Robinia pseudoacacia

INTRODUCTORY

Photo by Steve C. Garske, University of Wisconsin - Stevens Point

AUTHORSHIP AND CITATION:
Stone, Katharine R. 2009. Robinia pseudoacacia. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2010, February 8].

FEIS ABBREVIATION:
ROBPSE

NRCS PLANT CODE [323]:
ROPS

COMMON NAMES:
black locust
false acacia
yellow locust
white locust
green locust
post locust

TAXONOMY:
The scientific name of black locust is *Robinia pseudoacacia* L. (Fabaceae) [85,91,123,128,143,153,156,178,232,360].

Black locust hybridizes with Kelsey locust (*R. kelseyi*), New Mexico locust (*R. neomexicana*), clammy locust (*R. viscosa*), and bristly locust (*R. hispida*) (reviews by [167,203]). Several black locust cultivars are available [325].

SYNONYMS:
Robinia pseudoacacia var. *rectissima* (L.) Raber [178,203,311]

LIFE FORM:
Tree

FEDERAL LEGAL STATUS:
None

OTHER STATUS:
Information on state-level noxious weed status of plants in the United States is available at Plants Database.

DISTRIBUTION AND OCCURRENCE

SPECIES: Robinia pseudoacacia

GENERAL DISTRIBUTION:
Black locust is native to the United States, though the extent of its original range is not accurately known. It is thought that black locust was originally found in 2 regions. The eastern region was centered in the Appalachian Mountains and ranged from central Pennsylvania and southern Ohio south to northeastern Alabama, northern Georgia, and northwestern South Carolina. The western region included the Ozark Plateau of southern Missouri, northern Arkansas, and northeastern Oklahoma and the Ouachita Mountains of central Arkansas and southeastern Oklahoma. It is thought that outlying native populations existed in southern Indiana and Illinois, Kentucky, Alabama, and Georgia (review by [167]). The US Geological Survey provides a distributional map of black locust's native range in North America.

Black locust has been widely planted and frequently escapes cultivation ([53,123,124,128,190,215,325,360], review by [167]). As of 2009, it occurred throughout the conterminous United States and a number of Canadian provinces. Plants Database provides a map of black locust's distribution in North America. Black locust also occurs in parts of South America, Europe, Asia, Africa, and Australia (review by [340]).

HABITAT TYPES AND PLANT COMMUNITIES:
Plant community associations described below are organized into 2 sections, native range and nonnative range.

Native range: Black locust inhabits a broad range of forest types and conditions within its native range, though it develops and grows best in the cove or mixed-mesophytic forests of the central and southern Appalachian region (review by [167]). Plant community descriptions for black locust exist for all of the states within its native range except Illinois, Pennsylvania, South Carolina, and Georgia. Plant community descriptions are given for forests, regenerating old fields, and naturally revegetating reclamation sites. Black locust is rarely a canopy dominant in the communities described [2,7,40,47,92,172,205,223,276,305] except in some early successional or disturbed communities [174,309]. See Successional Status for more information on black locust dominance in early successional stands. Habitat types and plant communities described within this section are organized by state within the eastern and western regions of black locust's native range.

Eastern region:

Ohio: In southern Ohio, black locust was a very minor component of a forest dominated by sugar maple (*Acer saccharum*), northern red oak (*Quercus rubra*), and American beech (*Fagus grandifolia*) [315]. On the Wayne National Forest in southeastern Ohio, black locust occurred in small numbers only in the youngest forest stands (24-64 years old) dominated by yellow-poplar (*Liriodendron tulipifera*) and red maple (*A. rubrum*) and was not found in 84- to 129-year-old oak-maple (*Quercus-Acer* spp.) stands or old-growth (pre-European settlement) oak-hickory (*Carya* spp.) stands, the composition of which was determined from survey records [92].

In east-central Ohio, black locust occurred in 0.62- to12-acre (0.25-5 ha) patches bordering pastures and cropland, with American sycamore (*Platanus occidentalis*), American beech, oaks, and maples as associates [169]. In old fields reverting to forests in southwestern Ohio, black locust occurred in midsuccessional mixed-hardwood stands with honey-locust (*Gleditsia triacanthos)*, black walnut (*Juglans nigra*), and black cherry (*Prunus serotina*) [225].

West Virginia: In the Monongahela National Forest in eastern West Virginia, black locust was a minor component of valley floor and northwest slope forests. On valley floors, it occurred with dominant species such as white oak (*Q. alba*), sugar maple, pines (*Pinus* spp.), basswood (*Tilia americana*), and eastern hemlock (*Tsuga canadensis*). On northwestern slopes, it occurred with chestnut oak (*Q. prinus*), white oak, and pines [1]. In the Monongahela National Forest in central West Virginia, black locust was a minor component of a mixed-mesophytic community dominated by northern red oak, sugar maple, basswood, and white ash (*Fraxinus americana*) [2].

On the Fernow Experimental Forest in north-central West Virginia, black locust was a minor canopy component of a mixed-hardwood forest with northern red oak, yellow-poplar, black cherry, sugar maple, American beech, river birch (*Betula nigra*), red maple, basswood, white ash, chestnut oak, sassafras (*Sassafras albidum*), black tupelo (*Nyssa sylvatica*), and bitternut hickory (*C. cordiformis*). American chestnut (*Castanea dentata*) was formerly a canopy dominant [209].

Black locust was an abundant tree species on abandoned mine land revegetating for more than 10 years. Other important colonizing species included bigtooth aspen (*Populus grandidentata*), sweet birch (*B. lenta*), Devil's walking stick (*Aralia spinosa*), pin cherry (*P. pensylvanica*), and red maple [174].

Maryland: Black locust was a minor component in an old-growth forest remnant in western Maryland. Overstory species included chestnut oak, northern red oak, sweet birch, and red maple [88]. Black locust was listed in the yellow-poplar forest association found adjacent to or on bottomlands. This forest association contained red maple, flowering dogwood (*Cornus florida*), Virginia creeper (*Parthenocissus quinquefolia*), black tupelo, white oak, sassafras, black cherry, grapes (*Vitis* spp.), mockernut hickory (*C. tomentosa*), southern arrowwood (*Viburnum dentatum*), and Japanese honeysuckle (*Lonicera japonica*) [38].

In western Maryland and northern Virginia, black locust was a relatively common species in disturbed forests, occurring with basswood, chestnut oak, flowering dogwood, eastern hophornbeam (*Ostrya virginiana*), red maple, northern red oak, sugar maple, and white ash in the transitional hardwood forest, and with black tupelo, black oak (*Q. velutina*), chestnut oak, red maple, flowering dogwood, pignut hickory (*C. glabra*), northern red oak, white oak, eastern white pine (*P. strobus*), mockernut hickory, Virginia pine (*P. virginiana*), and white ash in the oak forest types [309].

Virginia: In a valley in northwestern Virginia, black locust occurred with river birch, yellow birch (*B. alleghaniensis*), striped maple (*A. pensylvanicum*), northern red oak, pignut hickory, basswood, and sugar maple. In this same region, it also occurred in an area dominated by pitch pine (*P. rigida*) and chestnut oak [134]. In western Virginia, black locust was a minor overstory and understory component in high-elevation northern red oak and river birch stands [305].

Kentucky: In the Cumberland Mountains of eastern Kentucky, black locust was listed as an understory tree in an oak-hickory community dominated by chestnut oak, hickories, and yellow-poplar; a ravine community dominated by chestnut oak and eastern hemlock; and a number of slope communities dominated by American beech, chestnut oak, and yellow-poplar. American chestnut was a canopy dominant at the time of study (1942) [29]. Small amounts of black locust occurred in remnant savanna-woodland portions of the Inner Bluegrass Plateau of Kentucky. Blue ash (*F. quadrangulata*), bur oak (*Q. macrocarpa*), chinkapin oak (*Q. muehlenbergii*), black walnut, shellbark hickory (*C. laciniosa*), shagbark hickory (*C. ovata*), and white ash were dominant [41]. Clifftop eastern redcedar (*Juniperus virginiana*) communities in the central lowland of Kentucky contained small amounts of black locust with white ash, eastern redbud (*Cercis canadensis*), slippery elm (*Ulmus rubra*), and honey-locust [39]. Loess bluff forests of southwestern Kentucky contained small amounts of black locust and were dominated by sugar maple, American beech, and sweetgum (*Liquidambar styraciflua*). White oak, yellow-poplar, black walnut, slippery elm, eastern hophornbeam, white ash, and basswood were associated species [40].

Illinois: In extreme southern Illinois, black locust occurred in 60-year-old bottomland hardwood forest dominated by pin oak (*Q. palustris*), willow oak (*Q. phellos*), sugar maple, red maple, and elms (*Ulmus* spp). [241].

Tennessee: Black locust was a minor species within chestnut oak-yellow-poplar forest remnants in eastern Tennessee [217].

Black locust occurred at low levels within high-elevation Great Smoky Mountain heath (Ericaceae) balds. Black locust was more associated with surrounding American chestnut (present in 1930 at time of study)-oak forest and Table Mountain pine (*P. pungens*)-heath forest than with bald vegetation [45]. It was also found occasionally in the Table Mountain pine-pitch pine forests of Tennessee and North Carolina. Virginia pine, chestnut oak, and scarlet oak (*Q. coccinea*) were important canopy trees [350]. In the Great Smoky Mountains of Tennessee and North Carolina, black locust was an uncommon tree in 2 forest communities, one dominated by northern red oak and the other by yellow-poplar [47].

North Carolina: In central North Carolina, black locust was an understory species in a chestnut oak-pitch pine plant community in the Piedmont region. It was also an understory species in a chestnut oak-heath community; an overstory species in the oak-hickory community; an overstory species in a mixed-hardwood forest; and an understory species in a rocky "knob" community, where it occurred with chestnut oak, pitch pine, and Table Mountain pine [352]. In the Pisgah National Forest in central North Carolina, black locust occurred in forests dominated by Table Mountain pine, Virginia pine, scarlet oak, and chestnut oak [270].

In southwestern North Carolina, black locust was found in small numbers on an "oak slope" site. Chestnut oak, red maple, and sweet birch were dominant. This area once had high numbers of American chestnut [205]. Black locust was found in western North Carolina riparian forests with yellow-poplar, black cherry, and basswood [149].

Black locust was a minor component of both the overstory and understory in eastern white pine stands in the southern Blue Ridge Mountains of western North Carolina [7]. In a southern Appalachian forest near Ashville, black locust occurred with dominant yellow-poplar, red maple, and flowering dogwood [78]. It was a minor component of the shrub layer of a 28-year-old river birch stand on river floodplains in western North Carolina [357].

In western North Carolina, black locust was a minor canopy component of a mixed-oak forest community [106]. In the Nantahala Mountains, black locust was a minor component of an oak-mixed-hardwood forest dominated by northern red oak, white oak, and sugar maple [211]. Black locust was listed as a "restricted species" in western North Carolina, where it occurred with the more common red maple, northern red oak, chestnut oak, eastern hemlock, mockernut hickory, and scarlet oak [223]. In the Nantahala National Forest, black locust was a common overstory dominant in midelevation (2,300 feet (700 m)), early-successional communities along with yellow-poplar, flowering

dogwood, eastern white pine, and oaks. Species composition differed between mesic and xeric sites, but black locust occurred in both. While not dominant in midsuccessional communities, black locust occurred with dominants white oak and black tupelo on mesic sites. At higher elevations (5,000 feet (1,525 m)), black locust occurred with black cherry, pin cherry, and pignut hickory and was present but not abundant on xeric sites. It was more common in early successional versus midsuccessional communities [54].

In the Black Mountains of western North Carolina, black locust was highly abundant in the mesic slope forest association, occurring with other dominants black tupelo, white oak, chestnut oak, and sassafras. American chestnut was also a dominant at the time of study (1930). It occurred at moderate frequency in the xeric slope and ridge forest associations, which were dominated by sourwood (*Oxydendrum arboreum*), scarlet oak, and Table Mountain pine [74]. For a table relating species composition to site characteristics for forests containing black locust in North Carolina, see Site Characteristics.

Alabama: In northern Alabama, black locust was found in 60-year-old stands (regenerated after clearcutting) with the dominant species eastern redcedar, white oak, chestnut oak, red oak, southern red oak (*Q. falcata*), flowering dogwood, yellow-poplar, shagbark hickory, and other hickories [246].

Western region:

Arkansas: In northwestern Arkansas, black locust was an uncommon species found on 2 soil types, limestone and chert. Major canopy associates on limestone were eastern redcedar, northern red oak, winged elm (*U. alata*), chinkapin oak, shagbark hickory, and white ash. Dominant tree species on chert were black oak, mockernut hickory, white oak, flowering dogwood, and Allegheny chinkapin (*C. pumila*) [268]. Black locust occurred in an Ozark forest dominated by black hickory (*C. texana*), post oak (*Q. stellata*), and chinkapin oak [172].

Oklahoma: Black locust was an uncommon forest species across Oklahoma, occurring with black oak, mockernut hickory, shortleaf pine (*P. echinata*), white oak, black tupelo, slippery elm, black walnut, flowering dogwood, sugar maple, and red maple [276].

Nonnative range: Though planted in all of the lower 48 states, black locust has naturalized more readily in some parts of the country than others. It is particularly problematic to land managers in pine barren, sand prairie, and black oak savanna plant communities (see Impacts) and establishes well in early-successional communities. Plant community descriptions from black locust's nonnative range in the United States are organized into the following regions: Southeast, Northeast, Great Lakes, Northern Great Plains, Northwest, California, Great Basin, and the Southwest. A few plant community descriptions are also given for locations outside of the United States.

Southeast: Black locust is found in a number of locations in the Southeast that are outside of its native range. Black locust seedlings were present but not abundant 4 years after thinning in a mature eastern cottonwood (*P. deltoides*) stand on the Mississippi River floodplain in western Tennessee. Dominant seedlings in this stand were boxelder (*A. negundo*) and red maple [294]. Black locust occasionally occurred in riparian areas in western Tennessee bottomland hardwood-baldcypress (*Taxodium distichum*) forest [168]. It is listed as a very minor upland species in a portion of the Georgia Piedmont; dominant species include loblolly pine (*P. taeda*), white oak, northern red oak, and yellow-poplar [68]. Black locust was also found in ravine and tributary stream bottoms in southern magnolia-American holly (*Magnolia grandiflora-Ilex opaca*)-American beech forest of southeastern Louisiana as early as 1821 [77].

