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Black Locust
in the Reclamation Equation

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Abstract

Black locust (*Robinia pseudoacacia*) has been planted and seeded more than any other tree species on lands surface-mined for coal in the Eastern United States. Benefits from planting black locust are: it provides quick cover for stabilization and esthetics; it supplies nitrogen and nutrient-rich litter to soil; it improves the site for establishment of other higher quality trees; it grows in a wide range of minesoil conditions, including extremely acid soils; it grows better than most trees in soils compacted by grading and topsoiling practices; it can be established by seeding and it is useful for posts, fuel, and biomass production. Problems associated with planting black locust are: it may overtop and damage companion trees; it may be susceptible to locust borer damage; it spreads to adjacent open areas by root suckers and seed; its thorns are hazardous to people and equipment; and seeded stands may be nearly impenetrable to about 6 to 8 years of age. Black locust continues to have an important place in mined-land reclamation; planning for its best use it warranted.

Introduction

A major goal in reclaiming disturbed lands is to develop a vigorous plant cover. Trees have been used widely and successfully for this purpose. Black locust (*Robinia pseudoacacia*) has been one of the best species, though it has limitations for some uses.

Early uses of black locust were along roadsides and in gullied fields to stop erosion and enrich soil nitrogen. As surface mining for coal evolved, this native legume was used in reclaiming mined lands, where often it grew faster than on unmined lands (Limstrom 1960). It is one of the most adaptable trees used in reclamation and has been planted more than any other tree species on mined-land spoils in the East. Black locust has been planted in pure stands and in mixtures with other trees on many types of minesoils throughout the Appalachian and Interior (Midwest) Coal Provinces.

A key feature of black locust is that it is a pioneer species, and surface mines are pioneer sites. Important contributions of this species in reclaiming surface mines are that it: enhances soil development by supplying nitrogen and nutrient-rich litter and improving infiltration; provides quick cover for erosion control and improved water quality; fosters successional development of high-quality forest stands; furnishes food and cover for wildlife; contributes to landscape design and esthetics; screens unsightly views; and limits access, at least temporarily, to hazardous and environmentally sensitive sites.

When black locust was first used on surface mines, methods of mining and reclamation were much different from today's regulated practices. Little or no attempt was made to segregate different geologic materials lying above the coal. The resulting mixture that was piled in ridges and hills became the rooting medium. Often, this medium was not good for plant growth; however, black locust was able to survive and grow on many of these sites where most other tree species failed.

Public concerns about mined areas that were not being suitably reclaimed led first to passage of state laws, and later to the Federal Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87). Numerous regulations aimed at achieving certain land uses resulted from this law and brought about changes in handling of soil and plant materials during reclamation. Planting of black locust has continued, but these regulations have introduced new obstacles to successful establishment of woody species. The record of tree growth under these new conditions is necessarily short, but locust promises to be especially useful in adapting to postmining conditions.

Ways to Plant Black Locust

The versatility of black locust is seen in the ways it can be planted and used. Some plantings are for direct use as fenceposts, biomass, and barriers, and for erosion control, landscaping, and environmental quality. Black locust also enhances soil building and site quality. It can serve as a nurse crop for more valuable hardwoods planted either with the locust or after the locust stands have improved the site and begun dying off, or which volunteer during natural ecological succession. Many of the locust stands planted on mined lands have deteriorated at age 15 to 30. Black locust is intolerant of shade and does not regenerate well under its own or other tree canopies. Stands can be managed, usually by cutting that results in regeneration from sprouts. Individual trees have persisted without management in some stands.

Locust commonly spreads by root suckers into adjacent open areas. Spreading can be advantageous in revegetating refuse sites, controlling erosion, and covering bare areas. Where not desired, chemical or mechanical control can be used.

Planting Seedlings

The spacing and number of black locust seedlings planted per unit area may vary depending on the intended use. Where planted alone, spacings have ranged from 7 by 7 feet or about 890 stems per acre, to 4 by 4 feet or about 2,725 stems per acre. Closer spacings are used mostly on steep slopes and potentially unstable sites and for barriers or screens. Densities of older stands may be greater than desirable even with the 7- by 7-foot spacing. Where used as a nurse or companion crop for other hardwoods, black locust may account for 25 to 50 percent of the total trees planted. Planting a locust in every other planting space in every other row provides a 25-percent composition. A simpler approach is to plant every third row to locust.

