h. (Inches)**
First thinning	235	4.0
Second thinning	131	6.2
Third thinning	73	9.1
Fourth thinning	41	13.0
Fifth thinning	23	18.0
Harvest	–	–

This procedure can be used with all upper and lower stocking levels and with any number of trees per acre.

Table 3. – *Tree crown area*
(In percent of an acre)

Inches	Diameter at breast height: Tenths of inches									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1	0.085	0.090	0.095	0.100	0.106	0.111	0.117	0.123	0.129	0.135
2	.142	.148	.155	.161	.168	.175	.182	.190	.197	.205
3	.212	.220	.228	.236	.245	.253	.262	.270	.279	.288
4	.298	.307	.316	.326	.336	.345	.356	.366	.376	.386
5	.397	.408	.419	.430	.441	.452	.464	.475	.487	.499
6	.511	.523	.535	.548	.560	.573	.586	.599	.612	.625
7	.639	.653	.666	.680	.694	.708	.723	.737	.752	.766
8	.781	.796	.812	.827	.842	.858	.874	.889	.906	.922
9	.938	.955	.971	.988	1.005	1.022	1.039	1.056	1.074	1.091
10	1.109	1.127	1.145	1.163	1.182	1.200	1.219	1.238	1.256	1.275
11	1.295	1.314	1.333	1.353	1.373	1.393	1.413	1.433	1.453	1.474
12	1.494	1.515	1.536	1.557	1.578	1.600	1.621	1.643	1.665	1.686
13	1.708	1.731	1.753	1.775	1.798	1.821	1.844	1.867	1.890	1.913
14	1.937	1.960	1.984	2.008	2.032	2.056	2.081	2.105	2.130	2.155
15	2.180	2.205	2.230	2.255	2.281	2.306	2.332	2.358	2.384	2.410
16	2.437	2.463	2.490	2.516	2.543	2.570	2.598	2.625	2.653	2.680
17	2.708	2.736	2.764	2.792	2.821	2.849	2.878	2.906	2.935	2.964
18	2.994	3.023	3.052	3.082	3.112	3.142	3.172	3.202	3.232	3.263
19	3.294	3.324	3.355	3.386	3.418	3.449	3.481	3.512	3.544	3.576
20	3.608	3.640	3.673	3.706	3.738	3.770	3.803	3.837	3.870	3.903
21	3.937	3.970	4.004	4.038	4.072	4.106	4.141	4.175	4.210	4.245
22	4.280	4.315	4.350	4.385	4.421	4.456	4.492	4.528	4.564	4.600
23	4.637	4.673	4.710	4.747	4.784	4.821	4.858	4.896	4.933	4.971
24	5.009	5.046	5.085	5.123	5.161	5.200	5.238	5.277	5.316	5.355
25	5.394	5.434	5.473	5.513	5.553	5.593	5.633	5.673	5.714	5.754
26	5.795	5.836	5.876	5.918	5.959	6.000	6.042	6.083	6.125	6.167
27	6.209	6.252	6.294	6.336	6.379	6.422	6.465	6.508	6.551	6.595
28	6.638	6.682	6.726	6.770	6.814	6.858	6.902	6.947	6.992	7.036

CCF = (table value) (number of trees per acre)

$$\text{Table value} = \frac{\text{CCF}}{\text{number of trees per acre}}$$

$$\text{Number of trees per acre} = \frac{\text{CCF}}{\text{table value}}$$

Metric Conversion Factors

To convert	*to*	*Multiply by*
Acres	Hectares	0.405
Board feet[1]	Cubic meters	0.005
Board feet/acre[1]	Cubic meters/hectare	0.012
Chains	Meters	20.117
Cords[1]	Cubic meters	2.605
Cords/acre[1]	Cubic meters/hectare	6.437
Cubic feet	Cubic meters	0.028
Cubic feet/acre	Cubic meters/hectare	0.070
Degrees Fahrenheit	Degrees Celsius	[2]
Feet	Meters	0.305
Gallons	Liters	3.785
Gallons/acre	Liters/hectare	9.353
Inches	Centimeters	2.540
Miles	Kilometers	1.609
Miles/hour	Meters/second	0.447
Number/acre	Number/hectare	2.471
Ounces	Grams	28.350
Ounces/acre	Grams/hectare	70.053
Pounds	Kilograms	0.454
Pounds/acre	Kilograms/hectare	1.121
Pounds/gallon	Kilograms/liter	0.120
Square feet	Square meters	0.093
Square feet/acre	Square meters/hectare	0.230
Tons	Metric tons	0.907
Tons/acre	Metric tons/hectare	2.242

[1]The conversion of board feet and cords to cubic meters can only be approximate; the factors are based on an assumed 5.663 board feet (log scale) per cubic foot and a cord with 92 cubic feet of solid material.