Northeast: There are numerous accounts of black locust persisting outside of cultivation in the northeastern United States. In central Maryland, black locust was locally abundant on abandoned old fields, occurring with establishing Virginia and pitch pines [161]. Near a Delaware River tidal freshwater marsh in New Jersey, black locust was common in second-growth forests dominated by hickories, American beech, yellow-poplar, and oaks [200]. Black locust occurred in low abundance in a 60-year-old successional floodplain forest along the Raritan River in New Jersey. The dominant tree species were ashes (*Fraxinus* spp.) and boxelder [116]. Black locust occurred on 2 Allegheny River islands in northwestern Pennsylvania, with the dominant overstory species sugar maple and American sycamore [332].

In southeastern New York, black locust established in the pitch pine-mixed-oak forests of Long Island [60]. Black

locust occurred on both open oak-pine (scarlet oak, white oak, northern red oak, black oak, and pitch pine) and barren upland (pitch pine with dominant shrub bear oak (*Q. ilicifolia*)) forest habitats on Long Island [245]. On Staten Island, New York, black locust occurred at low density (1.9% of total stand basal area) in a forest dominated by red maple, American elm (*U. americana*), and black willow (*Salix nigra*) [130]. Black locust, along with black cherry and northern red oak, dominated the seedling and sapling layer of a northern red oak-black oak dry forest in a Bronx, New York, park [260]. In southeastern New York, black locust was an uncommon tree species in an eastern hemlock old-growth forest in 1965 but was not found in 2004 resampling [342].

Farther north, trace amounts of black locust were found in American beech-red maple forests of central New York [347]. At another central New York site, black locust occurred in small amounts in northern hardwood stands regenerating 20 years after clearcutting. Dominant tree species were white ash, black cherry, and yellow birch [334]. Near Ithaca, New York, black locust was an uncommon tree occurring in a suburban hillslope forest dominated by sugar maple and the invasive Norway maple (*A. platanoides*) [214]. Near Albany, black locust occurred in nearly pure patches covering 1.2 to12 acres (0.5-5 ha); black locust patches were surrounded by pitch pine, bear oak, and chinkapin oak [231]. Black cherry also occurred in these pine barren communities [272]. Black locust occurred in a mixture of American beech-maple forests and abandoned agricultural fields in west-central New York, only dominating the canopies where it was planted [166]. In the Champlain Valley region of New York and Vermont, black locust occurred in northern hardwoods forests that included eastern white pine, shagbark hickory, white and northern red oak, American beech, yellow and paper birch (*B. papyrifera*), and sugar and red maple [336].

In south-central Connecticut, black locust occurred in red maple, black birch, and white, black, and scarlet oak dry-forest sites at very low densities: 4 trees/acre in 1927 and 1 tree/acre in 1957 [243]. Black locust also occurred in trace amounts in unmanaged mixed-hardwood forest stands of central Connecticut as early as 1927 [335].

In a guide to invasive plants in Massachusetts, black locust is listed as occurring in pine barren and meadow habitats (review by [337]). Old-field successional sites on Martha's Vineyard, Massachusetts, include pitch pine, eastern redcedar, and black locust. Black locust also occurred in 125- to 250-year-old second-growth forests dominated by pitch pine and white, black, and northern red oak [242]. In a second-growth forest in Massachusetts, black locust was a minor forest species occurring with the dominant overstory species pignut hickory, shagbark hickory, and gray birch (*B. populifolia*) [43]. Black locust also occurred in a number of pitch pine forests on the sand plains of Cape Cod National Seashore [100].

Great Lakes: In southwestern Ohio, black locust was common in 40- and 60-year-old secondary forest stands that grew up in an abandoned agricultural field. Common overstory species in these stands included sugar maple, white oak, northern red oak, American elm, hickories, black walnut, and American beech [80]. In Michigan, black locust was listed as most invasive in American beech-maple and aspen (*Populus* spp.) woods, as well as lightly wooded dunes and riverbanks [329]. In southwestern Michigan, black locust occurred within an oak-flowering dogwood mesic deciduous forest on the south slopes of a large moraine [189]. Plantation black locust spread and established in degraded jack pine (*P. banksiana*) barrens of northern Michigan as early as 1888 [183]. At the Little Bluestem Prairie Nature Preserve in west-central Indiana, black locust, along with the other nonnatives black cherry and sassafras, established in areas of mixed-vegetation types that included black oak woods; floodplain forests dominated by silver maple (*A. saccharinum*), eastern cottonwood, slippery elm, and American elm; slopes dominated by little bluestem (*Schizachyrium scoparium*) and smooth horsetail (*Equisetum laevigatum*); and sand prairie dominated by little bluestem [310]. In degraded wetland sites in northwestern Indiana, black locust was found at low frequency in mixed-oak (white oak, swamp white oak (*Q. bicolor*), northern red oak, black oak) floodplain forests [58]. Black locust also occurred in disturbed and native black oak savanna communities of the Indiana Dunes in northwestern Indiana [252]. At the Lincoln Boyhood National Memorial in south-central Indiana, an area once dominated by oak-hickory forest, young black locust were found at low densities on abandoned homesites. Black locust also occurred at low densities in both the overstory and understory of bottomland successional forests dominated by sweetgum and red maple and in mixed-hardwood forests dominated by yellow-poplar and sugar maple [251]. It occurred on sand dunes in central Illinois, where Kentucky bluegrass (*Poa pratensis*) established under its cover [133]. On the Sand Prairie Scrub Oak Nature Preserve in central Illinois, plantation black locust spread and established in sand prairies dominated by sandlove grass (*Eragrostis trichoides*), little bluestem, and prairie sandreed (*Calamovilfa longifolia*) as well in adjacent blackjack oak (*Q. marilandica*) and black hickory forest [5,6]. Black locust was a very rare tree in a white oak-black

oak forest in southwestern Wisconsin [67]. In a restored oak savanna and woodland site in Minnesota, black locust occurred at varying density, though in some areas density was so high that native vegetation was excluded (Kruger personal communication cited in a review by [283]).

Northern Great Plains: In the Northern Great Plains states, there are a few plant community descriptions for sites with black locust. Black locust established in a sand prairie in southeastern Iowa, a tallgrass prairie dominated by the graminoids big bluestem (*Andropogon gerardii* var. *gerardii*), Addison's rosette grass *(Dichanthelium ovale)*, and Muhlenberg's sedge *(Carex muehlenbergii)*, and the forbs rough false pennyroyal *(Hedeoma hispida)*, vente conmigo *(Croton glandulosus)*, spotted beebalm *(Monarda punctata)*, and western ragweed *(Ambrosia psilostachya)* [289]. Black locust established outside of plantings and by 1997 was found along the shorelines of major lakes in the sandhills of Nebraska [21]. In northwestern Kansas, it occurred in small amounts in big bluestem-little bluestem tallgrass prairie remnants and Conservation Reserve Program sites reseeded with native grasses including big bluestem, little bluestem, sideoats grama (*Bouteloua curtipendula*), switchgrass (*Panicum virgatum*), and indiangrass (*Sorghastrum nutans*) [173]. In northeastern Colorado, black locust occurred with Russian-olive (*Elaeagnus angustifolia*), Siberian elm (*U. pumila*), ponderosa pine (*P. ponderosa*), juniper (*Juniperus* sp.), honey-locust, and green ash (*F. pennsylvanica*) in planted shelterbelts. Adjacent shortgrass prairie species included blue grama (*B. gracilis*) and buffalo grass (*Buchloe dactyloides*) [244].

Northwest: Planted groves of black locust and Siberian elm expanded into old fields in degraded sagebrush (*Artemisia* spp.) steppe communities of the Columbia Plateau in eastern Washington [28]. In northeastern Oregon, black locust occurred in riparian communities dominated by black cottonwood (*P. balsamifera* subsp. *trichocarpa*), white alder (*Alnus rhombifolia*), ponderosa pine, and Douglas-fir (*Pseudotsuga menziesii*) [17]. It was planted in the sagebrush desert of south-central Oregon, but survivorship was low. Black greasewood (*Sarcobatus vermiculatus*) was an associate (review by [186]).

California: Black locust has established in plant communities throughout California. Multiple populations of black locust occurred on the Cleveland National Forest in southern California, an area dominated by chaparral vegetation, but also including coastal sage scrub, oak woodlands, riparian areas, and grasslands [122]. Black locust was an uncommon tree in riparian forests in the Central Valley, with boxelder, California sycamore (*P. racemosa*), Fremont cottonwood (*P. fremontii*), valley oak (*Q. lobata*), red willow (*S. laevigata*), and Pacific willow (*S. lucida* subsp. *lasiandra*) [279,333]. It occurred with willow (*Salix* spp.) at a desert riparian site in east-central California [111]. In northern California, ornamental black locust spread downstream along a riparian zone of the McCloud River, establishing in areas once dominated by Douglas-fir and western redcedar (*Thuja plicata*) [152].

Great Basin: In southwestern Idaho, black locust occurred within the sagebrush rangeland, an area dominated by sagebrush, black greasewood, antelope bitterbrush (*Purshia tridentata*), saltbush (*Atriplex* spp.), and rabbitbrush (*Chrysothamnus* spp.) [358]. For rehabilitation plantings, black locust was considered adapted to juniper-pinyon (Cembroides), mountain brush, and northern desert sagebrush communities in Utah (review by [257]).

Southwest: Black locust was among a mix of woody riparian species (cottonwood and willows) growing along the Mimbres River and its floodplain in New Mexico [22].

International range: Black locust has established in plant communities outside of the United States. It replaced European chestnut (*C. sativa*) forests in northern Italy and Switzerland (Cherubini personal communication cited in a review by [283]). Black locust also occurred in abandoned fields reverting back to forest within the oak-pine forest region of southern Poland [99]. In the former Yugoslavia, black locust was planted to revegetate logged areas within a native sessile oak (*Q. petraea*) forest [162]. In the bushveld and grassland ecosystems of the central Transvaal in South Africa, black locust was detected at low frequency at streamside, riverbank, veld, and roadside habitats (review by [343]).

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Robinia pseudoacacia

Photo by Jennifer Anderson @ USDA-NRCS PLANTS Database

GENERAL BOTANICAL CHARACTERISTICS:

Botanical description: This description covers characteristics that may be relevant to fire ecology and is not meant for identification. Keys for identification are available (e.g., [31,85,123,153,156,232,239,261,292,329]).

Belowground description: Black locust trees develop extensive root systems. Radial root extent is about 1 to 1.5 times tree height (review by [167]). Within black locust's native range, lateral surface root extensions of 165 feet (50 m) were documented [255]. In southeastern Ohio, no taproots were found within planted black locust stands, but extensive lateral root systems were observed. The roots spread from silty loam soil through loose shale and hard subsoil and below deep ravines caused by gully erosion [196]. On mined sites in eastern Kentucky, most of the fine roots of black locust seedlings were found within the top 6 inches (15 cm) of the soil [365].

While a number of sources state that black locust is commonly shallow-rooted (reviews by [72,167,312]), the species occasionally develops deep roots (review by [167]). Vertical roots were found at 20 to 25 feet (6.1-7.6 m) in the Southwest (review by [167]) and 21 feet (6 m) in the Oklahoma panhandle [42]. Trees planted in Oklahoma Richfield silty loam penetrated at least 26 feet (8 m) into the soil [42]. In eastern Nebraska, a 12-year-old, 27-foot (8 m) tall black locust planted in a shelterbelt on silty-clay loam penetrated to 8 feet (2 m) and laterally spread 10 feet (3 m) [301].

Root suckers form primarily where branch roots emerge from older roots [306]. See Vegetative regeneration for more information.

Black locust is a nitrogen-fixing species (review by [167]). In North Carolina, net nitrogen mineralization potential,

net nitrification potential, and phosphorus concentrations in the soil were highest in dense stands of black locust occurring in a regenerating clearcut and in a 17-year-old grass-to-forest successional stand, compared to undisturbed oak-hickory forest stands, eastern white pine plantations, and disturbed hardwood coppice stands without black locust [233]. Similarly, at the Coweeta Hydrologic Laboratory in the Nantahala Mountains of North Carolina, regenerating black locust stands had significantly higher concentrations of total nitrogen, organic matter, and nitrates compared to mixed-oak-hardwood forest (P<0.1). Net nitrogen accretion rates of 48 kg/ha/year, 75 kg/ha/year, and 33 kg/ha/year were found in 4-, 17-, and 38-year-old black locust stands, respectively [24]. In mixed-hardwood forests of the mid-Appalachian Mountains, black locust contributed to elevated stream nitrate concentrations [353].

Aboveground description: Black locust matures to a medium-sized tree, generally 40 to 60 feet (12-18 m) in height and 12 to 30 inches (30-76 cm) in diameter (review by [167]). Trees in Michigan have reached 3 to 5 feet (0.9-1.5 m) in diameter, though smaller stems are more common [329]. Within its native range, black locust averaged 4 stems/"rootstalk" [229]. Frequent frosts may result in crooked growth (review by [145]).

Young black locust bark is smooth and brown [113]. Young trees are thorny [31]. As trees age, the bark becomes thick, deeply furrowed, scaly, and dark brown [113]. Black locust leaves are deciduous, alternate, and pinnately compound, with 7 to 19 leaflets on a central stalk that is 8 to 12 inches (20-30 cm) long. Leaflets are 30 to 50 mm long [113]. Black locust flowers are showy, white, and fragrant, in drooping clusters about 6 inches (14 cm) long. Clusters arise from leaf axils near the tip of new shoots [113]. Black locust fruits are flat legumes 3 to 4 inches (7-10 cm) long [113]. Seeds are dark, bean-like, 3 to 5 mm long, and have a hard, impermeable coat. Each legume contains approximately 4 to 8 seeds [113].