State-operated forest nurseries are the chief source of black locust seedlings for large-scale plantings. Lesser numbers are available from some commercial nurseries. One-year-old (1-0) seedlings are planted almost exclusively in the Interior Coal Province (Indiana to Kansas) and as an alternative to direct seeding in the Appalachian Coal Province (Pennsylvania to Alabama).

Five hundred or more seedlings can be hand planted per day by one person, and several times that many with a tree-planting machine. Planting bars or mattocks are used for hand planting. An added advantage with machines is that they can be equipped with a spray apparatus for simultaneous herbicide application to control herbaceous competition and for fertilizer applications to correct soil nutrient deficiencies.

Direct Seeding

Black locust is one of the easiest tree species to establish by direct seeding; seed are commercially available at moderate prices. The small, hard seeds are prevented naturally from premature germination on harsh sites. Seed can be scarified with sulfuric acid before planting to increase the percentage of early germination. This increases the need to protect seed and newly emerged seedlings from climatic stress. Use of moderate amounts of bark or other mulch with treated seed has provided conditions for increased survival of seedlings on field plots (Roberts and Carpenter 1983). Other causes of seed or seedling loss are erosion and animal use.

Black locust seed can be broadcast by hand or mechanical seeders or drilled. Most seeding, especially in the Appalachian Coal Province, is done with hydraulic seeders that spread mixtures of grass, herbaceous legume, and locust seed as well as mulch and fertilizers in one application. Locust usually is seeded at rates of 1 to 3 pounds of pure live seed per acre (Vogel 1981). Newly germinated locust seedlings may be difficult to find in dense covers such as those of sericea lespedeza (*Lespedeza cuneata*) or Kentucky-31 tall fescue (*Festuca arundinacea*), but after 2 to 3 years, a dense stand of black locust saplings is visible. Usually, canopy closure and a decrease in stand density soon follow.

Use of Amendments and Herbicides

Both planted and seeded black locust, unlike many tree species, respond positively to fertilizers applied at planting. Growth of locust is increased on most mine-soils by phosphorus fertilizer; nitrogen applied with phosphorus usually results in additional early-growth response. In an experiment on extremely acid spoil in eastern Kentucky, dicalcium phosphate, rock phosphate, or treble superphosphate similarly increased growth response by planted locust seedlings. The phosphate fertilizer was mixed with soil in the planting holes and nitrogen fertilizer was applied in slits about 8 inches from the seedlings. This was done to prevent direct contact of the nitrogen fertilizer with seedling roots. Survival after 3 years was not affected by any of the fertilizer treatments (Plass 1972).

In a similar experiment, application of (1) lime alone, (2) lime and fertilizer, and (3) lime, fertilizer, and straw mulch increased the survival and growth of black locust seedlings planted on extremely acid spoil in eastern Kentucky and Ohio. A significant growth response resulted from each additional amendment (Table 1). The fertilizers dicalcium phosphate and ammonium nitrate, were applied in and adjacent to the planting holes as in the experiment cited previously. Ground limestone was mixed into the upper 4 inches of spoil. These treatments would be

Table 1.—Survival and growth response of planted black locust to lime, fertilizer, and mulch on acid surface-mine spoils in eastern Kentucky and Ohio after 3 years

Treatment	Survival		Height	
	Kentucky	Ohio	Kentucky	Ohio
	-- Percent --		-- Feet --	
Control[a]	60	60	2.4	3.6
Lime[b]	100	75	5.3	5.2
Lime and fertilizer[c]	100	90	11.3	6.9
Lime + fertilizer + mulch[d]	95	95	13.6	8.7

[a] Average pH of unlimed spoil: Kentucky 3.8; Ohio 3.3.
[b] Finely ground agricultural lime applied at rate of 15 tons/acre and worked 4 inches deep into spoil.
[c] Ammonium nitrate and dicalcium phosphate fertilizers applied at rates equivalent to 50 lb of nitrogen and 100 lb of P_2O_5 per acre.
[d] Straw mulch 2 to 3 inches deep held in place with poultry wire.

too costly and unnecessary in reclamation prescribed by present regulations. However, they may be useful in revegetating acid-toxic spoils such as those found on some abandoned mined areas.

