Melia azedarach

INTRODUCTORY

Photo by Chuck Bargeron, University of Georgia, Bugwood.org

AUTHORSHIP AND CITATION:
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FEIS ABBREVIATION:
MELAZE

NRCS PLANT CODE [128]:
MEAZ

COMMON NAMES:
chinaberry
China-berry
China berry
Chinaberrytree
pride-of-India
umbrella-tree
white cedar

TAXONOMY:
The scientific name of chinaberry is *Melia azedarach* L. (Meliaceae) [69]. Two chinaberry cultivars occur in North America: 'Umbraculiformis' ([55,130], review by [33]), and 'Jade Snowflake' (review by [33]).

SYNONYMS:
None

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: Melia azedarach

GENERAL DISTRIBUTION:
Chinaberry is a nonnative tree in North America. It occurs throughout the southern United States north to Virginia and west to central California [20,128]. It also occurs in Utah, Oklahoma, Missouri and New York [28,135]. It has been recommended for highway planting in Nevada [115] and may occur there. It also occurs in Hawaii and Puerto Rico [128]. In southern forests, its estimated cover is greatest in Georgia, Alabama, Mississippi, and eastern Texas [90]. Plants Database provides a map of chinaberry's distribution within the United States.

Because chinaberry has been extensively cultivated around the world, its native distribution is uncertain [144]. Chinaberry is considered native to southeastern Asia, specifically central and western China, northern India (review by [33]), the Himalayan region ([31], review by [78]), Burma, and Malaysia [79]. It is also native to tropical Australia [79]. In addition to North America, chinaberry occurs as a nonnative in Mexico, Argentina (reviews by [10,94]), and other warm-temperature parts of the world [144].

Chinaberry has been cultivated and planted in many parts of the world since the 16th century. In North America, it was initially introduced in 1830 to South Carolina and Georgia as an ornamental (review by [61]). Chinaberry readily escapes cultivation [22,35,130,137,146] and spreads to disturbed sites and wildlands.

HABITAT TYPES AND PLANT COMMUNITIES:

Chinaberry often occurs around human habitation or on sites associated with anthropogenic disturbance (see Site characteristics). Where it escapes to wildlands, it occurs in coniferous, deciduous, and mixed riparian/floodplain forests [14,17,26,31,38,39,44,67,86,99,100,141], swamps [67,108], thickets ([31,47], review by [88]), upland forests [53,74,129,140], open woodlands [1,31,39,47], and forest margins ([31,45,47], review by [88]). Information on specific habitat types and plant communities associated with chinaberry is lacking; however, a sufficient amount of incidental information is available to provide a broad description of its common associates in North America.

Southeastern United States: Chinaberry occurs with a variety of overstory species including longleaf pine (*Pinus palustris*) [74,129], loblolly pine (*P. taeda*) [12,27,48,86,95], hickory (*Carya* spp.) [27,44,86], sweetgum (*Liquidambar styraciflua*) [12,44,48,86,95,113], southern red oak (*Quercus falcata*) [44,113], water oak (*Q. nigra*) [44,48,113], and live oak (*Q. virginiana*) [98,113]. In Florida, it has occasionally been collected in oak hammocks and pine flatwoods [1,113,145] and may establish in wet grasslands in areas where fire has been excluded (review by [118]). In one study, chinaberry occurred in abandoned agricultural fields infested with kudzu (*Pueraria montana* var. *lobata*) [58].

South-central and Southwestern United States: In riparian and floodplain forests, chinaberry occurs with live oak, pecan (*Carya illinoensis*), netleaf hackberry (*Celtis reticulata*) [141], eastern swampprivet (*Forestiera acuminata*) [100], and sugarberry (*Celtis laevigata*) [17]. In New Mexico, chinaberry occurred in a cottonwood-(*Populus* spp.) dominated floodplain forest [14]. In Texas, chinaberry occurred in an upland pine-oak forest (*Pinus* spp.-*Quercus* spp.) dominated by shortleaf pine (*P. echinata*) [140], an oak-sweetgum upland forest that had been logged [53], and upland grasslands (Randall and Rice unpublished cited by [10]). In one instance, chinaberry formed impenetrable patches of vegetation in combination with pokeweed (*Phytolacca* sp.) and boneset (*Eupatorium* sp.) on an island off the coast of Texas [121].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Melia azedarach

Photo by James H. Miller, USDA Forest Service, Bugwood.org

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., [31,60,105,132,146]).