Stand and/or population structure: In early successional communities, black locust often grows in dense thickets or clones (reviews by [72,167]) due to the ability of individuals to root or stump sprout following disturbance [46]. Generally, the oldest trees are located in the center and youngest trees on the edges of stands (review by [72]). In late successional communities, black locust is generally an uncommon species, occurring at low density. See Seedling establishment and plant growth and Successional Status for further information.

Age and/or mortality: In general, black locust trees are fast growing but short lived [303], living approximately 90 years [113]. Seedlings may have high survivorship. One source suggests that early survival rates are usually high because wide-spreading root systems support "vigorous" growth (review by [314]). Black locust had the highest 6-year survival (69%) of all native and nonnative plants studied on reclamation strip-mined land in Missouri, Kansas, and Oklahoma [59]. On limestone and acid-shale reclamation sites in Ohio, 78% of direct-seeded black locust survived 7 years after planting [202]. At a biofuel farming site in Las Cruces, New Mexico, 2-year-old black locust survival was 78% [185]. In contrast, in mixed-oak, cove, and northern hardwood forests in North Carolina, mature black locust had relatively high mortality, with estimated annual mortality rates of 7% [361]. In plantations and reclamation projects, black locust mortality increases with higher density planting [59,120]. See Other Uses for specific agents of black locust mortality.

Raunkiaer [266] life form:
Phanerophyte
Geophyte

SEASONAL DEVELOPMENT:
Within its native range, black locust generally flowers from April to June ([165,261,311,356], review by [167]), though one source states it may flower as early as February in the Southeast [97].

In its nonnative range, flowering occurs mostly from May to June in the Pacific Northwest [156], California [239], the Southwest [325], Northeast and Canada [123], and Great Plains [128,313]. Earlier flowering occurs from March to May in north-central Texas [85], while later flowering occurs in some parts of New England, extending into July [292]. In the uplands of the Adirondacks, flowering generally occurs only in June [190].

Fruit begins ripening as early as July in the Carolinas [261] or August in Arkansas [165], and ripening extends into November [165,261]. In the Southwest, fruit ripens from September to October [325]. Black locust seeds persist

through the winter [113,165], though dispersal is described as occurring from September to April in both its native (review by [167]) and nonnative [325] ranges.

REGENERATION PROCESSES:

Black locust reproduces both from seed and by sprouting from the roots or stump. Sprouting is considered more common than sexual reproduction. Limited seed dispersal, seed coat impermeability, and high light requirements for germination all limit reproduction by seed.

Pollination and breeding system: Black locust is insect pollinated [113]. Flowers are also visited by hummingbirds [165].

Seed production: Black locust begins producing seeds at about 6 years of age (reviews by [26,167]). Seed production is best between 15 and 40 years of age and continues through approximately age 60 (review by [167]). Seeds are produced every year, but good crops are produced at intervals of 1 to 2 (review by [167]) or 2 to 3 [113] years.

Seed dispersal: Black locust seeds are dispersed by gravity (review by [26]), wind ([273,280], review by [26]), and potentially by birds [154,155].

Large size causes most black locust seeds to fall near the parent plant (review by [314]), and black locust is generally considered to have a low dispersal rate [87]. However, long-distance dispersal is possible; black locust recruited by seed onto a revegetating landfill site on Staten Island, New York. The closest seed source was 397 feet (121 m) from the landfill [280].

Seed banking: Black locust seeds may persist in the soil for long periods of time. A Michigan flora states that seeds may survive for more than 88 years in the soil [329]. In a laboratory study, seed from 107 plant species was buried up to 42 inches (107 cm) in soil. Black locust was 1 of 16 plant species with more than 15% of seeds viable after 39 years [316]. Other sources state that seeds remain viable for more than 10 years ([325], review by [26]) or "many" years [87,113]. In mixed-oak and northern hardwood forests of western North Carolina, black locust seeds remained viable in the soil for more than 1 year. Soil seed densities were higher than seed rain, suggesting low annual seed mortality and the presence of seeds from previous years [155].

Because black locust seeds are persistent, they may accumulate to great levels in the seed bank. In Hungary, seeds accumulated over decades in the top 4 inches (10 cm) of soil (review by [181]). In a second-growth mixed-hardwood forest in Great Smoky Mountains National Park, black locust seeds were found in the soil at a density of 29,817 seeds/acre (73,680 seeds/ha) [118]. In contrast, in a mature mixed-oak-maple forest in southwest Virginia, black locust seeds were found at a density of only 121 seeds/acre (300 seeds/ha). The authors suggested that the continuous cover of mature forest would make it difficult for early-successional species like black locust to produce a large quantity of seeds [285].

Germination: Black locust seeds require scarification ([325], reviews by [167,181]) and bare mineral soil ([164,216], review by [314]) for successful germination. Though one source cites germination rates as high as 68% in its native range [325], most sources suggest that seed germination is low (review by [131]) due to high seed coat

impermeability ([252], review by [226]) and shade intolerance [164,252]. Direct-seeded black locust on limestone and acid-shale sites in Ohio had low germination rates, ranging from 3% to 17%. Survival of these germinants ranged from 23% to 78% [202]. Fifteen to 33 days after planting in a greenhouse, fall-collected black locust seeds from New Haven, Connecticut, exhibited 45% germination. The addition of various salt concentrations delayed and slightly lowered percent germination [19].

In greenhouse trials, black locust seeds germinated uniformly over a 5-week period [87].

Seedling establishment and plant growth:

Establishment: Black locust requires open conditions for establishment ([252,297], reviews by [167,314]). Establishment is often linked to natural ([37,164], review by [167]) and manmade ([99,103,285], review by [167]) disturbances. See Successional Status for more information on this topic.

Growth rate: Black locust is known for its rapid juvenile growth rate ([24,59,126,137,202,291,361], review by [167]). In mixed-oak, cove, and northern hardwood forests in North Carolina, the 5-year average radial growth rate for black locust was 1.31 mm/yr, which was the highest of the 7 species tested [361]. The growth rate of black locust seedlings is limited by plant density ([120], review by [167]) and insect infestations [120,365] and enhanced by light [164], moisture [23,185], and fertilization [23,365].

In its native range, black locust grows rapidly following disturbances such as logging or mining. In regenerating hardwood forests in North Carolina, black locust seedlings grew 26 feet (8 m) in 3 years. They grew faster than any other species for 10 to 20 years [24]. Black locust had the second-tallest mean height of dominant hardwood species 5 years after clearcut treatments in mixed-oak stands in Virginia, with trees as tall as 8.6 feet (2.6 m) [364]. After overstory removal in Pennsylvania mixed-oak stands, black locust seedlings were 3.4 feet (1.0 m) tall 1 year after treatment and 8.1 feet (2.5 m) tall 4 years after treatment [126]. On limestone and acid-shale mine sites in Ohio, direct-seeded black locust reached an average height of 25 feet (8 m) in 7 years, which was higher than any other plant species [202].

Black locust growth rates are also high in its nonnative range. A review states that black locust growth rates in plantations in the central states could average as much as 42 feet (12.8 m) in 10 years, 68 feet (20.7 m) in 25 years, and 84 feet (25.6 m) in 40 years [167]. In experimental old-field rehabilitation plantations in Iowa, 12- to 15-year-old black locust had the highest annual height growth (μ=2.47 feet (0.75 m)) of any species planted [137]. On mine reclamation sites in southeast Kansas, black locust had the fasted growth of all planted species, growing 23 feet (7 m) in 10 years [291].

Density: Black locust may grow at high or low densities depending on local site characteristics. Within its native range, seedling densities are variable. There are often few seedlings under canopies containing mature black locust [172,297]. Black locust seedling density was 125 seedlings/ha in an old-growth mixed-hardwood forest in West Virginia [2]. In contrast, in the Nantahala National Forest in North Carolina, oak-hickory-poplar forest gaps created by clearcutting contained numerous black locust seedlings (3,854 seedlings/ha) and sprouts (2,616 sprouts/ha) 2 years after treatment [297].

Within mature forests of its native range, black locust usually occurs as a canopy tree at low density [1,2,7,40,47,88,92,106,172,205]. For example, there were significantly more black locust stems in 35-year-old, second-growth (22.3 stems/ha) compared to old-growth (4.1 stems/ha) mixed-hardwood forest in eastern Kentucky (P<0.05) [220]. See Successional Status for more information.

In its nonnative range, black locust trees may establish in high densities outside of plantation settings ([231,252], reviews by [72,226]). In a disturbed forest regenerating after a horticultural area was abandoned in New York, black locust established 97 stems/acre (240 stems/ha) in the 8- to 12-inch (20-30 cm) size class and 32 stems/acre (80 stems/ha) in the 12- to 16-inch (30-40 cm) size class in 20 to 40 years. Black locust also dominated the seedling and sapling layer of a mixed-oak dry forest, occurring at a density of 898 stems/acre (2,220 stems/ha) in the 0- to 1-inch (0-2.5 cm) size class [260]. In a pine barrens community near Albany, New York, black locust occurred in nearly pure patches covering 1.2 to 12 acres (0.5-5 ha); these patches were surrounded by pitch pine and scrub oak [231]. In

restored oak savanna and woodland sites in Minnesota, black locust stem densities ranged from 4 to 400 stems/acre (10-1,000 stems/ha), with some areas completely dominated by black locust (Kruger personal communication cited in a review [283]).

Vegetative regeneration: Vegetative regeneration is important to the establishment, spread, and persistence of black locust. It is thought to be a more common means of reproduction than seed (reviews by [26,131,314]). Black locust commonly sprouts from roots [90,102,133,156,239,258,272,291,306,363] or the stump ([90,102,108,291,306,365], reviews by [72,167,226]). Sprouting often occurs in response to stem or root damage ([90], reviews by [167,226]) due to cutting ([108,306,365], reviews by [72,167]), fire ([108,133], review by [72]), wind, or disease (review by [72]). Root sprouting is also a common means of reproduction following logging treatments [15,363] and a means of spread into revegetating reclamation sites [139] and out of plantations and into abandoned fields [183].

Root sprouting usually begins when plants are 4 to 5 years old (reviews by [131,167]) and increases rapidly in full sun, open areas, and particularly in sandy soils (review by [131]). Though sprouting is a common response to disturbance, sprouts need sufficient light to survive [35].

See Physical and/or mechanical control for more information on how black locust's regenerative abilities impact control efforts.

SITE CHARACTERISTICS:
The following section examines site characteristics such as general types of sites, elevation, soil characteristics, topography, and climate in black locust's native and nonnative ranges.

Native range:
General site characteristics: In its native range, black locust occurs in a wide range of forest communities (see Habitat types and plant communities for specific community associations), as well as a variety of disturbed sites such as old fields ([169,225,332], reviews by [167,314]) and logged areas [15,46,184,220,228,288,317]. It generally occurs at low density within the forest interior but establishes well in forest openings, edges [216], and other early-successional habitats. See Successional Status for more information.

Elevation: A silvics guide states that in its native range, black locust thrives best on moist slopes of the eastern mountains below 3,400 feet (1,040 m) (review by [167]). It occurs below 300 feet (90 m) in parts of Kentucky [41] and Tennessee [350] and above 4,000 feet (1,200 m) in Great Smoky Mountains National Park ([45], review by [167]).

Soils: Black locust occurs in a variety of soil types within its native range. Numerous sources associate black locust with limestone ([39,41,121,172,268,311], reviews by [167,312]), but it is also associated with sandstone [2], chert [268], and mica-gneiss substrates [211]. Soils tend to be loams ([129], reviews by [167])) or sandy loams [246]. Other soil characteristics associated with black locust include "rich" ([41], reviews by [167,312]), deep ([41], review by [312]), well-drained ([2,38,129], review by [312]), and moist ([78], review by [167]) conditions.

Black locust may not grow well on very sandy, very acid, or wet soils (review by [312]). It is sensitive to soil conditions that produce either minimal or excessive aeration and drainage (reviews by [66,167]). Black locust growth is limited by water-logged soils or soil compaction (review by [66]).

In its native range, black locust tolerates a range of soil acidities; a pH of 4.6 to 8.2 is listed as "acceptable" in 2 reviews [26,167]. Soil at a site within its native range in the Nantahala Mountains of western North Carolina had a pH of 4.7 [211]. In the Great Smoky Mountains of Tennessee and North Carolina, black locust was found in soils with a pH of 5 [47].

Topography: Black locust is often found on slope forests within its native range ([1,2,29,211,350], review by [167]). In the Monongahela National Forest in central West Virginia, black locust occurred on slopes of 45% to 55% [2]. In

the Nantahala Mountains of western North Carolina, it occurred on a 21.6° slope [211]. Black locust has been found on northwestern slopes in eastern West Virginia [1] and southerly slopes in North Carolina and Tennessee [350].

Black locust is also found on valley floors [1], bottomlands [38], floodplains [77], ridges [350], rolling uplands [41], and loess hills [40,77].

Black locust occurs in a variety of forest types in the Black and Craggy Mountains of western North Carolina, though at very low densities [222].

Relative density of black locust in xeric to mesic oak forests [222]

Forest type	Dominant species	Forest characteristics	Percent density of all trees
Mixed-oak	mixed-oaks, yellow-poplar, red maple, American beech, hickories	2,500-3,400 ft, moderately sheltered low ridges, flats and valleys, dry-mesic, moderate nutrients	1.3
White oak	white oak, American beech, red maple	well-drained valley flats and terraces, dry-mesic, nutrient rich, high pH	1.6
Scarlet oak	scarlet oak, red maple, sourwood	<3,400 ft, south- and west-facing ridges, slopes, and flats, dry-mesic, intermediate in nutrients and pH	2.3
Northern red oak, chestnut oak, yellow-poplar	northern red oak, chestnut oak, yellow- poplar, red maple	3,200-4,000 ft, open slopes of all aspects, intermediate nutrients and pH	1.5
Chestnut oak	chestnut oak, scarlet oak, black oak, northern red oak, pignut hickory, red maple, black tupelo	3,000-4,500 ft, south- and southwest-facing slopes and narrow ridges of most aspects, xeric, nutrient poor	1.6
Red oak	northern red oak, red maple, sweet birch, American beech, eastern hemlock	4,000-5,000 ft, middle and upper slopes, ridgetops, intermediate in moisture and nutrients	0.5

Relative density of black locust in mesic to wet forests [222]			
Forest type	**Dominant species**	**Forest characteristics**	**Percent density of all trees**
Cove hardwoods	sugar maple, basswood, American beech, yellow buckeye (*Aesculus flava*), yellow birch	<5,000 ft, low, predominantly north-facing slopes, coves, and sheltered slopes, wet-mesic, high nutrients and pH	1.3
Northern red oak	northern red oak, yellow-poplar, sugar maple, eastern hemlock, American beech	slopes adjacent to cove forests, slightly lower moisture, nutrients and pH compared to cove forests	0.7
Alluvial	American sycamore, yellow birch, eastern hemlock, red maple	floodplains and terraces of large streams, mesic, moderate nutrients	0.2
Hemlock hardwoods	yellow birch, eastern hemlock, red maple, sweet birch, witch-hazel (*Hamamelis virginiana*)	slopes and hollows adjacent to mesic red oak forests, upstream from alluvial forests, 1st- and 2nd-order stream flats and in ravines, mesic, low nutrients and pH	0.4

Climate: Climate conditions in black locust's native range are humid, though it has been successfully introduced into many parts of the world where climate conditions vary widely from those listed below (review by [167]).