Establishment and growth of seeded black locust can be enhanced with amendments. The broadcast application of treble superphosphate on eastern Kentucky spoils seeded to black locust produced seedlings the first year that were 3 to 5 times taller than seedlings on unfertilized spoils. Nitrogen fertilizer applied with phosphorus resulted in additional growth, but the nitrogen was not necessary for success of the locust (Vogel and Berg 1973). Locust roots have nodules in which *Rhizobium* bacteria fix appreciable amounts of nitrogen.

Under current regulations, trees are planted in or with a grass and legume ground cover that is established for erosion control. The application of fertilizer increases growth of the ground cover which, in turn, increases competition with the trees. Black locust usually is more successful than other trees in becoming established in such ground cover (Vogel 1977).

Use of herbicides to control herbaceous competition has improved tree survival and growth. Herbicides must be used as specified, and their effectiveness varies depending on soil leachability, seasonal weather conditions, and types of plants to be controlled. Damage to black locust trees from proper use of a wide spectrum of herbicides has ranged from none to significant depending on the chemical and the dosage (White and Rolfe 1983). Bentazon and 2,4-DB reduced the growth of locust seedlings.

Survival and Early Growth

Black locust seedlings ranked well compared to other kinds of trees in USDA Forest Service studies of survival and early growth on prelaw ungraded spoils. The number of surviving black locust trees in Illinois after 10 years exceeded 70 percent of those planted except on densely vegetated areas or very acid spots, where survival was less than 20 percent for any tree species tested (Boyce and Neebe 1959). After 10 years, black locust survived and grew better than other trees tested in Ohio (Finn 1958) and western Kentucky (Boyce and Merz 1959), and was rated good in independent studies in Pennsylvania (Hart and Byrnes 1960).

Spoils at most of the planting sites in Illinois and Indiana were neutral to moderately alkaline. Survival of black locust on these spoils tended to increase with an increase in pH, a relationship not found for the more acidic minesoils of the Missouri, Kansas, and Oklahoma plantings (Table 2). Survival of black locust after 11 years on acid bituminous spoil in Pennsylvania was 50 percent or better only on spoil with pH levels above 3.6; tree height on the three best sites averaged only 10.1 feet (Davidson 1979). In general, growth in Illinois, Indiana, Missouri, Kansas, and Oklahoma was relatively independent of pH (Table 2). Adherence to current reclamation requirements should result in a minesoil pH range suitable for good survival and growth of black locust.

Table 2.—Spoil pH and black locust survival and growth on plots in Illinois and Indiana, and in Missouri, Kansas, and Oklahoma[a]

Illinois/Indiana				Missouri/Kansas/Oklahoma				
pH				pH				
1947	1976	Survival	D.b.h.	1948	1976	Survival	D.b.h.	Height
		Percent	*Inches*			*Percent*	*Inches*	*Feet*
3.4	4.7	16	7.7	3.7	5.7	50	5.3	44
4.3	4.8	21	4.5	4.5	6.5	34	5.6	40
6.1	6.1	16	6.5	5.1	5.5	42	5.8	39
6.9	7.0	38	5.0	5.2	5.9	19	5.1	39
7.2	7.7	38	7.5	5.9	7.5	34	5.1	37
7.5	8.2	35	7.2	6.0	5.8	40	6.9	42
7.6	7.2	30	8.2	6.3	7.3	11	7.3	48
7.6	7.7	34	6.5	6.5	6.3	54	6.7	41
8.0	7.8	30	6.1	6.8	6.7	41	7.1	46
8.1	8.1	64	6.8	6.8	6.5	22	6.6	34
8.2	6.0	42	4.1	7.5	7.4	43	6.3	46
8.3	7.6	66	7.0					

[a] Survival and growth measured in 1976; trees planted in 1947.

Locust Mortality and Tree Invasion

The canopy formed by rapid early growth of black locust often does not persist. There may be a large loss of trees and breakup of the stand. Mortality, breakage, and growth loss in black locust stands often occur by age 15. These symptoms of decline are caused primarily by the locust borer (*Megacyllene robiniae*) and to a lesser degree by the twig borer (*Ecdytolopha insiticiana*), the leaf miner (*Adontota dorsalis*), and rimosus heart rot (*Fomes rimosus*) (Hoffard and Anderson 1982). Large monoculture stands are more susceptible than dispersed individual trees to attack from exploding populations of insects.