[2]To convert °F to °C, use the formula $\frac{5/9\ (°F-32)}{1.8}$.

Common and Scientific Names of Plants and Animals

Plants

Alder, European	*Alnus glutinosa*
Anthracnose	*Gnomonia leptostyla*
Ash, green	*Fraxinus pennsylvanica*
Ash, white	*Fraxinus americana*
Autumn-olive	*Elaeagnus umbellata*
Basswood, American	*Tilia americana*
Beech, American	*Fagus grandifolia*
Boxelder	*Acer negundo*
Coffeetree, Kentucky	*Gymnocladus dioicus*
Cottonwood, eastern	*Populus deltoides*
Elm, American	*Ulmus americana*
Hackberry	*Celtis occidentalis*
Locust, black	*Robinia pseudoacacia*
Oak, northern red	*Quercus rubra*
Redcedar, eastern	*Juniperus virginiana*
Trumpetcreeper	*Campsis radicans*
Walnut, black	*Juglans nigra*
Willow	*Salix* spp.
Yellow-poplar	*Liriodendron tulipifera*

Animals

Casebearers	*Acrobasis* spp.
Caterpillar, black walnut	*Datana integerrima*
Squirrel, eastern fox	*Sciurus niger*

PESTICIDE PRECAUTIONARY STATEMENT

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key – out of the reach of children and animals – and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

Note: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

LITERATURE CITED AND OTHER REFERENCES

Althen, F. W. von. 1971. Effects of weed control on the survival and growth of planted black walnut, white ash, and sugar maple. For. Chron. 47(3):223-226.

Ashley, Burl S. 1974. Tree straightening–Nature's way. Black Walnut Advisory 37, 2 p. Northeast. Area, State & Private For., Upper Darby, Pennsylvania.

Auten, J. T. 1945. Some soil factors associated with site quality for planted black locust and black walnut. J. For. 43:592-598.

Baker, Frederick S. 1921. Black walnut; its growth and management. U.S. Dep. Agric., Agric. Bull. 933, 43 p.

Bey, Calvin F. 1973. Corrective pruning young black walnut trees–a new twist. North. Nut Grow. Assoc. Annu. Rep. 63(1972):26-28.

Bey, Calvin F. 1973. Growth of black walnut trees in eight midwestern states–a provenance test. USDA For. Serv. Res. Pap. NC-91, 7 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Bey, Calvin F., and Robert E. Phares. 1968. Seasonal growth pattern for five sources of black walnut. Cent. States For. Tree Improv. Conf. Proc. 6:44-47.

Bey, Calvin F., John R. Toliver, and Paul L. Roth. 1971. Early growth of black walnut trees from twenty seed sources. USDA For. Serv. Res. Note NC-105, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Bey, Calvin F., and Robert D. Williams. 1976. Weed control in black walnut plantations. USDA For. Serv. Res. Note NC-203, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Callahan, John C., and Robert P. Smith. 1974. An economic analysis of black walnut plantation enterprises. Purdue Univ. Agric. Exp. Stn. Res. Bull. 912, 20 p.

Clark, F. Bryan, and K. W. Seidel. 1961. Growth and quality of pruned black walnut. USDA For. Serv. Tech. Pap. 180, 11 p. Cent. States For. Exp. Stn., Columbus, Ohio.

Engle, L. G., and F. B. Clark. 1959. New rodent repellents fail to work on acorns and walnuts. USDA For. Serv. Stn. Note 138, 2 p. Cent. States For. Exp. Stn., Columbus, Ohio.

Erdmann, Gayne G. 1967. Chemical weed control increases survival and growth in hardwood plantings. USDA For. Serv. Res. Note NC-34, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Ferell, Raymond S., and Allen L. Lundgren. 1976. Mathematical functions for predicting growth and yield of black walnut plantations in the central states. USDA For. Serv. Gen. Tech. Rep. NC-24, 5 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Grey, Gene W., and Gary G. Naughton. 1971. Ecological observations on the abundance of black walnut in Kansas. J. For. 69(10):741-743.