Climate conditions for black locust's native range (review by [167])		
	Minimum	Maximum
January normal daily temperatures	-7 to 2 °C	2 to 13 °C
August normal daily temperatures	13 to 21 °C	27 to 32 °C
Mean length of average frost-free period	150 days	210 days
Normal annual total precipitation	1,020 mm	1,830 mm
Mean annual total snowfall	5 cm	152 cm

Nonnative range:

General site characteristics: Outside of its native range, black locust thrives in disturbed ([12,91,210,231,237,272], review by [26]) or "waste" areas [31,329]. Specific examples of disturbed areas include roadsides ([53,85,113,128,153,215,329], reviews by [26,72]), railroad right-of-ways [144], constructed wetland edges [200],

disturbed hammock margins [360], man-made sandflats [224], and channel levees [296].

Many disturbed black locust sites are also associated with human habitation and agricultural operations. Black locust occurs in fencerows and hedgerows ([85,113,124,143,161,325,329,341], review by [72]), abandoned agricultural fields [60,80,97,160,165,210,237,327,329,332] and pastures ([113,128,313], review by [72]), and near old home or farm sites [53,152,153,156,192,198,231,231,325,341].

Black locust spreads from disturbed sites into areas such as forests ([58,113,116,161,232,329], forest edges [124,165], reviews by [71,72]), woodlands [128], woodland openings [165], thickets [128,232], or prairies and other grasslands ([310], review by [72,173,289]). See Habitat types and plant communities for descriptions of plant communities where black locust occurs outside its native range.

Black locust often establishes in riparian areas such as stream- and riverbanks and floodplain forests throughout its nonnative range, including locations in the Southeast [77,294], Northeast [12,116,200,224,254,332], Great Lakes [58], Northern Great Plains [128], Northern and Central Rockies [91,192] Northwest [17,156,198,259], Southwest (review by [307]), and California ([73,94,111,152,153,197,279,296], reviews by [26,95,290]).

Elevation: In its nonnative range, black locust is found at a wide range of elevations. The following table demonstrates that black locust may occur anywhere from 30 to 6,500 feet (10-2,000 m) in its nonnative range.

Elevation (feet)	Location
30-350	southeastern Louisiana [77]
80-240	central Maryland [161]
160-6,300	California ([153], review by [26])
1,000	southwestern Wisconsin [67]
3,115-3,135	Grand Canyon National Park, Arizona (review by [307])
3,770	Las Cruces, New Mexico [185]
4,450	midwestern Himalaya of India [182]
4,500-5,500	Colorado [143,341]
4,920-7,545	southwestern New Mexico [22]
5,000-6,200	Sierra Nevada, California [295]
6,500	New Mexico (review by [302])

Soils: In its nonnative range, black locust is found in a wider range of soil conditions than within its native range. An association with limestone or calcareous soil is noted in the Southwest [325], the Northeast, and Canada [113]. In contrast to its native range, a strong association with sandy soils is found in the Northern Great Plains [303], north-central Texas [85], Illinois [5,133], the Northeast [236], Maryland [254], California ([296], review by [131]), and Hungary ([218], review by [181]). Many of these locations are either sand dunes or sand prairies [5,133], or stream or river deposits [236,254,296]. Black locust was found on fertile loam near the Sacramento River in California [197], Richfield silty loam in the high plains regions of the Oklahoma panhandle [42], silty-clay loam in eastern Nebraska [301], well-drained loams in eastern Washington and northern Idaho [32], and silty or sandy loams with loose structure in Hungary (review by [181]). Clayey soils were listed as "inappropriate" in Hungary (review by [181]), and sandy or constantly wet soils were not conducive to growth in eastern Washington and northern Idaho [32].

A preference for moist sites is noted in the Northern Great Plains [313], northern United States and southern Canada [113], and Hungary (review by [181]). Black locust's deep rooting ability may allow it to grow in locations much drier than in its native range (review by [167]). Black locust was one of the most abundant trees establishing in dense stands on "poor", dry soils on man-made sandflats along the Hudson River in eastern New York [224]. Several sources suggest that as in its native range, black locust does best on well-drained sites ([313,325], review by [204]). One

source states that black locust prefers deep soils in the Southwest [325], though another states that it may grow well on shallow soils in the Northeast (review by [204]). Black locust is found on sites that range from low ([224], review by [204]) to intermediate [236] and high [197] soil fertility in its nonnative range. The ability of black locust to establish and persist in areas with low soil nutrient levels (like the pitch pine-scrub oak forest type in New York [272] or dry grasslands in Europe ([99], review by [340])) is highly problematic to land managers (see Impacts).

Black locust has been planted on soils with a wide range of pH and tolerates extremely acidic soils, particularly in strip-mine reclamation sites [3]. For example, 21% of 1- to 2-year-old black locust seedlings survived soil pH as low as 2.85 on acid strip-mine spoil in southwest Indiana, though higher survival was observed when lime was added to raise the pH [151]. One biofuel plantation site in Las Cruces, New Mexico, had a soil pH of 7.9 [185].

Topography: Black locust is commonly found on slopes across its native and nonnative ranges. In southwestern Michigan, it occurred on the south slope of a large moraine [189]. In Ohio, black locust was most abundant on dry hillsides [31]. In California, it was locally abundant on canyon slopes [153]. In the Palouse prairie region of eastern Washington and northern Idaho, black locust occurred on hills and slopes too steep to plow [32].

Climate: Black locust is highly susceptible to frost and cold weather damage (reviews by [167,312]), which may limit expansion of its range. Black locusts planted in Ontario were limited by hard winter frosts that killed new growth [16]. Frost is listed as the most important abiotic threat to black locust in Hungary; it may damage shoots and decrease growth, leading to dwarfed trees over time (review by [181]).

Few authors report climate data for areas where black locust has either been planted or established outside its native range. Plantations of black locust were started in Las Cruces, New Mexico, an area with a minimum winter temperature of 18.1 °F (-7.7 °C) and a maximum summer temperature of 100.9 °F (38.3 °C) [185]. Near Albany, New York, black locust established in a region with average temperatures of 21 °F (-6 °C) in January and 72 °F (22 °C) in June [272]. Black locust also established in western Maine, where January temperatures ranged from 4.5 to 27.0 °F (-15.3 to -2.8 °C) and July temperatures ranged from 54.7 to 80.8 °F (12.6-27.1 °C) [12].

Black locust grows well in the Palouse prairie region of eastern Washington and northern Idaho, where average annual high and low temperatures for Moscow, Idaho, are 58.1 °F (14.5 °C) and 35.8 °F (2.1 °C) respectively, and average annual high and low temperatures for Colfax, Washington, are 59.9 °F (15.5 °C) and 36.5 °F (2.5 °C) respectively. This area infrequently experiences long periods of subzero temperatures in the winter [32].

Low precipitation may also limit black locust persistence or range expansion. Only 8% of black locust survived that were planted in the sagebrush desert of south-central Oregon, an area receiving less than 10 inches (250 mm) of annual precipitation (review by [186]). For rehabilitation in Utah, a reclamation handbook notes that black locust grows as a shrub at temperate climate sites that receive more than 12 inches (305 mm) of annual precipitation, and as a small tree at sites receiving more than 15 inches (380 mm) of annual precipitation (review by [257]). Black locust was found in southwestern Wisconsin, an area with an average annual precipitation of 30.6 inches (777.2 mm) [67], as well as in western Maine, where average annual precipitation was 44 inches (1,116 mm) [12].

SUCCESSIONAL STATUS:
Black locust is a shade-intolerant species ([11,15,24,61,103,104,113,140,164], review by [167]). Its ability to tolerate shade improves on fertile sites (review by [278]). It establishes well in early-successional stands ([103,187,233], reviews by [167,314]), particularly following disturbance ([103,285], review by [167]), though its dominance is usually temporary ([20,24,61,102,103,297], review by [167]). For example, black locust biomass in both cove hardwood and mesic, mixed-oak forests in western North Carolina peaked 16 years after clearcutting and was declining 20 years after the treatment [103]. Pure, persistent stands of black locust occur very rarely within its native range and are usually associated with planting, land abandonment, fire, or other severe disturbances (review by [278]).

In later-successional forest communities, black locust generally occurs at low density and is considered uncommon [1,7,40,88,92,106,172,211,217,276].

Successional role: Black locust's prevalence in early-successional stands has important consequences for plant

community development in its native range. Several authors discuss black locust in terms of facilitating later-successional plant species, particularly because of its ability to fix nitrogen ([24,180,365], review by [167]) and stabilize the soil ([180], reviews by [167,278]). In a North Carolina oak-hickory-yellow-poplar forest, high biomass and net primary production of black locust in large forest openings created from logging increased soil nitrogen and accelerated growth rates of cooccurring plant species [297]. Because black locust is short lived, shade-tolerant species in the understory often release after its death [24].

Historically, disturbances such as fire ([2,45,108,270,350], reviews by [30,55]), drought [101,104,108,205,350], insect [108,205,350] and disease [1] outbreaks, windfall ([2,45,112,205], review by [55]), lightning [205,282], ice storms [205,350], and landslides [45] played an important role in shaping plant community dynamics within black locust's native range. After settlement by Europeans, disturbances such as logging ([1,25,104,309], reviews by [30,55]), fire exclusion [1], burning and clearing land for settlement and agriculture [104,309], grazing ([104], review by [30]), gypsy moth outbreaks [1,350], loss of American chestnut [1,104,205,304], pollution [1,350], and the presence of introduced species [350] also became important within the native range of black locust. Black locust responses to some natural and anthropogenic disturbances have been well studied.

Natural disturbances:

Canopy gap formation: Black locust may thrive in canopy gaps within its native range, though this response is not consistent and may depend on gap size. Black locust responded favorably to logging treatments that simulated natural canopy gap formation. In the Nantahala Mountains of North Carolina, 4 sizes of forest openings (0.040, 0.20, 1.0 and 5 acre (0.016, 0.08, 0.4, and 2 ha)) were created by clearcutting to investigate the impact of gap size on forest succession. The original forest was dominated by hickories, yellow-poplar, and oaks. One and 2 years after treatment, black locust increased consistently in relative importance from small to large openings, and contributed the most of any species to net primary production in the 2 largest gap sizes. It also contributed most to sprout production [255]. There were large numbers of black locust seedlings (3,854 seedlings/ha) and sprouts (2,616 sprouts/ha) 2 years after treatment. Black locust remained prominent 12 years following treatment but declined 17 years following treatment [297]. In West Virginia, black locust is common in hardwood forest canopy gaps [228].

Other research suggests that canopy gaps have little or no effect on black locust abundance. In a North Carolina mixed-oak forest, black locust rarely established in single-tree canopy gaps and was not found in multitree canopy gaps [62]. Similarly, black locust was of low abundance after experimental multitree gaps were made in a North Carolina mixed-oak forest [84]. Black locust stem density was not significantly different in gap versus nongap plots in mixed-oak forest in Georgia ($P<0.001$) [213]. Though it occurred in 26% of the stands that once contained American chestnut, black locust was only found in 7% of the 2,569 openings created by the death of individual American chestnut trees in Great Smoky Mountains National Park [359]. Black locust was a minor overstory species in both undisturbed forest and in canopy gaps created by southern pine beetle-induced pitch pine mortality in southwestern North Carolina [299].

Debris avalanches: Black locust was 1 of the 4 most important species regenerating 10 years after debris avalanches in a Virginia mixed-hardwood forest. It was not present or present at a very low density in adjacent undisturbed plots [164].

While disturbances often favor the establishment of black locust, some disturbances also lead to direct mortality of or damage to established trees. For example, 7 years of drought in western North Carolina led to high levels of black locust mortality (31%) across the watershed for all stem classes, driven mostly by high mortality (42.8%) in the 2- to 4-inch (5-10 cm) size class [101]. Black locust also sustains high levels of wind damage [112].

Anthropogenic disturbances:

Logging: In general, black locust is abundant in logged stands [15,46,184,220,228,288,317]. It responds favorably to logging, often responding immediately through vigorous sprouting [24,102,221,317,354,363], rapid growth [102,126,354,364], and increased abundance compared to pretreatment levels [24,103,106,107,127,317,331]. In some instances, black locust dominates regeneration [20,24,235,354,363], though this dominance is often short lived [20,24,102]. For example, in mixed-oak forests in Virginia, black locust was the clear dominant in the tree stratum 4

and 5 years after clearcutting. Other trees surpassed black locust in dominance in years 6 and 7, but it was still one of the most abundant species. The authors predicted its dominance would likely decline further [20]. Three years after shelterwood cutting in the Nantahala National Forest in western North Carolina, understory black locust increased in 2 mixed-hardwood stands from a density of 101 stems/ha to 879 stems/ha in one stand, and 92 stems/ha to 1,223 stems/ha in another [107].

Mining: Black locust establishes on open surfaces created by mining operations. It was an abundant tree species in revegetating abandoned mine land in West Virginia [139,174], Maryland [139], and Tennessee [238,264].