Borer attacks are least severe, or absent, on vigorously growing trees (Hall 1933). Shade, highly correlated with lessened attacks, may be an effect of unbroken crown canopy which develops quickly from vigorous trees. Drought, acidic spoil, fire, or other damage that weakens trees and retards canopy closure may lead to increased borer damage. In southeastern Kentucky, borer damage may be found on black locust growing on sites disturbed by surface mining and road building, though such damage usually is not found on locust that regenerates naturally after logging of forest sites.

It may be that susceptibility to borer damage is greater for black locust outside the original range for this species. A more favorable forest environment and the presence of better adapted genetic strains in the natural range may lessen the prevalence of borer attack. Much of the commercially available black locust seed used for nursery plantings and in direct seeding originates in Europe from genotypes of unknown origin taken there many years ago.

Several studies have documented the general opinion and numerous observations that mortality is widespread in locust stands on disturbed lands. For example, a locust stand in southern Illinois planted in 1938, 3 years after mining, had 2,700 trees per acre after 1 year, 1,170 per acre after 10 years, and 400 per acre after 15 years (Ashby et al. 1966). As locust trees died they were replaced by boxelder (*Acer negundo*), elm (*Ulmus* spp.), and other mesic hardwoods. Woodland herbs, predominantly white snakeroot (*Eupatorium rugosum*), had formed a continuous ground layer. Natural mortality in black locust stands in eastern Kentucky was similar at 10 years to that in the stand in southern Illinois (Eigel et al. 1980).

Detailed studies of a hydroseeded stand in Bell County, southeastern Kentucky, showed 290 black locust trees per acre 12 years after seeding, with a third of the trees dead. Most of the 195 live trees per acre were less than 4 inches in diameter and would not have been commercially valuable for posts. The locust had grown through an initially thick stand of sericea lespedeza and Kentucky-31 tall fescue to form a dense thicket of seedlings at about age 6. At age 12, about one-third of the area had a ground layer predominantly of Ky-31 fescue, while the majority of the area had a dense, waist-high cover of white snakeroot, touch-me-not (*Impatiens capensis*), pokeberry (*Phytolacca americana*), and other woodland herbs. Borer damage was nil and little locust regeneration was observed. Only 32 stems of woody invaders per acre were counted, about half of them shrubs. Sugar maple (*Acer saccharum*), red maple (*A. rubrum*), and ash (*Fraxinus* spp.) accounted for most of the tree invasion. Lack of seed sources, or the vigor of the herbaceous layer, may have been the reason for the meager tree invasion. Some older stands in southeastern Kentucky have shown continued locust mortality with numerous invading trees of other species that later formed a continuous canopy. Locust is shaded out as the new trees grow taller.

The kind and number of trees that invade or volunteer in black locust stands differ from those invading in planted stands of other tree species. They also differ from one minesoil type to another. In Ohio, for example, black cherry (*Prunus serotina*) volunteers were more abundant in plantations of black locust than in plantations of other species, and were more abundant on acidic and neutral spoils than on calcareous spoils (Larson 1984).

Regional differences have also been noted. In Illinois, 30-year-old locust stands were invaded preferentially by boxelder and elm; in Illinois and Indiana by sugarberry (*Celtis laevigata*) and hackberry (*Celtis occidentalis*), and in Missouri and Kansas by red mulberry (*Morus rubra*) (Ashby et al. 1980). In Indiana, Japanese honeysuckle (*Lonicera japonica*) has formed deep mats of vines between and on the remnants of pure locust plantings.

To summarize, as black locust die from whatever cause and stand densities decrease and give way to a more open overstory, the existing herbaceous ground layer is maintained, or one develops. Shade-tolerant, cool-season grasses, especially Ky-31 fescue, that often are seeded with the locust commonly form a dense ground cover that persists and even thrives with the locust (Fig. 1). This fescue-locust community frequently found on reclaimed surface mines in the Appalachian and Interior Coal Provinces appears to be unusually stable. Where not dominated by Ky-31 fescue, crown vetch (*Coronilla varia*), or other shade-tolerant species, the main ground-cover component under open locust stands typically is the woodland herb flora described earlier (Fig. 2). Sericea lespedeza where sown with grass and black locust typically dominates the ground cover for several years, but seemingly is reduced in density or shaded out when the locust canopy closes. Tree invasion that eventually replaces the locust takes place at varying rates depending on type of herbaceous understory and the proximity and kind of forest-seed source.