Hacskaylo, J., R. F. Finn, and J. P. Vimmerstedt. 1969. Deficiency symptoms of some forest trees. Ohio Agric. Res. and Develop. Cent., Res. Bull. 1015, 68 p.

Krajicek, John E. 1975. Planted black walnut does well on cleared forest sites–if competition is controlled. USDA For. Serv. Res. Note NC-192, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Lee, K. C., and R. W. Campbell. 1969. Nature and occurrence of juglone in *Juglans nigra*. HortScience 4(4):297-298.

Losche, Craig K., and Richard C. Schlesinger. 1975. Predicting site index in young black walnut plantations. USDA For. Serv. Res. Note NC-187, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Phares, Robert E., and Glenn A. Cooper. 1974. Potential yield of walnut dimension from plantation thinnings. *In* Whole tree utilization of hardwoods–an international meeting. p. 120-128. Second Annu. Hardwood Res. Council Symp. Proc., Cashiers, North Carolina.

Phares, Robert E., and Raymond F. Finn. 1972. Using foliage analysis to help diagnose nutrient deficiencies in black walnut. North. Nut Grow. Assoc. Annu. Rep. 62(1971):98-104.

Phares, Robert E., David T. Funk, and Charles M. Nixon. 1974. Removing black walnut hulls before direct seeding not always protection against rodent pilferage. Tree Plant. Notes 25(4):23-24.

Phares, Robert E., and Robert D. Williams. 1971. Crown

release promotes faster diameter growth of pole-size black walnut. USDA For. Serv. Res. Note NC-124, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Schlesinger, Richard C. 1976. A tentative stocking guide for black walnut plantations. North. Nut Grow. Assoc. Annu. Rep. 66(1975):160-162.

Schneider, G., Ghaus Khattak, and John Bright. 1970. Modifying site for the establishment of black walnut. *In* Tree growth and forest soils. Third North Am. For. Soils Conf. Proc., Raleigh, North Carolina, Aug. 1968. p. 155-169.

Williams, Robert D. 1966. Planting stock grades. *In* Black Walnut Culture, p. 16-17. USDA For. Serv., North Cent. For. Exp. Stn., St. Paul, Minnesota.

Williams, Robert D. 1970. Plant large black walnut seedlings on cultivated sites. Tree Plant. Notes 21(2):13-14.

Williams, Robert D. 1972. Storing black walnut seed. North. Nut Grow. Assoc. Annu. Rep. 62(1971):87-89.

Williams, Robert D. 1975. Planting methods and treatments for black walnut seedlings. USDA For. Serv. Res. Pap. NC-107, 5 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Williams, Robert D., David T. Funk, Robert D. Phares, and others. 1974. Apparent freeze damage of black walnut seedlings related to seed source and fertilizer treatment. Tree Plant. Notes 25(3):6-8.

Zarger, T. G., R. E. Farmer, Jr., and K. A. Taft. 1970. Natural variation in seed characteristics and seed yield of black walnut in the Tennessee Valley. South. For. Tree Improv. Conf. Proc. 10:34-40.

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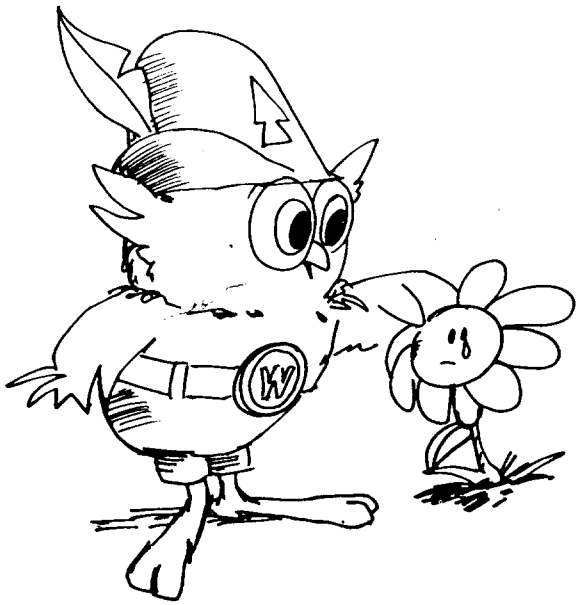

Birds, animals and flowers are dying to tell us...no pollution, please!