Aboveground: In North America, chinaberry is a deciduous tree (reviews by [26,78]) that typically has a single trunk [124] and a rounded crown ([39,135], reviews by [33,78]). In Australia, chinaberry is semi-evergreen [103]. In North America, chinaberry typically grows from 32 feet (9.8 m) [60,104] to about 50 feet (15 m) tall [31,36,39,104,130,135], with about a 20-inch (60 cm) diameter (DBH) [36]. In Hawaii, it may grow to about 70 feet (20 m) tall [112]. In the United States, the largest recorded chinaberry tree occurs in Hawaii and is 75 feet (23 m) in height, 18.6 feet (5.64 m) in circumference, and has a 96-foot (29 m) canopy spread [47]. Occasionally, chinaberry is shrub-like ([47,79], review by [77]). On chinaberry trees that have been cut, fasciation (change from relatively round stem to relatively flat stem) may occur on 4- to 5-foot (1-2 m) long, branched segments [136]. Chinaberry's dark green leaves [39] are 2 to 3 times compound, about 1 ([31], review by [78]) to 2 feet (0.3-0.6 m) long ([22,84,130], reviews by [33,77,78,89]), and about 9 to 16 inches (20-41 cm) wide (review by [89]).

Chinaberry's inflorescence is a loose, many-flowered [124], stalked panicle [13,28,105,132], sometimes cymose [124]. Chinaberry's fruit is a globose [105] to subglobose [130,132] drupe [22,28,105,137] about 0.4 to 0.8 inches (1-2 cm) in diameter [47,105,130,132], but may be as much as 2 inches (5 cm) wide (review by [33]). At maturity the chinaberry fruit is various shades of yellow ([47], reviews by [33,77]). In chinaberry's native Asian range, fruit grows in clusters of 2 to 15 or more and drupes are 0.3 to 0.59 inches (0.8-1.5 cm) in diameter [144]. Chinaberry seed is fleshy and is 7.6 mm long × 3.2 mm wide [82], but may be as small as 3.5 mm long × 1.6 mm wide in some cultivars [79].

Cultivars: Mabberley [79] indicated that chinaberry cultivars throughout the world are variable in form and are morphologically different from wild types growing in Asia. It is likely that all chinaberry trees introduced to this continent descended from some form of cultivar. In the United States, two cultivars occur that are morphologically distinct from the common type (see above description) in North America. 'Umbraculiformis' is distinguished from the common type by its multiple stems, umbrella-like canopy and shorter stature (20 to 25 feet (6-7.6 m) tall) (reviews by [33,55,78]). 'Jade Snowflake' is distinguished by its variegated leaves (review by [33]).

Belowground: Available literature as of this writing (2009) suggests that chinaberry's root system may vary under different growing conditions. In India, 6-year-old chinaberry trees growing in a nonirrigated plantation lacked tap roots. Lateral roots occurred at an average depth of 39.9 inches (76.0 cm) and weighed about 2.9 pounds (1.3 kilograms)/tree [123]. In Argentina, chinaberry trees on wildlands had both lateral roots and a tap root. First order lateral roots grew horizontally, within 2 inches (4 cm) of the soil surface [124].

Stand structure: Chinaberry can occur as scattered trees (review by [77]) but can also form dense stands, as has been observed in Florida (review by [77]) and Texas [39,121]. Chinaberry density was 6 trees/acre (15 trees/ha) in a red maple (*Acer rubrum*) swamp forest in Florida [108]. On an island off the coast of Texas, dense stands of chinaberry, in combination with pokeweed and boneset, were "impenetrable" [121]. Following physical damage (from fire, herbivory, etc.) chinaberry may exhibit clonal growth [124], which may increase its potential to form dense stands.

Longevity: One review indicated that chinaberry may be short-lived [78]. Chinaberry wood is weak (review by [33]) and susceptible to heartwood rot and rapid decay (review by [55]).

Other: In the laboratory, dried material from chinaberry suppressed the germination and growth of radish, leading researchers to conclude that chinaberry had allelopathic potential. Dried chinaberry material only moderately reduced weed emergence in a rice paddy, leading researchers to speculate that allelopathic potential of chinaberry could be influenced by soil chemistry and microorganisms [62]. Chinaberry's allelopathic potential has not been studied in wildlands.

Raunkiaer [106] **life form:**
Phanerophyte
Geophyte

SEASONAL DEVELOPMENT:
Reproduction: In Florida ([26], reviews by [77,89]) and Texas [130], chinaberry flowers from March through April or May. Fruits and seeds are produced by July (reviews by [77,89]) and ripen from September to October ([130], review by [33]). Fruit often remains on the tree until the leaves fall ([47,130], review by [77]) or longer; sometimes until winter (reviews by [33,89]), the next spring ([25], review by [33]), or the following summer (review by [55]). In Japan, chinaberry fruits ripen autumn through winter [93].