Figure 1.—The understory cover in this planted stand of black locust is Ky-31 tall fescue. Locust-fescue communities remain relatively stable for many years.

Figure 2.—The understory cover in this 12-year-old stand of seeded black locust is predominantly pioneer woodland forbs. The ground cover previously was a dense stand predominantly of sericea lespedeza.

Interplanting and Underplanting with Other Trees

Three methods of improving or creating hardwood stands in black locust plantings are (1) interplant desirable trees with locust, (2) underplant deteriorated locust stands, and (3) cut out or chemically kill the locust and replant with desired species. The first two have been of greatest importance on surface mines. Selection of shade-tolerant companion trees can enhance the probability of success.

A major reason for planting black locust with other more desirable or commercially important trees is the role of locust in improving soil and supplying fixed nitrogen to companion trees. Also, planting trees is a way to control stand composition of desirable species. Natural plant succession, too, brings new kinds and numbers of trees, but these often are of less value for forest products, for example the elm or mulberry listed previously.

Hardwood-black locust mixtures have been evaluated for survival and growth both of the locust and of the associated species. Sometimes direct comparisons of each species planted alone, and mixed, were possible. In other cases, the experimental design of 30 years ago only allows inferences from reasonably comparable plantings.

Black locust in mixed plantings generally had similar or better survival than in pure plantings (Table 3). Growth after 30 years was variable. Locust trees tended to be larger in plantings with the higher percentages of black locust in the mixture. The values were affected by different companion trees planted with locust in the several areas, by amount of locust borer damage, and by climatic stress and other environmental factors.

The primary interest and concern in interplanting is the influence of black locust on the growth of companion trees. Interplanting with black locust has in some cases enhanced and in others limited the growth of companion trees. Several early reports on mixed plantings indicated overtopping and crowding of companion trees by locust and damage from wind whipping of tender shoots by thorny locust branches. Despite these early adverse effects, several companion species have grown well (Ashby and Kolar 1977).

Interplanting pines (*Pinus* spp.) with locust has not been very successful. Kellogg (1936) reported failure for numerous pine species interplanted with locust. Larson and Vimmerstedt (1983) found that only 13 percent of the white pine (*Pinus strobus*) that had been interplanted with black locust survived after 30 years. This compares with 21 percent survival where pine was not interplanted. Tree diameter also was greater for pine not interplanted.

One study in southeastern Ohio showed enhanced growth of trees planted in mixture with black locust on acid spoils. At age 10, tulip-poplar (*Liriodendron tulipifera*), green ash (*Fraxinus pennsylvanica*) and redcedar (*Juniperus virginiana*) were 228, 268, and 194 percent taller, respectively, where interplanted with locust than where planted in pure stands. Total nitrogen content in leaves was 166 percent greater on trees planted with locust (R. F. Finn and R. W. Merz, unpublished report, Central States Forest Experiment Station). Though associated with better tree growth, higher nutrient content in plant tissue may produce undesirable side effects. For example, deer browsing was greater on pines growing near black locust than on those not near locust in Pennsylvania (Davidson 1970).

Table 3.—Thirty-year survival and growth of black locust in pure stands and mixed with other trees. Ohio data from Larson and Vimmerstedt (1983).

Area	Survival	D.b.h.	Height
	Percent	*Inches*	*Feet*
		PURE LOCUST	
Ohio	18	5.3	28
Indiana	68	5.5	41
Missouri	39	6.5	42
Kansas	33	5.4	40
Oklahoma	11	7.2	48
		MIXED	
Ohio	34	5.0	28
Indiana	64	6.9	55
Northern Illinois	34	5.7	—
Southern Illinois	22	7.2	—
Kansas	25	6.7	49

Growth differences at age 30 were not great between trees planted alone and trees mixed with locust in several states (Table 4). Two of seven comparisons showed greater diameter with locust, while the other five showed better growth where planted alone. Older comparisons are not available to predict the future growth of these stands.