Old fields: Black locust commonly establishes in old fields throughout its native range [13,61,187,201,225]. Reforestation of abandoned agricultural fields by black locust, sassafras, and yellow-poplar in Great Smoky Mountains National Park was accomplished in approximately 5 years [187]. Black locust and yellow-poplar were codominants in 15-year-old, regenerating old fields in Great Smoky Mountains National Park, but black locust was absent when the stand was 42 years old [61].

Nonnative range: Black locust prefers open conditions ([56,252,303], review by [26]) and does not persist in shade [342]. For example, in southeastern New York, black locust was an uncommon tree species in an eastern hemlock old-growth forest in 1965 but was not present in 2004. In general, this stand changed from open to closed conditions over 39 years [342]. Black locust is a pioneer species in abandoned agricultural fields [60,80,97,160,161,165,210,237,325,327] and pastures ([113,128,313], review by [72]).

Black locust is found in some later-successional communities that have an open structure and/or are maintained by fire, like the pine barren forests of Cape Cod [100] and New York [60] or the black oak savanna communities of the Indiana Dunes in northwestern Indiana [252]. See Fuels, Fire regimes, and Fire Management Considerations for more information on the interaction between black locust and fire outside its native range.

Successional role: A common concern with the establishment of black locust in its nonnative range is its ability to replace native vegetation. Developing black locust thickets may prevent other plants from establishing and could block historical successional trajectories ([269], review by [131]). Through its nitrogen-fixing abilities, black locust may alter local soil characteristics. While advantageous within its native range and on some plantations, this ability may be problematic to managers outside of its native range, particularly in areas of low soil fertility (see Impacts).

In native black oak savanna communities of the Indiana Dunes in northwestern Indiana, black locust canopies blocked sunlight, shading out black oak seedlings and saplings and native herbaceous species. At all sites, herbaceous species diversity was lower in mature (50-year-old) than in young black locust stands. Nitrate and ammonium concentrations were higher under old black locust trees than in control plots. The increased soil nitrogen produced in black locust stands facilitated the dominance of the nitrogen-responsive, nonnative cheatgrass (*Bromus tectorum*). Cheatgrass dominance was higher in mature black locust stands than in young black locust stands. The authors state that "black locust may not only slow the rate of succession but may have long-term effects on the trajectory of succession due to the increased soil nitrogen in a naturally low-nutrient soil" [252].

Black locust altered successional pathways on gravel sand pits on lowland sites in the Czech Republic; black locust stands establishing after 10 years of recovery encouraged an array of nitrophilic species at the expense of native wooded grassland species. There was no evidence of black locust stands succeeding to forests dominated by native tree species [269]. In abandoned fields reverting back to forest within the oak-pine forest region of southern Poland, black locust reduced the number of woodland and grassland species. The cover of nitrophilic and ruderal herbaceous species was positively correlated with black locust cover ($P<0.001$). One hundred ten years after black locust's introduction in Poland, there was no documentation of black locust forest succeeding to native forest [99].

Disturbance: Most of the literature describing disturbances in black locust's nonnative range discusses limitations to black locust's success in plantations. Drought caused high levels of mortality in some areas. Extreme drought like that seen in the 1930s caused 75% mortality in black locust tree plantations in the lowlands of the midwestern prairies [338]. Similarly, in the high plains region of the Oklahoma panhandle, a combination of drought and locust borer

attack killed 55.5% of black locust trees from 1930 to 1937 [42].

Black locust is impacted by inclement weather including ice, wind, and snow. Eleven planted black locust trees were examined after an ice storm in west-central Illinois for their susceptibility to breaking by ice accumulation; 55% had little injury, 9% had moderate injury, and 36% were badly broken [70]. Frost, windbreak, and snowbreak are listed as abiotic threats to planted black locust in Hungary (review by [181]). In contrast, The Nature Conservancy expressed concerns that natural disturbance such as windstorms would encourage black locust establishment to the detriment of native species in the Adirondack region of New York [37].

Outside of a plantation setting, canopy gaps resulting from tree and seedling removal of the invasive Norway maple in a New Jersey mixed-hardwood forest facilitated the establishment and proliferation of other nonnative species, including black locust [339].

One natural disturbance process that is not mentioned within its native range but is mentioned often in its nonnative range is flooding. In a literature review of plants in the Pacific coastal region, black locust is listed as flood tolerant, meaning it withstands flooding for most of one growing season. Two black locust trees survived 45 days of constant inundation at a depth of 1.5 feet (0.5 m) during the growing season [333]. Black locust is associated with flooded conditions on northeastern floodplains [236], in western Maine [12], New Jersey [116], and the Pacific coastal region [333]. The Nature Conservancy listed flooding as a natural disturbance that may encourage black locust establishment in the Adirondack region of New York [37].

FIRE EFFECTS AND MANAGEMENT

SPECIES: Robinia pseudoacacia

FIRE EFFECTS:

Immediate fire effect on plant: Black locust is often top-killed during fire [5,6,109,133,250], though it is possible for stems to survive. On the Albany Pine Bush Preserve in New York, 31- to 34-year-old black locust exhibited fire scars from a fire occurring 15 years previously [272]. Underground structures may survive and sprout, sometimes within the same growing season [5]. Thin bark and shallow roots may make young plants susceptible to mortality from fire ([216], review by [66]). Because increased germination and seedling density are observed in the years immediately following fire, it is likely that some seeds survive fire [109,146,310,346].

Postfire regeneration strategy [308]:

Tree with adventitious buds, a sprouting root crown and/or root suckers
Ground residual colonizer (on site, initial community)
Initial off-site colonizer (off site, initial community)

Fire adaptations and plant response to fire:

Fire adaptations: Black locust exhibits a number of characteristics that make it well-adapted to surviving and persisting after fire. Black locust seeds require scarification ([325], reviews by [167,181]) and bare mineral soil ([164,216], review by [314]) for successful germination, conditions that may result from fire. One author suggests that black locust and other "legume seeds are hard and not destroyed by fire, and may even be favored by fire scarification of the seeds" [310]. Even if black locust seeds are killed by fire, black locust's capacity for vegetative regeneration, which is generally more common than reproduction by seed (reviews by [26,131,314]), furthers its ability to persist on or spread to a burned site. Black locust requires open conditions for establishment ([252,297], reviews by [167,314])

and, once established, exhibits rapid juvenile growth ([24,59,126,137,202,291,361], review by [167]).

Plant response to fire: Black locust is often top-killed during fire [5,6,109,133,250], though fire stimulates black locust sprouting [35,105,109,122,146,231,265,346] from the stump [5,6,60,90,108,171,310] and/or from the roots ([90,133,310], review by [72]). Fire also contributes to lateral spread (review by [72]) and increased seed germination [109,122,310,346]. In the short term, fire generally increases local abundance [5,90,93,105,109,213,270,319,346,348], though a decline usually occurs as time since fire increases [76,109,146,346,348].

The following examples document either a short-term increase in black locust after fire or relatively high abundance in burned versus unburned plots in its native range.

In western North Carolina, a cutting and burning treatment was conducted on an 80-year-old oak-pine forest. Vegetation on three 10-acre (4 ha) sites was cut in summer and burned in September with fires of "high intensity but low severity". Temperatures on the forest floor and in mineral soil ranged from 113 to 140 °F (45-60 °C) at 1.0 to 2.0 inches (2.5-5.0 cm) below the soil surface, and peak flame temperature ranged from 1,157 to 1,477 °F (625-803 °C). Average fuel moisture ranged from 28% to 37%. Prior to treatment, black locust occurred as solitary root sprouts and was uncommon in the forest. By year 4 after treatments, black locust ranked ninth out of 18 species in woody biomass and second in basal diameter, averaging 0.9 inch (2.2 cm) [63].

Two years after a low-severity surface wildfire in a mixed-oak forest in Georgia, black locust had significantly more understory stems in burned plots (1,169.36 stems/ha) compared to unburned plots (99.46 stems/ha) ($P<0.001$) [213].

On the Cumberland Plateau of east Tennessee, black locust seedlings were detected 3 years after clearcutting in an oak-hickory forest stand; the species had not been detected prior to treatment. No sprouts were found. Four years after cutting and 1 year after a spring prescribed backing fire, black locust density was 270.4 stems/acre in burned plots and 166.8 stems/acre on unburned plots [331].

The examples below are longer-term studies documenting both a short-term increase in black locust abundance and an eventual decline after fire.

After a March prescribed fire (air temperature <81 °F (27 °C), wind speed <17 miles/hr (28 km/hr), relative humidity 25%) in oak-hickory forest clearcuts in western Virginia, black locust >1.6 feet (0.5 m) tall increased from 0.2 plants/m² prior to the fire to 3.3 plants/m² the 1st year after fire, then decreased to 1.3 plants/m² the 2nd year after fire [348].

After wildfires in a pine-oak forest in Great Smoky Mountains National Park, black locust seedlings and sprouts less than 0.2 inch (0.5 cm) DBH increased from 40 stems/ha the 1st year after fire to 167 stems/ha the 2nd, eventually decreasing to 83 stems/ha 17 to18 years after fire. Black locust canopy trees were present in very low numbers before fire (2 trees/ha), were not present the 1st year after fire, greatly increased 8 to 9 years after fire (80 trees/ha), and decreased but were still present 17 to 18 years after fire (33 trees/ha) [146].

An April prescribed fire was conducted in a mixed-hardwood forest in West Virginia. The authors described the fire as moderate in severity because it caused some mortality of overstory trees. Black locust increased from 526 seedlings/acre prior to fire to approximately 2,000 seedlings/acre 3 years after fire. However, by postfire year 5, black locust decreased to 500 seedlings/acre, just slightly below the prefire density. Black locust sprouts were not present before the fire, but there were 658 sprouts/acre 5 years after the fire [346]. See the Research Paper of Wendel and Smith's [346] study for details on the fire prescription and fire effects on black locust and 6 other tree species.

After an April "low- to moderate-intensity" prescribed fire (temperatures ranging from 151 to 1,472 °F (66-800 °C), averaging 370 °F (188 °C); flame lengths of 12 to 24 inches (30-60 cm)) in a western North Carolina mixed-hardwood forest, 58% of all canopy trees died. Prior to the fire, black locust was a minor understory species, occurring at a density of 53 stems/ha. All plants were top-killed in the fire. One year later, black locust dominated the seedling layer, becoming the third most abundant tree with an average of 15,707 stems/ha. Of black locust stems present, 52% were sprouts, while 48% were new seedling recruitment. The authors predicted that partially shaded conditions would prevent long-term black locust persistence and growth into the canopy [109].

Though the studies above demonstrate that black locust often increases greatly after fire, the following study suggests that even with a relative increase, black locust may remain a minor component of the forest. On the Daniel Boone National Forest in Kentucky, a low-severity prescribed fire was conducted in March in a shortleaf pine-mixed-oak forest. Though black locust established and increased 2 years after fire, it was still a minor component of the forest vegetation [319].

Black locust presence in the understory and groundlayer vegetation 2 years after a low-severity prescribed fire [319]				
Stratum		Prefire	Postfire year 1	Postfire year 2
Understory (<2.5 cm DBH; >1 m tall)	Density (stems/ha)	0	43.8	75.0
	Importance value*	0	0.6	1.8
Groundlayer vegetation (<1 m tall)	Cover (%/m²)	0	0	1.3
	Importance value	0	0	3.1

*Importance value calculated as relative density plus relative height.

Similarly, in a mixed-oak-hardwood forest in east-central Pennsylvania that experienced 3 "major" fires from 1954 to 2004, black locust seedlings and saplings occurred at densities similar to those of other species (62 seedlings/ha, 742 saplings/ha). Black locust seedlings and saplings occurred at a low enough density that oak regeneration was not considered at risk [298].

Fire severity may play a role in the response of black locust to fire, with high-severity fire favoring black locust regeneration. On the Nantahala National Forest of western North Carolina, strip head fires were used to burn an approximately 741-acre (300 ha) study area. On the ridge, the fire was stand-replacing, and the understory was consumed. At the low-slope position, the fire was patchy and burned only the understory [105]. Aboveground flame temperatures and heat penetration were measured using heat-sensitive painted tiles. Flame temperatures were measured 3 and 7 feet (1 and 2 m) above ground. Belowground heat penetration was measured at the forest floor and in the mineral soil [328].

Above- and belowground temperatures produced by the fire at low, mid-, and ridge positions [328]				
Slope position	Flame temperature (°C)		Average (range) soil heat penetration (mm)	
	1 m	2 m	45 °C	59 °C
Ridge	<52 to >800	<52 to >800	27.5 (9-55)	24.0 (7-55)
Midslope	<52 to 160	<52 to 90	18.2 (1-52)	16.8 (4-52)
Low slope	<52	<52	0.5 (0-3)	0.6 (0-4)

Black locust saplings were not found on the ridge 3 months after the stand-replacing fire. However, black locust sapling density increased 80-fold compared to prefire numbers 1 year after the fire. Seedling density increased both 3 and 15 months after the fire. At the midslope position, black locust decreased in the canopy and was not found in the understory 3 months after the prescribed fire. At the low-slope position, black locust density in the canopy remained the same 3 months after the fire and was not found in the understory before or after fire [105]. See the Research Project Summary of this study for additional information on the fire prescription, fire behavior, and postfire plant

responses of >40 other plant species in the southern Appalachians of North Carolina.

For information on the response of black locust to prescribed fire, see Use of prescribed fire as a control agent.

FUELS AND FIRE REGIMES:

Fuels: Outside its native range, black locust may alter fuels in 2 ways that influence fire regimes. First, black locust may increase the extent and relative density of forest compared to native plant communities. This change in structure was noted specifically in open habitats in the Northeast and mid-Atlantic states [83,273], and is likely of concern in other open habitats where black locust establishes. Second, black locust may produce a litter layer that differs from that produced by native vegetation. Natural and planted stands of 21- to 35-year-old black locust in Illinois, Indiana, and Ohio contained 10,200 dry-weight pounds of litter/acre [9]. On the Albany Pine Bush Preserve in New York, black locust stands had a 2-fold greater litterfall mass compared to native vegetation [272]. Black locust litter decomposes quickly [9,272] and is generally moist, which may differ from the litter characteristics of native vegetation [90]. One author suggests that black locust stands in pitch pine-scrub oak forests have higher live:dead fuel ratios and fuel moisture than native vegetation, slowing surface fire rate-of-spread and consequently altering fire regimes [90]. It is therefore unclear whether the quantity of litter represents an increased fuel load or the characteristics of the litter represent a decreased fuel hazard.