Growth: In India, chinaberry shoot growth was initiated by bud burst and new leaf development in late February. Most chinaberry growth (69-80%) occurred during the next 4 months. Maximum shoot growth occurred during the dry months of the growing season from March to April. Increases in chinaberry diameter occurred primarily from April through August [13].

REGENERATION PROCESSES:

- **Pollination and breeding system**
- **Seed production**
- **Seed dispersal**
- **Seed banking**
- **Germination and seedling establishment**
- **Plant growth**
- **Vegetative regeneration**

Photo by Chris Evans, River to River CWMA, Bugwood.org

Chinaberry typically reproduces from seed ([36,124], review by [88]) but also sprouts from root buds ([124], review by [77]) or stumps [7]. In wild populations, sexual reproduction may be more common in undisturbed conditions [87], while vegetative regeneration may be limited to chinaberry trees that have been damaged [124].

Pollination and breeding system: Chinaberry trees have perfect (reviews by [33,47]) flowers or a combination of perfect and staminate flowers (review by [147]). Chinaberry flowers are fragrant (review by [89]), which may serve as an attractant for insect pollinators. The mahogany family (Meliaceae) as a whole uses nectar and fragrance to attract pollinators, most often moths and bees (review by [147]). Flowers of the chinaberry clutivar 'Umbraculiformis' are self-pollinated or cross-pollinated [79], and it is likely both methods occur in wild chinaberry.

Seed production: A review indicates that chinaberry is a prolific seeder and may begin flowering in the seedling stage [134]. Available literature (2009) regarding chinaberry seed production is inconsistent. Numerous North American floras indicate that chinaberry drupes are 1-seeded [60,70,105]; other literature indicates that the drupe contains 3 to 6 seeds ([63,130], reviews by [55,89]). Mabberley [79] describes chinaberry's drupes as having 1 to 8 locules that each contain 1 or 2 seeds. Welsh [135] describes chinaberry fruit as containing 1 seed per locule but does not indicate how many locules chinaberry has per drupe. A flora from China indicates that chinaberry fruit has 5 to 8 locules, with 2 ovules per locule [144].

Seed dispersal: In North America, chinaberry seed is dispersed by animals, gravity, and possibly water. Birds and mammals eat chinaberry fruit and disperse its seed ([95,130], reviews by [33,77,134]). Cattle egrets in Texas use fruit-bearing twigs of chinaberry for nesting material, thus dispersing its seed [121]. Seedlings emerge in abundance near the parent plant (review by [55]), suggesting that much of the seed is gravity dispersed. In Hawaii, chinaberry does not appear to have a natural dispersal agent and is thought to be dispersed by humans [112]. In Africa, chinaberry is dispersed by water and birds [59,64].

Seed banking: Chinaberry likely forms a short-term seed bank, and its longevity may be extended under certain conditions. A review [9] classified chinaberry with a group of other rainforest species that may undergo at least a short period of physiological dormancy (see Germination and seedling establishment). In Australia, chinaberry occurred occasionally in a tropical rainforest where viable chinaberry seeds were collected from soil samples at depths up to 2 inches (5 cm). A total of 13 chinaberry seeds germinated from 2 of the 12 samples [65]. In a forested sand dune in Virginia, chinaberry failed to germinate from 3-inch-deep (8 cm) soil samples although it occurred as a minor component in the overstory [95]. Menvielle and Scopel [87] indicated that under nondisturbed conditions, an annual supply of fresh chinaberry fruit may be necessary to maintain a continually viable chinaberry seed bank.

Chinaberry seed may retain viability for at least 1 year if kept in dry storage ([130], review by [34]). In a laboratory, seed in chinaberry stones stored at temperatures from -4 to 50 °F (-20 to 10 °C), and in variable moisture conditions, remained viable for 26 months. Seed viability declined with increased temperature and moisture, and lowest viability occurred in stones stored at 50 °F (10 °C) and 11.7% moisture. Researchers concluded that chinaberry seed may remain viable when stored over a wide range of air and moisture conditions, but longevity is typically increased with decreases in temperature and moisture [63].

Germination and seedling establishment: Some chinaberry seed may undergo a short period of dormancy prior to germination. A review indicated that in a nursery, chinaberry seed may take 1 to 3 months to germinate [34]. A propagation manual indicated that when grown in a nursery, 65% of chinaberry seed could be expected to germinate within 3 weeks after being sown [130] but no details were given on growing conditions or potting medium. In the laboratory, 50% of chinaberry seed germinated in 4 weeks [63]. A review suggested that chinaberry seed undergoes physiological dormancy for more than 4 weeks before germinating, but dormancy is broken by warm or cold stratification (Nikolaeva 1977 cited in [9]).