If suppression by black locust limits early growth of interplanted companion trees, underplanting deteriorated locust stands may avoid this problem and take advantage of improved soil conditions. Results of underplanting have ranged from failure to highly successful, with little explanation for the differences. Data on tree performance in underplanted black locust stands compared with plantings in the open are not available. A comparison of underplanted locust versus underplanted shortleaf pine (*Pinus echinata*) of the same age generally showed better survival of trees planted under the pine but better growth under the black locust (Ashby and Kolar 1977). By age 37, 30 years after the underplanting, survival of both locust and pine was 6 percent.

We do not know of surface-mined areas planted after the complete removal or deadening of black locust. The residual effects of harvested locust have supported superior growth of hardwoods on poor, old-field soils (Carmean et al. 1976).

Table 4.—Thirty-year growth of hardwoods and white pine planted alone or mixed with black locust on Indiana, Kansas, and Ohio strip mines. Ohio data from Larson and Vimmerstedt (1983).

Species	D.b.h.		Height	
	Alone	Mixed	Alone	Mixed
	- - *Inches* - -		- - *Feet* - -	
Sweet gum (*Liquidambar styraciflua*) (IN)	8.8	7.2	62	57
Red oak (*Quercus rubra*) (IN)	8.1	6.9	62	53
Silver maple (*Acer saccharinum*) (IN)	6.0	7.3	58	56
Black walnut (*Juglans nigra*) (IN)	5.0	4.1	47	36
Black walnut (KS)	3.0	3.6	23	31
Tulip tree (*Liriodendron tulipifera*) (OH)	6.2	6.0	38	35
White pine (*Pinus strobus*) (OH)	7.3	6.0	34	33

Grading Effects on Trees in Reclamation

Significant changes in post-mining soil conditions have been noted following enactment of state and Federal reclamation laws. Where chemical factors once were perceived as the major limitations to plant growth, today, much concern and research is directed toward physical limitations, chiefly those associated with grading.

Graded landscapes are much more complex than often realized. The smooth surfaces may hide differences that become evident only after trees are planted. Studies on graded versus ungraded pre-law minesoils showed that grading interacted with site and spoil conditions to produce several types of tree-growth response. In an Ohio study, black locust grew better on the fill material on graded spoil banks than on the cut area from which the fill material was removed. Average tree height on partially graded banks was greater than on leveled banks and about the same as on ungraded banks. Tree growth was best on side slopes of the partially graded and ungraded banks (Fig. 3).

Locust on plots partially leveled by dragline pullback in southern Illinois had a diameter at breast height (d.b.h.) of 6.5 inches after 30 years compared to 7.7 inches on ungraded plots. Survival percentages were equal even though spoil pH was 6.1 and 3.4 for the graded and ungraded plots, respectively. The grading limited tree growth more than the extreme acidity.