Fire regimes: Vegetation in the native range of black locust was historically maintained by a variety of disturbances, including fire (see Successional Status for more information on disturbances). Black locust is well adapted to disturbances such as fire (see Fire adaptations and plant response to fire), and fires in these ecosystems likely played a historical role in black locust establishment.

The current distribution of black locust includes ecosystems that historically experienced both frequent and infrequent fires of various severities. The impacts of black locust on these fire regimes is largely unknown, though there is some concern that black locust may alter fire regimes in fire-adapted ecosystems like the pitch pine-scrub oak forests in the Northeast. In these systems, black locust is less flammable than the vegetation it is replacing [83]. Some managers even consider black locust "nonflammable" [81]. In a series of laboratory trials, black locust had significantly lower combustion rates and total heat release than pitch pine ($P<0.0001$) [83]. Black locust litter lies flat on the forest floor and tends to stay relatively damp due to the closed-canopy conditions under dense stands. High live:dead fuel ratios and fuel moistures develop under these stands, which may slow surface fires [90]. These characteristics lead a number of authors to suggest that fire intensity, fire-return intervals, and fire regimes may be altered in pitch pine-scrub oak forests where black locust is established [81,83,90]. In pitch pine sites, black locust may lengthen the fire-return interval to an unsustainable level, with pitch pine eventually being shaded out along with native fire-adapted understory plants [81]. In this and other ecosystems, black locust also facilitates the establishment of nonnative grasses and other invasive species [82,90,133,252], which might further alter fire regimes.

See the Fire Regime Table for further information on fire regimes of vegetation communities in which black locust may occur in its native and nonnative ranges.

FIRE MANAGEMENT CONSIDERATIONS:

Potential for postfire establishment and spread: While fire may result in an increase in black locust in areas where black locust is already established, it may also facilitate the establishment of black locust into new areas [5,60,147,270,310]. In a study documenting vegetation change over time in Virginia pine-pitch pine forests of Great Smoky Mountains National Park, black locust established in new areas and persisted in the canopy 20 years after a "hot fire" removed 25% of the canopy tree basal area [147]. Three years after a November mixed-severity surface wildfire in a North Carolina pine-oak forest, black locust was one of many trees detected on burned forest plots that were considered "immigrants" because they were not found in unburned plots of representative community vegetation [270]. Black locust was found on burned plots in "large numbers" [271].

Fire may facilitate black locust establishment in new areas outside its native range. Because black locust establishment dates matched historical fire dates, one author suggests that black locust's northward expansion in southeastern Long Island depended on agricultural field abandonment and fire. In one location, all documented black locust trees were seedlings or stump sprouts established after an "intense" 1964 fire [60]. Similarly, at the Albany Pine Bush Preserve in

New York, prescribed fire resulted in dense stands of black locust sprouts in areas that previously had very little black locust [90]. On the Little Bluestem Prairie in west-central Indiana, black locust expanded its local range after a March prescribed fire, increasing its cover 5 times over in the area [310] (see Fire and integrated management for more information about this study).

Three black locust populations occurred within areas burned by "high-intensity", mixed-severity wildfire on the Cleveland National Forest in southern California, an area dominated by chaparral vegetation. In a Vegetation Resource Assessment, managers hypothesized that establishment of black locust in areas disturbed during fires was "highly probable", especially in areas where heavy equipment and fire crews traveled through and worked within the largest black locust populations [122].

Preventing postfire establishment and spread outside the native range of black locust: Preventing invasive plants from establishing in weed-free burned areas is the most effective and least costly management method. Prevention can be accomplished through early detection and eradication, careful monitoring and follow-up, and limiting dispersal of invasive plant seed into burned areas. Specific recommendations include:

- incorporate cost of weed prevention and management into fire rehabilitation plans
- acquire restoration funding
- include weed prevention education in fire training
- minimize soil disturbance and vegetation removal during fire suppression and rehabilitation activities
- minimize the use of retardants containing nitrogen and phosphorus
- avoid areas dominated by high priority invasive plants when locating firelines, monitoring camps, staging areas, and helibases
- clean equipment and vehicles prior to entering burned areas
- regulate or prevent human and livestock entry into burned areas until desirable site vegetation has recovered sufficiently to resist invasion by undesirable vegetation
- monitor burned areas and areas of significant disturbance or traffic from management activity
- detect weeds early and eradicate before vegetative spread and/or seed dispersal
- eradicate small patches and contain or control large infestations within or adjacent to the burned area
- reestablish vegetation on bare ground as soon as possible
- avoid use of fertilizers in postfire rehabilitation and restoration
- use only certified weed-free seed mixes when revegetation is necessary

For more detailed information on these topics see the following publications: [8,33,125,322].

Use of prescribed fire as a control agent: Attempts to control black locust using fire are generally ineffective [5,6,93,171,310]. Consequently, fire should be used with caution. One manager at the Albany Pine Bush Preserve warns that high densities of shoots may be produced after prescribed fire on sites that previously had minor amounts of black locust. Similarly, black locust may establish in a burned site through root sprouting if it is present in adjacent, unburned forest. For these reasons, it is suggested that "to effectively control locust sprouts, burning should occur on a strict return interval, during the late spring/early summer, under prescription parameters, and on a targeted unit. This intensive form of fire management however, is not feasible for the Albany Pine Bush, given the landscape context, urban interface issues, smoke management issues, strict prescription parameters, limited resources, and higher priority areas targeted for fire management". This manager emphasizes that fire should be considered an appropriate management tool in pitch pine-scrub oak systems only after a site is restored, meaning nonnative species are removed [90].

The following studies on the use of prescribed fire to control black locust on the Sand Prairie Scrub Oak Nature Preserve in central Illinois likewise support the need for caution when using fire to control black locust. Black locust was planted on the Sand Prairie Scrub Oak Nature Preserve to prevent wind erosion of dunes; it subsequently established in large areas of sand prairie and oak-hickory forest. A prescribed fire was conducted in March 1977 to control black locust and to study the responses of native species in the prairie and adjacent forest communities [5]. The fire burned 95% to 99% of the surface litter [6], with flames that were often >16 feet (5 m) tall. The fire top-killed all black locust in both the prairie and forest communities. Shortly after the fire, small black locust stems

increased significantly in the prairie, with seedling numbers more than doubling (P<0.001). Saplings were significantly reduced by about 83% in the prairie following the fire (P<0.01) but increased significantly in subsequent years (P<0.001). While data for black locust seedlings and saplings were not collected prior to fire in the forest, the authors suspected that fire generated a pattern similar to that observed for the burned prairie: an initial "wave" of reproduction followed by a growth of these stems into the sapling size class. There were many fewer black locust seedlings and saplings in the unburned forest compared to the burned forest or the prairie [5].

Density (stems/ha) of black locust seedlings and saplings before and after prescribed fire in 3 areas of the Sand Prairie Scrub Oak Nature Preserve, Illinois [5]

Sample date	Prairie		Burned forest		Unburned forest	
	Seedling	Sapling	Seedling	Sapling	Seedling	Sapling
1976-1977 (prefire)	27,062	300	no data	no data	no data	no data
September 1977	55,937	50	11,117	67	5,375	50
August-September 1978	35,376	1,000	8,083	533	4,000	100
August-September 1979	23,250	2,175	8,500	600	2,938	375

All of the black locust seedlings and saplings present after the fire were identified as sprouts from existing plants [5]. Though the majority of seedlings and saplings were blackjack oak before the fire, black locust dominated the seedling and sapling layer afterwards [6]. The results of this study led the authors to conclude that "black locust is not controlled by fire and its spread is encouraged by burning" [5].

Fire and integrated management: Fire has been used in combination with other methods in an attempt to control black locust. One weed control guide states that a combination of mowing and burning will temporarily control black locust, but mowing stimulates seed germination, while burning stimulates sprouting (review by [72]). A prairie restoration handbook states that mowing and burning are temporarily effective, but follow-up is almost always needed (review by [300]).

Black locust trees and blackberries (*Rubus* spp.) dominated a shrubby meadow in Shenandoah National Park, Virginia. Attempts to control these nonnative species using mow (late 1974), burn (April 1974), and mow-burn combination treatments were considered effective in reducing black locust cover for at least 4 months following the burn treatment. All treatments reduced black locust cover by more than two-thirds. The combination treatment was the most effective at reducing black locust cover. Results for more than 4 months after treatment were not presented [64].

The following example again highlights the need for caution in using fire to control black locust, even when integrated with other control strategies. At the Little Bluestem Prairie Nature Preserve in west-central Indiana, managers combined cutting, stump herbicide application, and prescribed fire in an attempt to control black locust, black cherry, and sassafras. All woody stems up to 6 inches (15 cm) DBH were cut to ground level twice between 1979 and 1985, and stumps were immediately hand-sprayed with picloram. Burning occurred in mid-March of 1985. The entire "invasion" area and most of the sand prairie were burned (8 acres (3 ha) total for site), with a fire temperature of approximately 446 °F (230 °C) at ground level. Vegetation was sampled in May, July, and September the years before and after fire [310]. Nearly half of the cut black locust stumps sprouted after treatment, and more than 111 new black locust seedlings or root sprouts were counted [171]. Black locust was not present in sample plots prior to treatment but was detected afterwards at a density of 2,000 stems/ha [93]. Of great concern to managers was the spread of black

locust into areas where it was not found previously. After treatment, researchers identified an area of "increased black locust reproduction" near the uninvaded sand prairie community which was described as "an advancing edge of black locust sprouting which could result from either root-sucker growth or seed germination", possibly initiated by the treatments [310].

MANAGEMENT CONSIDERATIONS

SPECIES: Robinia pseudoacacia

IMPORTANCE TO WILDLIFE AND LIVESTOCK:
Though often considered poisonous to livestock, black locust is grown in some areas specifically as livestock forage. Black locust provides food and structural habitat for a variety of wildlife species.

Palatability and/or nutritional value: Numerous accounts describe parts of the black locust as poisonous to livestock including mules (review by [69]), horses ([136,313], review by [69]), cattle [136,303,313], and domestic sheep ([313], review by [69]) due to the presence of the poison robotin [136]. Poisonous plant parts include the roots [303], young shoots ([136,303,313], review by [98]), seeds [85,153,190,258,313], twigs [113], leaves [85,153,258], and bark ([85,113,136,153,258,313], review by [98]). In some cases, poisoning may be fatal to livestock ([136,153], review by [69]), though one author asserts that fatality from poisoning is rare [313]. In livestock, symptoms of black locust poisoning may include reduced hearing, stupor, vomiting, and purging (review by [98]).

Despite the potential for black locust poisoning and its classification in one guidebook as worthless to poor forage for livestock (review by [69]), black locust is used as livestock feed in parts of its introduced range. It is grown to feed domestic goats in northern Pakistan [10], domestic sheep and goats in New Zealand [193,249], and general livestock in Bulgaria and Korea (review by [181]). In Mendocino County, California, chickens were observed eating black locust seeds, and horses ate the leaves sparingly [57]. In North Carolina, domestic goats and cattle defoliated black locust shoots in an abandoned orchard. The level of browsing was substantial enough to kill all black locust after 4 years of browsing [206].

Black locust is a food item for many wildlife species. White-tailed deer heavily browse black locust in North Carolina, [79], Georgia [141], and Arkansas (review by [69]), though one study found a lack of white-tailed deer herbivory on black locust in Maryland and West Virginia [139]. Mule deer browse black locust in Washington [50], California ([199], review by [132]), and New Mexico (review by [191]). Rabbits browse on stems ([188], review by [263]). Ruffed grouse eat black locust leaves [348]. Squirrels ([313], reviews by [69,312]), doves [320], California quail (review by [132]), northern bobwhite ([110,138,170,275], review by [312]), chukar (review by [132]), pheasants ([303], review by [312]), ruffed grouse [348], and other game birds ([303], review by [312]) eat black locust seeds.

Invertebrate species also consume black locust. Freshly fallen black locust leaves were palatable to millipedes in laboratory studies [207]. Black locust was a host to the Lepidopteran species the silver-spotted skipper and the three-staff underwing in the southeastern United States [320], and it is widely visited by bees for its nectar throughout its native and nonnative ranges ([313], review by [167]).

Nutritional content: Black locust seeds are high in crude protein ([253,258], review by [312]), phosphorus ([253], review by [312]), and crude fats and low in calcium (review by [312]). Black locust leaves had the highest nitrogen content of any tree tested in a North Carolina mixed-oak-hardwood forest [75]. Five- to 10-year-old black locust in a western North Carolina mixed-oak and cove hardwood forest had significantly higher leaf nitrogen than the other 7 dominant species tested (P=0.0001). Along with yellow-poplar, black locust also had higher leaf potassium and

phosphorus compared to other species (*P*=0.0001) [103].

Humans: Black locust is poisonous to humans [85,153,313]. In some cases, poisoning may be fatal [153]. Symptoms of black locust poisoning include dilated pupils, feeble pulse, severe vomiting, and a death-like pallor [136]. Humans may get dermatitis from exposure to black locust wood [3].

Some people eat fried or cooked black locust flowers [303,313]. Tea can be made from the flowers [313].

Cover value: Black locust is an important cover species for wildlife (review by [167]), providing nesting, roosting, and thermal cover. The persistent nature of black locust stems after plant death makes it an important resource for cavity-dependent wildlife species [248]. A disproportionate number of snags were identified as black locust in a Maryland old-growth forest remnant [88], a 24- to 64-year-old yellow-poplar-red maple stands in southeast Ohio [92], and second- and old-growth mixed-hardwood forests in eastern Kentucky [220]. Compared to surrounding forest, a disproportionate number of cavities were found in black locust trees in mixed-hardwood [177] and oak-hickory [48] forests in West Virginia.