Chinaberry seed remaining encased within the stone may be capable of germinating. Under laboratory conditions, chinaberry seed germinated from 80% of stones after 91 days at alternating temperatures from 68 to 86 °F (20-30 °C) [63].

Germination may occur across a range of pH; however, seedling establishment and vigor may be negatively impacted by highly acidic conditions. Reduced seedling emergence and "severe" leaf damage were observed in chinaberry when exposed to acid rain (pH 2-6). In the laboratory, chinaberry germinated in solutions of various pH ranging from 2 to 6. Continual exposure of germinated chinaberry seed to pH 2 caused primary shoots and roots to rot, leading to "very low" seedling emergence [41].

Plant growth: In North America, chinaberry is a fast growing tree ([17], reviews by [33,55,78,96]) and sometimes produces fruit in as little as 3 to 4 years (review by [33]). In its native range, annual growth rings are wide, sometimes as much as 0.5 inch (1 cm) (review by [55]). Chinaberry seedlings planted in experimental croplands in Uganda grew to 15 feet (4.5 m) tall and 1.8 inches (4.5 cm) wide (root-collar diameter) within 30 months. On another site, chinaberry seedlings grew to nearly 30 feet (10 m) tall and 8 inches (20 cm) wide within 50 months of planting. Seedlings planted at 4,100 feet (1,250 m) elevation grew faster than those planted at 5,280 feet (1,610 m) [102]. On a plantation in northwestern India, 6-year-old chinaberry trees had an average height of 32 feet (9.8 m), a diameter (DBH) of 4.17 inches (10.6 cm), and a crown spread of about 18 feet (5.6 m) [13].

Vegetative regeneration: When damaged, chinaberry sprouts from roots ([124], review by [77]) or from stumps [7,124]. Root sprouts grow from root buds on lateral roots as a response to physical damage (e.g., fire, animal injury, tree felling) [124]. Chinaberry has been propagated from cuttings, root suckers [130], and adventitious buds that

develop on the callus tissue of root segments. The larger the diameter of root segment, the more sprouts it will produce [124].

Chinaberry trees produced from sprouts may grow faster and reproduce earlier than trees produced from seed. Following disturbance, survivorship of chinaberry root sprouts (ca. 40%) was higher than for seedlings (0.5-3%). Within 2 years, trees produced from root sprouts accumulated more than 200 times the biomass of trees produced from seed, and some trees had reached reproductive stage [124].

SITE CHARACTERISTICS:
In North America, chinaberry occurs in many habitats (review by [33]) and variable environments.

Climate: Chinaberry's North American distribution is likely restricted by winter temperatures. Based on the United States Department of Agriculture's hardiness zone classification system, it has been suggested that in temperate climates, chinaberry can withstand winter temperatures ranging from 5 to 30 °F (-15 °C to -1.1 °C) (reviews by [33,78]), or maybe as low as -10 °F (-23.3 °C) [130]. A review by Dirr [33], however, indicated that chinaberry would be severely injured or killed at temperatures at or below -3 °F (20 °C). In North America, chinaberry's most northern distribution at the time of this writing (2009) is New York state, where average January temperature can range from near 22 °F (-6 °C) along the coast to below -14 °F (-10 °C) in the mountains [143], suggesting that chinaberry may tolerate moderately cold winter temperatures even if it only occurs in the warmer portions of this state.

Available information indicates chinaberry occurs in climates of variable humidity and precipitation. A study from India indicated that chinaberry is suitable for arid regions (Randhawa 1965-1983 cited in [109]). In the northern Cape of Africa, where chinaberry is nonnative, it was common along streambanks and roadsides in a semiarid savanna, but its abundance declined in arid regions [59]. In North America, chinaberry has been observed in humid climates (Alabama [129] and Virginia [95]), subtropical humid, subtropical subhumid [99], and dry-subhumid to semiarid climates (Texas) (Larkin and Bomar 1983 cited in [141]). In North America, chinaberry occurs in areas that receive average rainfalls of about 20 to 60 inches (600-1,500 mm)/year ([86,99,143], Larkin and Bomar 1983 cited in [141], National Oceanic and Atmospheric Administration 1979 cited in [27]). Rainfall may be uniformly distributed throughout the year (National Oceanic and Atmospheric Administration 1979 cited in [27]) or may be seasonally distributed [99].