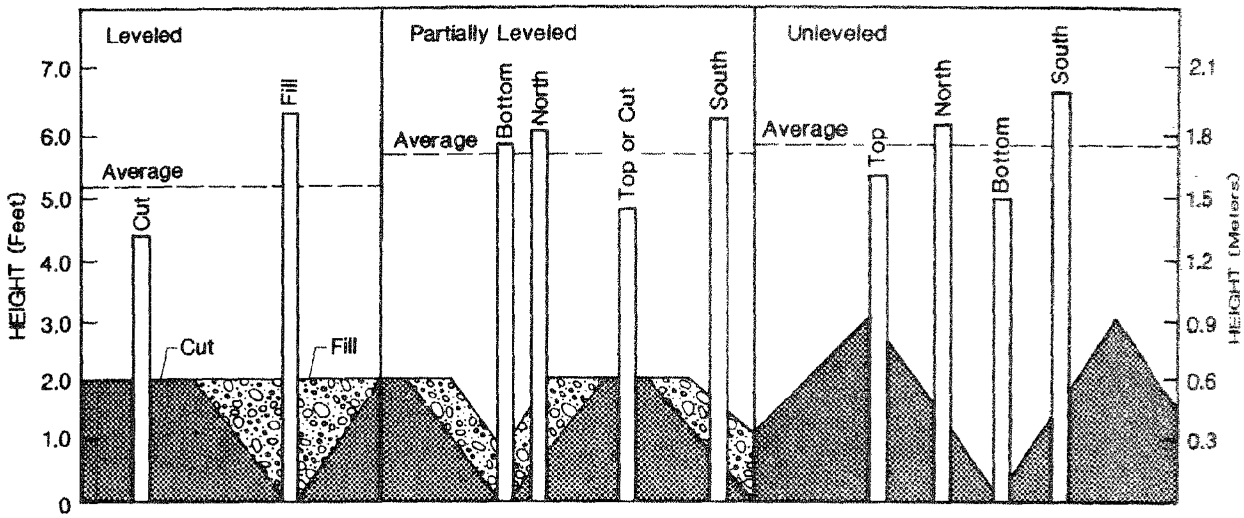

Figure 3.—Relative height of 2-year-old black locust planted on leveled, partially leveled, and unleveled spoil banks in Ohio (from Merz, R. B. unpublished Central States Forest Experiment Station Research Report, 1948).

There was little difference in locust survival, d.b.h., and height on unleveled, partially leveled, and completely leveled plots in Ohio though trees on the partially leveled area had a significantly smaller average d.b.h. than on the other two areas (Larson and Vimmerstedt 1983). Detrimental effects of grading on height growth of locust were found in West Virginia by Brown (1973). We found 2 to 11 percent greater diameter and height growth of locust after 30 years on ungraded areas than in similar plantings on graded minesoils in Missouri and Kansas. The effect of possible interactions of soil compaction with borer damage or other factors on locust were not identified in these studies.

Grading was beneficial to survival and growth of black locust on coarse-textured anthracite minesoils in Pennsylvania (Czapowskyj 1970). Locust survival after 5 years averaged 64 percent on graded and 22 percent on ungraded coarse spoil materials. Rolling and sliding rocks and erosion caused considerable mortality on ungraded banks. Trees were 9.8 feet tall on the graded sites and only 4.6 feet on the ungraded. On an area with finer textured soils (sandy clay loam), the average height of trees on the graded site was 6.2 feet compared to 5.2 feet on the ungraded. Thus, grading appears to benefit growth of black locust on coarse-textured materials, but is detrimental to growth on finer textured minesoil materials, such as are commonly found in the Midwest.

Growth of black locust at age 10 was less affected by grading than three other tree species in Ohio (Finn 1958). At age 30, locust had the highest survival but not the best growth of 13 species planted on graded sites in Missouri, and the second best survival in Kansas. Our recent studies in Illinois showed that survival of black locust after 2 years was only 40 percent on graded sites compared to 100 percent on ungraded sites. Tree height averaged 4.9 feet on graded and 11.5 feet on ungraded sites. Development of root systems also was markedly reduced on the graded spoils. Even so, the locust had deeper roots and grew more vigorously than the other 12 kinds of trees planted on the graded sites.

Black locust recently has been planted on graded agricultural mine soils to test the hypothesis that locust root systems are more effective than alfalfa (*Medicago sativa*) or sweet clover (*Melilotus* spp.) in penetrating compacted soil layers. Locust may well be a good choice for improvement of minesoils in the early years after mining and before planting corn and other row crops. This would be a means to offset adverse effects caused by grading the replaced fine-textured surface-soil materials.

Consumptive and Other Uses

Black locust is a relatively dense wood with high value for firewood. It ranked 6th (behind oak) in density and heat value out of 33 woods reported by the USDA Forest Service (n.d.). The cutting and removal of firewood should limit the buildup of borer populations and encourage sprouting to renew the stand.

Black locust is one of the most promising species to plant on surface mines for production of wood for industrial heating and generation of electrical power, and as a chemical feedstock. Young stands typically are harvested for such biomass production. The wide adaptability of locust to a diversity of sites, its nitrogen-fixing capacity, and quick growth provide an early harvestable crop (Eigel et al. 1980). Locust sprouts are more vigorous than the original planting and have produced more than 2.25 tons per acre of biomass per year in western Kentucky (Carpenter and Eigel 1979). Locust had superior performance in a Kansas energy forest (Naughton 1980).

Letting the stand grow to a size for fenceposts or mine props is a traditional use of black locust (Rogers 1951). Fencepost production may well be deferred to a sprout generation to gain vigor, a denser canopy, and stands less subject to borer attacks (Finn and Limstrom 1957). Where not exposed to borer attack before a sprout canopy is renewed, better trees could be left for posts during short-rotation harvesting for biomass or firewood.