Black locust cavities are used for nesting and roosting by bats and birds. Black locust cavities were used as maternity roosts for long-eared bats in West Virginia [228,248] and the endangered Indiana bat in the Champlain Valley [336], and as day roosts for male northern bats in West Virginia [115]. In its native range, black locust provides nesting cavities for birds such as the hairy woodpecker [65], downy woodpecker [65], northern flicker [65,219] and red-bellied woodpecker [219]. In Kentucky, eastern screech-owls roosted in black locust cavities in the winter [96].

Black locust cover is also important to birds. Black locust was positively associated with red-eyed vireo habitat in southwestern Virginia [163] and rufous-sided towhee habitat in Maryland [119]. In a mixture of small deciduous woodlots and thickets interspersed with old fields in Kentucky, adult and juvenile eastern screech-owls used black locust stands for roosting in the postfledging period [18].

Outside of the native range of black locust, birds that nest in black locust foliage include the black-billed magpie, western kingbird, Baltimore oriole [28], and Swainson's hawk in eastern Washington [14,28], the long-eared owl [212] and loggerhead shrike in Idaho [358], and the dickcissel in central Oklahoma [247]. Near Cape Cod, Massachusetts, black locust stands provided suitable cover for northern bobwhite and American woodcock [275]. In south-central Kansas, 62 breeding bird species were detected in shelterbelts containing black locust [287], and black locust was highly recommended for planting as wildlife habitat in the Northern Great Plains region (review by [148]).

Black locust occurring in small (0.52 acre (0.21 ha)) to large (8.92 acre (3.61 ha)) patches in the Palouse prairie region of eastern Washington and northern Idaho provided winter thermal, loafing, and hiding cover for 7 mammal species (moose, white-tail deer, coyote, North American porcupine, striped skunk, house cat, and mountain cottontail), 23 avian species (including gray partridge, ring-necked pheasant, red-tailed hawk, rough-legged hawk, great-horned owl, and short-eared owl), and 1 reptile (garter snake) [32].

OTHER USES:
The wood of black locust is heavy, strong, and durable [85,113,156,165,311] and shrinks little upon drying [303]. Its strength is due to high lignin content [142]. Consequently, the wood of black locust is valuable for a variety of uses, such as fenceposts [3,31,97,113,165,311,313,344], railroad ties ([165,313], review by [167]), insulator pins ([3], review by [167]), mine timbers ([3], review by [167]), shipbuilding ([3,311], review by [167]), furniture [3], handles [165], barrel staves (review by [145]), boxes and crates, pulp, and fuelwood (review by [167]).

Black locust has been widely planted for windbreaks and shelterbelts ([97,277], review by [167]), as woody biomass for energy production [23], and as a street or ornamental tree ([97], reviews by [145,167]). It has also been widely planted for honey production ([344], reviews by [145,167,181]). One author claims that black locust plantations provide the basis for Hungary's commercial honey industry (review by [181]).

The nitrogen-fixing abilities of black locust have prompted its planting in nurseries and plantations to assist the growth of other desired trees ([59], review by [167]). Black walnut [286], southern catalpa (*Catalpa bignoides*) [114], and

hardwoods in Indiana [49] have shown improved growth when planted with black locust. In Canada, black walnuts interplanted with black locust had higher foliar nitrogen content than those not planted with black locust [326]. However, the wide-spreading crown and prolific root sprouts of black locust may suppress or kill slow-developing interplanted tree seedlings in some plantation settings [256].

Black locust was once a favored tree for restoration or rehabilitation because its extensive root system holds and stabilizes the soil surface, it sprouts vigorously and prolifically, it increases soil fertility through nitrogen fixation [180], and it forms a leaf litter that protects the soil [9,180,291]. Its main use has been in the rehabilitation of former surface mine sites ([3,16,51,113,159,238,267], reviews by [167,204]) and for erosion control ([31,97,121,176,313], review by [157]), but it is also used to rehabilitate contaminated soils [52,267], depleted soils [27], gravel pits [113], and logged areas [267] and to stabilize railroad embankments (review by [145]) and highway edges (review by [302]).

In both its native and nonnative range in North America, mortality is caused by insects and disease ([117,281,303], review by [167]). Black locust is highly susceptible to witches' broom disease caused by the virus *Chlorogenus robiniae* (review by [167]), as well as fungal diseases leading to heart rot ([117], review by [167]). In South Carolina hardwood stands, 13.5 % of poletimber-sized and 30.4 % of sawtimber-sized black locust had hardwood cankers [4]. In the Great Plains, black locust was susceptible to stem decay fungi; about 25% of the 40-year-old windbreak black locust planted in Oklahoma was infected with stem decay fungi (review by [274]).

In the United States and Canada, the most serious insect threat to black locust is the locust borer ([113], reviews by [26,167]). This species is often the cause of rapid population declines in plantation settings in black locust's native [27,121,281] and nonnative ranges ([36], review by [86]), and a major reason that planting black locust has fallen out of favor in the United States [121]. An Element Stewardship Abstract for black locust suggests that rapidly growing trees more than 10 years old are not usually attacked by locust borer (review by [66]). However, another author states that locust borers require the furrowed bark of older trees for egg laying. Consequently, young trees with smooth bark are not impacted [365]. On mined sites in Illinois, planted black locust declines attributed to the locust borer were seen within 15 years of planting, and after 60 years, all black locust were dead [281]. In a dense, early-successional black locust stand in western North Carolina, 21% of the black locust stems were standing dead, and 18% had greater than 50% crown dieback, primarily from damage by the locust borer [234]. Locust borer infestations not only cause mortality, but may inhibit growth ([121], review by [167]) and reproduction [59]. Locust borer infestations may be higher when trees are stressed due to poor soils ([27], review by [167]) or dense stand conditions [234].

Other potential insect pests in the native range of black locust include locust leaf miners ([117,365], review by [167]) and the locust twig borer (review by [167]). Outside of its native range in the Northern Great Plains, black locust is susceptible to the carpenterworm and ash and honey-locust plant bugs (review by [86]). Roots of the black locust are parasitized by root-knot and root-lesion nematodes in nurseries in the Northern Great Plains ([284], review by [274]).

A lack of mortality-inducing insects or diseases outside of North America is one reason black locust plantations remain popular throughout the world. In 1980, there were approximately 2.5 million acres (1 million ha) of planted black locust across the globe (review by [181]).

IMPACTS AND CONTROL:

Impacts: Numerous references suggest that black locust stands may replace existing native vegetation. Native species exclusion has been documented in the Northeast ([37,81,90,210,272,273,327], reviews by [226,337]), mid-Atlantic states [200,273], Midwest ([5,58,133,144,252], reviews by [72,283]), California ([295], reviews by [26,290]), and parts of Europe ([99,162], reviews by [283,340]). Black locust populations are often dense, clonal, closed-canopy stands that block sunlight to the understory [252], and black locust stands differ in structure from native plant communities [272]. Black locust also alters local soil characteristics ([210,252,269,272], review by [226]). It changes the dynamics of nitrogen cycling through its capacity to fix nitrogen and the high levels of nitrogen in its leaf litter. Cycling of other nutrients such as calcium and phosphorus is similarly altered. Even after black locust trees are physically removed, soils continue to exhibit altered qualities like higher nitrogen availability [272]. Black locust is also suspected of allelopathy, which may inhibit the growth of other plants (review by [72]).

One of the systems most impacted by black locust establishment is the globally rare pitch pine-scrub oak forest type,

like that found at the Albany Pine Bush Preserve in New York. This fire-adapted ecosystem contains many rare plant and animal species that are adapted to low-nutrient, high-light environments. Black locust populations expanded into this area from adjacent agricultural lands or established on disturbed sites such as sand pits, roads, and fire breaks. The authors of one study state that "high rates of nitrogen availability ... may alter plant community interactions and affect successional trajectories" in pitch pine-scrub oak forests [272]. Black locust may also alter the fire regime in pitch pine-scrub oak forests (see Fire regimes). Though black locust establishment may reduce fire danger in the wildland-urban interface, black locust also reduces overall plant diversity [81] and alters habitat of the federally endangered Karner blue butterfly [81,90]. Other authors note the negative impact black locust may have on pitch pine-scrub oak forests ([210], review by [337]).

Other oak-dominated forests are considered vulnerable to black locust establishment. In native black oak savanna communities of the Indiana Dunes, a dense black locust canopy blocked sunlight, leading to the death of black oak seedlings and saplings and native herbaceous species. At all sampled sites, herbaceous species diversity was lowest in mature (50-year-old) stands of black locust and highest in the young stands [252]. Other oak woodlands at risk include restored oak savanna and woodland sites in Minnesota (Kruger personal communication cited in a review [283]), hickory and oak woodlands at the Sand Prairie Scrub Oak Nature Preserve in Illinois [5], sessile oak (*Q. petraea*) forests of the Pannonic Plain in the former Yugoslavia [162], and pine-oak forests in southern Poland [99]. Black locust replaced entire valleys of European chestnut (*Castanea vesca*) forest in northern Italy and Switzerland (Cherubini personal communication cited in a review by [283]).

Treeless habitats at risk of black locust invasion include prairies ([93,144,289,310], reviews by [66,300,340]), sand dunes [133], and meadows ([218,269], review by [337]). Black locust establishment is also problematic in wetland and riparian habitats ([58,200], reviews by [290,307]).

In some situations, black locust facilitates the spread of other nonnative species, largely through its ability to change local soil dynamics [90,210]. Increased soil nitrogen produced by black locust facilitated the dominance of the nitrogen-responsive cheatgrass, a nonnative species of concern in native black oak savanna communities of the Indiana Dunes [252]. Kentucky bluegrass was able to establish only under black locust cover on sand dunes in central Illinois [133]. Elevated nitrogen levels in black locust stands hampered restoration efforts in pitch pine-scrub oak forests in New York. Though black locust was removed from the area, the elevated nitrogen levels in some cases facilitated the dominance of nonnative weedy species and native perennial grasses at the expense of desired native forbs. Net nitrification rates were approximately 30 to 150 times higher in black locust compared to native oak-pine stands [210]. At the Albany Pine Bush Preserve, nonnative species such as Tatarian honeysuckle (*L. tatarica*), raspberry (*Rubus* spp.), common barberry (*Berberis vulgaris*), and garlic mustard (*Alliaria petiolata*) are associated with black locust clones [90]. The establishment of problematic nitrophilic and ruderal species in black locust stands has also been documented in Europe [99,269].

There is concern in New England that black locust's abundant nectar may attract pollinators away from native species (review by [226]).

Managers in some areas do not consider black locust a serious problem. In 1993 most survey respondents did not consider black locust to be a problem species in Canada, and black locust was characterized as "a limited invasive of a local nature that is stable" (review by [349]). At the Lincoln Boyhood National Memorial in south-central Indiana, an area once dominated by oak-hickory forest, black locust was found at low densities at abandoned homesites and in the overstories and understories of bottomland successional forests and mixed-hardwood forests. It was not listed as an introduced species needing management at the site in 1989 [251].

Rate of spread: Black locust may quickly establish dense stands in abandoned fields or other open habitats. In abandoned old fields in Lancaster County, Pennsylvania, scattered black locust plants developed into stands 35 to 40 feet (10-15 m) wide, with some trees more than 35 feet (10 m) tall, within 7 years [179]. At the Albany Pine Bush Preserve in New York, black locust populations expanding from firebreaks, disturbed areas, and former agricultural lands created a closed-canopy forest within 20 years [210]. Reforestation of abandoned agricultural fields by black locust, sassafras, and yellow-poplar in Great Smoky Mountains National Park occurred in approximately 5 years [187]. In a mixture of American beech-maple forests and abandoned agricultural fields in Monroe County, New York, black

locust was detected in 7% of sampled stands in 1938 and 23% of those same stands in 1999 [166]. An area regenerating after horticultural activities were abandoned in New York developed into a black locust-black cherry forest in 20 to 40 years, with 240 black locust stems/ha in the 8- to 12-inch (20-30 cm) size class and 80 stems/ha in the 12- to 16-inch (30-40 cm) size class [260]. Ten to 15 years after grazing ceased, black locust from neighboring plantations established in a 65-foot (20 m) wide strip in a "sandy-steppe meadow" in Hungary [218].

Control: In all cases where invasive species are targeted for control, the potential for other invasive species to fill their void must be considered, no matter what method is employed [34]. Information presented in the following sections may not be comprehensive and is not intended to be prescriptive in nature. It is intended to help managers understand the ecology and control of black locust in the context of fire management. For more detailed information on control of black locust, consult the references cited here or local extension services.

Control of black locust is difficult and no technique has been identified as entirely effective ([37], review by [66]). Sprouting is a common treatment response ([230,310], reviews by [26,72,283,300]), so follow-up treatment is often needed (review by [300]).

Prevention: It is commonly argued that the most cost-efficient and effective method of managing invasive species is to prevent their establishment and spread by maintaining "healthy" natural communities [208,293] (e.g., avoid road building in wildlands [321]) and by monitoring several times each year [175]. Managing to maintain the integrity of the native plant community and mitigate the factors enhancing ecosystem invasibility is likely to be more effective than managing solely to control the invader [158].

Weed prevention and control can be incorporated into many types of management plans, including those for logging and site preparation, grazing allotments, recreation management, research projects, road building and maintenance, and fire management [322]. See the Guide to noxious weed prevention practices [322] for specific guidelines in preventing the spread of weed seeds and propagules under different management conditions.

Fire: For information on the use of prescribed fire to control black locust, see Fire Management Considerations.

Cultural: Though cultural methods to control black locust have not been specifically tested, interactions with other plants, particularly in early-successional communities, may limit black locust establishment or growth. One review states that grasses may prevent black locust seedling establishment, though they may not prevent sprouting [26]. On experimental plots on mine spoils in Tennessee, black locust biomass was significantly lower on plots that had seeds from the local seed bank plus a "reclamation mix" (sericea lespedeza (*Lespedeza cuneata*), tall fescue (*Festuca arundinacea*), weeping lovegrass (*E. curvula*), and Italian ryegrass (*Lolium multiflorum*)) compared to plots that had only the native seed bank (P=0.05) [330]. One year after a mixed-oak-yellow-poplar forest in North Carolina was clearcut, black locust had significantly greater aboveground biomass in areas where the herbaceous-shrub layer was removed compared to untreated plots (P<0.05). The plant that most limited black locust growth was blackberry (*Rubus* sp.) [354].

Physical and/or mechanical: Because mechanical damage results in prolific root suckering ([365], reviews by [26,72,283]) and clonal spread (review by [72]), cutting or girdling stems does not generally control black locust. A coppicing study in eastern Kentucky demonstrates the potential risk of using mechanical treatments alone to control black locust. Black locust was directly seeded onto abandoned mine spoils, and a subset of the established seedlings were coppiced after 5 years. Coppice sprouts developed on stumps within weeks of treatment, with an average of 103,763 stems/ha developing 2 months after treatment. Sprout numbers in treated stands eventually declined to 35,000 stems/ha after the 1st growing season and 14,000 stems/ha after the 3rd growing season. The mean number of basal sprouts from 6-year-old stumps (1 year after treatment) was 8.93 sprouts/stump. The growth rate of the treated stands was nearly twice that of the untreated stands, with a mean shoot height of 8.5 feet (2.6 m) the year after coppicing. Treated stands reached a mature stage (defined by the onset of flowering) in half the time required by untreated stands. Also, 2-year-old coppiced sprouts had a higher leaf area index (6.1 versus 2.5) than uncoppiced sprouts [365].

Cutting treatments repeated for several years may be effective (reviews by [26,131]). Mowing may not be successful

in killing seedlings or sprouts (review by [26]), and may promote seed germination by scarifying the coats of previously dropped seeds (review by [283]). One weed control guide from the Upper Midwest suggests that annual mowing may control first-year seedlings and prevent black locust spread into prairies (review by [72]).

Removal of entire trees and clones is a time- and work-intensive method of controlling black locust, though it has been attempted [90,210]. At the Albany Pine Bush Preserve in New York, black locust stands were controlled by cutting the trees, removing the stumps with a bulldozer, raking roots with a tractor, and reseeding with a mixture of native grasses and forbs [210]. Management guides suggest that surface bulldozing may be an appropriate control option on highly disturbed sites (reviews by [72,283]).

Combining physical and mechanical techniques with other control methods is usually a more effective option than these treatments alone. See Integrated Management for more information.

Biological: Biological control of invasive species has a long history that indicates many factors must be considered before using biological controls. Refer to these sources: [324,355] and the Weed control methods handbook [318] for background information and important considerations for developing and implementing biological control programs.

In North America, black locust is susceptible to a number of insects, particularly the locust borer, though black locust plantations outside of North America lack damaging insects or diseases [181] (see Other uses). As of 2000, there were no biological programs in place to control black locust (review by [26]).

Livestock has been used infrequently to control black locust populations. In North Carolina, cattle and domestic goats were used to control woody vegetation establishing within an abandoned orchard. Both cattle alone and combining cattle with domestic goats effectively controlled the height growth of black locust through repeated defoliation. After 4 seasons, all black locust were dead where both cattle and domestic goats had browsed, and 75% were dead in the cattle-only pasture [206].

Chemical: Herbicides are effective in gaining initial control of a new invasion or a severe infestation, but they are rarely a complete or long-term solution to weed management [44]. Herbicides are more effective on large infestations when incorporated into long-term management plans that include replacement of weeds with desirable species, careful land use management, and prevention of new infestations. Control with herbicides is temporary, as it does not change conditions that allow infestations to occur [362]. See the Weed control methods handbook for considerations on the use of herbicides in natural areas and detailed information on specific chemicals.

Chemical control of black locust populations has shown variable success. Black locust control was successful using applications of glyphosate ([345], reviews by [26,300]), triclopyr ([230], reviews by [26,300]), picloram [240,363], and an atrazine-simazine mixture [351]. In greenhouse experiments, 1- to 2-year-old black locust seedlings were susceptible to growth retardation after the injection of 2 chemical growth regulators [89]. However, sprouting is a potential response to chemical application ([230], reviews by [26,300]). One weed control guide stresses that all stems in a clone must be treated for the application to be successful (review by [72]).

In general, a combination of chemical application with other control techniques may be more effective than chemical application alone (see Integrated Management).

Integrated management: Managers have tried a few integrated management techniques to control black locust. The combination of cutting black locust stems and applying chemicals to the stump to prevent sprouting is widely suggested ([227,310], reviews by [26,66,72,131,300,337]). One weed control guide suggests that cut-stump treatment with glyphosate works best when glyphosate is applied in late summer, early fall, or during the dormant season when temperatures are above freezing (review by [72]). The Weed control methods handbook suggests that a combination of girdling with herbicide application may also be effective [318]. In Wisconsin, The Nature Conservancy attempted to control black locust by cutting stems with brush cutters, dozing pieces into piles for burning, dozing to remove stumps, and treating the remaining stumps with glyphosate. This integrated management approach achieved 95% control (Liegel and others unpublished 1983, 1984 studies cited in a review by [66]).

For information on the integration of fire with other control techniques, see Fire and integrated management.

APPENDIX: FIRE REGIME TABLE

SPECIES: Robinia pseudoacacia

These Fire Regime Tables summarize characteristics of fire regimes for vegetation communities in which black locust may occur within its native and nonnative ranges based on descriptions in available literature. Follow the links in the tables to documents that provide more detailed information on these fire regimes. These tables do not include plant communities across the entire distributional range of black locust. For information on other plant communities in which black locust may occur, see the complete FEIS Fire Regime Table.

Native range
Nonnative range

Fire regime information on vegetation communities in which black locust may occur within its **native range**. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [195], which were developed by local experts using available literature, local data, and/or expert opinion. This table summarizes fire regime characteristics for each plant community listed. The PDF file linked from each plant community name describes the model and synthesizes the knowledge available on vegetation composition, structure, and dynamics in that community. Cells are blank where information is not available in the Rapid Assessment Vegetation Model.

Northeast | South-central US | Southern Appalachians

Northeast

- Northeast Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northeast Forested					
Northern hardwoods (Northeast)	Replacement	39%	≥1,000		
	Mixed	61%	650		
Appalachian oak forest (dry-mesic)	Replacement	2%	625	500	≥1,000
	Mixed	6%	250	200	500
	Surface or low	92%	15	7	26

South-central US

- South-central US Woodland
- South-central US Forested

Vegetation Community		Fire regime characteristics			
				Minimum	Maximum

(Potential Natural Vegetation Group)	Fire severity*	Percent of fires	Mean interval (years)	interval (years)	interval (years)
South-central US Woodland					
Interior Highlands dry oak/bluestem woodland and glade	Replacement	16%	25	10	100
	Mixed	4%	100	10	
	Surface or low	80%	5	2	7
South-central US Forested					
Interior Highlands dry-mesic forest and woodland	Replacement	7%	250	50	300
	Mixed	18%	90	20	150
	Surface or low	75%	22	5	35
Gulf Coastal Plain pine flatwoods	Replacement	2%	190		
	Mixed	3%	170		
	Surface or low	95%	5		
West Gulf Coastal plain pine (uplands and flatwoods)	Replacement	4%	100	50	200
	Mixed	4%	100	50	
	Surface or low	93%	4	4	10
West Gulf Coastal Plain pine-hardwood woodland or forest upland	Replacement	3%	100	20	200
	Mixed	3%	100	25	
	Surface or low	94%	3	3	5

Southern Appalachians

- Southern Appalachians Woodland
- Southern Appalachians Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Southern Appalachians Woodland					
Appalachian shortleaf pine	Replacement	4%	125		
	Mixed	4%	155		
	Surface or low	92%	6		
Table Mountain-pitch pine	Replacement	5%	100		
	Mixed	3%	160		
	Surface or low	92%	5		
	Replacement	23%	119		

Oak-ash woodland	Mixed	28%	95		
	Surface or low	49%	55		
Southern Appalachians Forested					
Bottomland hardwood forest	Replacement	25%	435	200	≥1,000
	Mixed	24%	455	150	500
	Surface or low	51%	210	50	250
Mixed mesophytic hardwood	Replacement	11%	665		
	Mixed	10%	715		
	Surface or low	79%	90		
Appalachian oak-hickory-pine	Replacement	3%	180	30	500
	Mixed	8%	65	15	150
	Surface or low	89%	6	3	10
Eastern hemlock-eastern white pine-hardwood	Replacement	17%	≥1,000	500	>1,000
	Surface or low	83%	210	100	>1,000
Oak (eastern dry-xeric)	Replacement	6%	128	50	100
	Mixed	16%	50	20	30
	Surface or low	78%	10	1	10
Appalachian Virginia pine	Replacement	20%	110	25	125
	Mixed	15%	145		
	Surface or low	64%	35	10	40
Appalachian oak forest (dry-mesic)	Replacement	6%	220		
	Mixed	15%	90		
	Surface or low	79%	17		

*Fire Severities—
Replacement: Any fire that causes greater than 75% top removal of a vegetation-fuel type, resulting in general replacement of existing vegetation; may or may not cause a lethal effect on the plants.
Mixed: Any fire burning more than 5% of an area that does not qualify as a replacement, surface, or low-severity fire; includes mosaic and other fires that are intermediate in effects.
Surface or low: Any fire that causes less than 25% upper layer replacement and/or removal in a vegetation-fuel class but burns 5% or more of the area [135,194].

Fire regime information on vegetation communities in which black locust may occur in its **nonnative range**. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [195], which were developed by local experts using available literature, local data, and/or expert opinion. This table summarizes fire regime characteristics for each plant community listed. The PDF file linked from each plant community name describes the model and synthesizes the knowledge available on vegetation composition, structure, and dynamics in that community. Cells are blank where information is not available in the Rapid Assessment Vegetation Model.

Pacific Northwest	California	Southwest	Northern Great Plains
Great Lakes	Northeast	Southeast	Southern Appalachians

Pacific Northwest

- Northwest Shrubland
- Northwest Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northwest Shrubland					
Salt desert shrub	Replacement	50%	>1,000	500	>1,000
	Mixed	50%	>1,000	500	>1,000
Wyoming big sagebrush semidesert	Replacement	86%	200	30	200
	Mixed	9%	>1,000	20	
	Surface or low	5%	>1,000	20	
Wyoming sagebrush steppe	Replacement	89%	92	30	120
	Mixed	11%	714	120	
Low sagebrush	Replacement	41%	180		
	Mixed	59%	125		
Northwest Forested					
Mixed conifer (eastside mesic)	Replacement	35%	200		
	Mixed	47%	150		
	Surface or low	18%	400		

California

- California Shrubland
- California Woodland
- California Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
California Shrubland					
Coastal sage scrub	Replacement	100%	50	20	150
Coastal sage scrub-coastal prairie	Replacement	8%	40	8	900
	Mixed	31%	10	1	900
	Surface or low	62%	5	1	6

Chaparral	Replacement	100%	50	30	125
California Woodland					
California oak woodlands	Replacement	8%	120		
	Mixed	2%	500		
	Surface or low	91%	10		
California Forested					
California mixed evergreen	Replacement	10%	140	65	700
	Mixed	58%	25	10	33
	Surface or low	32%	45	7	

Southwest

- Southwest Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Southwest Forested					
Riparian deciduous woodland	Replacement	50%	110	15	200
	Mixed	20%	275	25	
	Surface or low	30%	180	10	

Northern Great Plains

- Northern Plains Grassland

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northern Plains Grassland					
Nebraska Sandhills prairie	Replacement	58%	11	2	20
	Mixed	32%	20		
	Surface or low	10%	67		
Central tallgrass prairie	Replacement	75%	5	3	5
	Mixed	11%	34	1	100
	Surface or low	13%	28	1	50
Southern tallgrass prairie	Replacement	96%	4	1	10

(East)	Mixed	1%	277		
	Surface or low	3%	135		

Great Lakes

- Great Lakes Woodland
- Great Lakes Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Great Lakes Woodland					
Northern oak savanna	Replacement	4%	110	50	500
	Mixed	9%	50	15	150
	Surface or low	87%	5	1	20
Great Lakes Forested					
Northern hardwood maple-beech-eastern hemlock	Replacement	60%	>1,000		
	Mixed	40%	>1,000		
Great Lakes pine forest, jack pine	Replacement	67%	50		
	Mixed	23%	143		
	Surface or low	10%	333		
Oak-hickory	Replacement	13%	66	1	
	Mixed	11%	77	5	
	Surface or low	76%	11	2	25

Northeast

- Northeast Woodland
- Northeast Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northeast Woodland					
Pine barrens	Replacement	10%	78		
	Mixed	25%	32		
	Surface or low	65%	12		
Oak-pine (eastern dry-	Replacement	4%	185		
	Mixed	7%	110		

xeric)					
	Surface or low	90%	8		
Northeast Forested					
Northern hardwoods (Northeast)	Replacement	39%	≥1,000		
	Mixed	61%	650		
Northern hardwoods-eastern hemlock	Replacement	50%	≥1,000		
	Surface or low	50%	≥1,000		
Beech-maple	Replacement	100%	>1,000		

Southern Appalachians

- Southern Appalachians Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Southern Appalachians Forested					
Bottomland hardwood forest	Replacement	25%	435	200	≥1,000
	Mixed	24%	455	150	500
	Surface or low	51%	210	50	250
Appalachian oak-hickory-pine	Replacement	3%	180	30	500
	Mixed	8%	65	15	150
	Surface or low	89%	6	3	10
Appalachian oak forest (dry-mesic)	Replacement	6%	220		
	Mixed	15%	90		
	Surface or low	79%	17		

Southeast

- Southeast Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Southeast Forested					
Loess bluff and plain forest	Replacement	7%	476		
	Mixed	9%	385		

	Surface or low	85%	39		
Southern floodplain	Replacement	7%	900		
	Surface or low	93%	63		

*Fire Severities—
Replacement: Any fire that causes greater than 75% top removal of a vegetation-fuel type, resulting in general replacement of existing vegetation; may or may not cause a lethal effect on the plants.
Mixed: Any fire burning more than 5% of an area that does not qualify as a replacement, surface, or low-severity fire; includes mosaic and other fires that are intermediate in effects.
Surface or low: Any fire that causes less than 25% upper layer replacement and/or removal in a vegetation-fuel class but burns 5% or more of the area [135,194].

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