Living fences or barriers of black locust can be useful for public safety, for example, next to ramps, steeper shores of strip-mine lakes, roadways, and industrial sites. They help prevent access by off-road vehicles or other trespass into reclaimed fields or forest plantings. The barrier can be renewed and maintained parallel to the areas of interest by harvesting alternate strips for biomass and to bring about sprout production.

Profuse flowering by black locust provides springtime color. The flowers are eagerly sought by bees and furnish pollen and nectar that contribute to the buildup of bee populations and honey production later in the season. Locust trees planted along the edge of an alfalfa or clover pasture provide early-season support to bee populations.

Wildlife values of black locust are variable. It's rapidly developing cover contributes to habitat for numerous birds and mammals. Locust is a good producer of seed that is a major food resource for quail in winter.

Benefits and Problems Using Black Locust

Mining permits or reclamation plans are prepared to fit site and land-use requirements of each mine. The overall desirability of using black locust will depend both on site conditions and on the projected postmining land use. The following is a summary of many of the potential benefits and problems from including black locust in reclamation planning and plantings.

Potential Benefits

1. Can be planted as seed or seedling; both are readily available and relatively inexpensive.
2. Is adapted to a wide range of climatic and soil (spoil) conditions.
3. Usually grows faster than other kinds of trees the first several years after planting.
4. Survives well in competition with grasses and other herbaceous cover.
5. Promotes soil permeability and water entry which in turn decreases surface runoff and erosion.
6. Has root nodules with bacteria that fix nitrogen symbiotically.
7. Produces leaf and woody liter that contributes to rapid building of soil organic matter and cycling and availability of nutrients.

8. Will spread by root suckers in coal slurry and other unstable rooting media, resulting in dust and erosion control.
9. Produces quick cover and screening for erosion control and landscape and esthetic enhancement.
10. Young dense stands can furnish an effective barrier against trespass or entry to other plantings and hazardous areas.
11. Produces large quantities of cordwood for fuel or charcoal.
12. Produces substantial biomass with early regrowth from root suckers and stump sprouts after cutting.
13. Under favorable growth conditions, provides short-term production of cordwood or durable fenceposts.
14. Afford habitat for several kinds of wildlife. Seed is prime food for quail in some regions.
15. Supports bee colonies and honey production by early spring flowering.
16. Natural release of interplanted or underplanted timber trees can result from borer attack or other causes of locust mortality.

Potential Problems

1. Pure stands, particularly direct-seeded ones, are nearly impenetrable during the thicket stage from about age 2 to 8.
2. Thorns can be a hazard to people and equipment when underplanting or harvesting.
3. May be too competitive where planted with other trees in mixed stands. This problem can be alleviated by choosing suitable percentages of locust in the mix, suitable spacings between trees, and suitable timing of plantings.
4. Cannot grow under shade.
5. In some plantings, especially on poorer sites, locust borer often destroys the commercial potential for fenceposts and firewood.
6. Unless controlled by management, vigorous sprouting after intensive cutting reduces the chance to introduce more valuable trees.
7. Spreads into adjacent unmanaged open areas.

These benefits and problems encompass a range of potential uses both on lands newly mined and on older mining operations still needing revegetation. A new era for use of black locust has opened with the need to overcome limitations of compaction on graded minesoils. Its vigorous root-system is useful for improving soil physical and chemical conditions prior to development of agricultural row-crop production. Black locust has the potential to contribute significantly to accelerated forest development within the framework of current regulatory requirements. This species remains a valuable biological resource for meeting diverse needs in reclamation. If full advantage is taken of this potential resource, the reclamation equation will include the planting of millions more black locust seedlings and seed in the years to come.

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Black locust has been planted and seeded more than any other tree species on lands surface-mined for coal in the Eastern United States. Benefits from planting black locust are: it provides quick cover for stabilization and esthetics; it supplies nitrogen and nutrient-rich litter to soil; it improves site for establishment of other higher quality trees; it grows in a wide range of minesoil conditions, including extremely acid soils; it grows better than most trees in soils compacted by grading and topsoiling practices; it can be established by seeding, and it is useful for posts, fuel, and biomass production.

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