In parts of its native range, chinaberry may occur in areas that receive seasonally restricted rainfall. In India, chinaberry occurs in dry monsoon climates with average annual rainfall from 2 inches (50 mm) to 40 inches (1,000 mm) [13,123]. In Australia, chinaberry is a rainforest canopy species [103,117] and occurs in areas that received average annual rainfall of 55 inches (1,401 mm) to 172 inches (4,383 mm), primarily during summer months (November to May) [65,103].

General Habitat and Moisture: Chinaberry occurs on sites altered by human activity such as fence rows [36,47], abandoned agricultural fields [58], pastures [132,138], highways (review by [33]), logging sites [53,117], and riparian areas that are heavily grazed [14]. It is frequently associated with disturbance [26,31,45,105,132], especially soil disturbance [92]. Chinaberry occurs on sites impacted by hurricanes [45,65,117] and flooding [17,64]. In wildlands it occurs in both disturbed [1,53] and undisturbed [12,124] plant communities.

Chinaberry occurs in wet and dry habitats and may occur in either extreme. In Texas, chinaberry occurred in habitat that was inundated year-round [100]. It established in a Texas floodplain where deep, high velocity flooding occurred [17]. In the mediterranean region of California, chinaberry withstood flooding for almost an entire growing season while continuing to develop new roots [133]. Four out of 6 chinaberry trees that were partially submersed up to 1.5 feet (0.46 m) during the growing season were alive after 45 days and were classified as intermediately tolerant to flooding [85]. In Africa, chinaberry occurred in a wet floodplain floor that experienced periodic flooding [64].

In Hawaii, chinaberry prefers dry sites, especially in gulches and pastures [132]. Reviews indicate that chinaberry is drought tolerant in Texas (reviews by [21,49]), although one flora indicated otherwise [130]. In southwestern Alabama, chinaberry was an occasional species on well drained sites [44]. In the southeastern United States, chinaberry occurs with longleaf pine [74,129], a species found on well-drained sites [40]. In Florida, chinaberry was

one of a number of species that established in a hammock after its hydrology had been changed from wet to mesic by draining [45]. A study from India indicated that chinaberry is drought-resistant (Randhawa 1965-1983 cited in [109]).

Elevation: Information pertaining to chinaberry's elevational range is sparse; however, available information indicates that chinaberry occurs over a range of elevations in North American, from sea level on the coast, up to 3,000 feet (915 m) in one western state. Chinaberry may be uncommon at high elevations in the southeastern United States (review by [88]). One review indicated that where it is native, chinaberry occurs in both lowland and highland rainforests [134].

Reported elevational ranges for chinaberry	
North America	
Location	Elevation
Alabama	210 feet (63 m) [129]
California	0 to 656 feet (0-200 m) [20]
Hawaii	0 to 2,000 feet (0- 610 m) [132]
Texas	381 to 430 feet (116-131 m) [140]
Utah	2,800 to 3,000 feet (850- 900 m) [135]
Other Countries	
Australia	300 feet (100 m) [65]
Pakistan	up to 5,600 feet (1,700 m) [2]

Substrate: Chinaberry does not appear to be limited by soil texture. In Texas, chinaberry occurred in a floodplain with deep, well-drained (Coffee and others 1980 cited in [99]) silty clays [100]; in a riparian area characterized by loams (Carter 1931 cited in [141]); and near a lake on sands and sandy loams [140]. In 24 sampled sites across the south-central United States, chinaberry was most frequently associated with soils containing a high percent of clay [91]. In a Louisiana floodplain, chinaberry occurred on a site with poorly drained silt loams and silty clay loams [86]. In South Carolina, chinaberry occurred on abandoned agricultural lands in soils that were primarily loams [58].

Little information is available on other characteristics of chinaberry substrates at the time of this writing (2009). One study reported chinaberry in a Texas floodplain in which the entire study area was described as having calcareous, moderately alkaline soils with a pH ranging from 7.6 to 7.8 [99]. In Georgia, chinaberry occurred in an area with pH ranging from 4.9 to 6.9 and an average pH of 5.6 [27]. In a tropical rainforest in Australia, chinaberry occurred on a site where drainage was impeded, and soils derived from granite overlaid sandstone and schist bedrock [65].

SUCCESSIONAL STATUS:
Chinaberry has not been studied from a successional perspective as of this writing (2009), but available evidence suggests it may occur across a range of successional stages, from early to late succession.

Shade tolerance: Chinaberry grows in full sun and in forests (see Habitat Types and Plant Communities and Site Characteristics), but its tolerance to shade is unclear. One review indicates that chinaberry is not shade tolerant [10], but it does occur in forests. In the wild, chinaberry occurs as an overstory tree [95] and in relatively open habitats such as flatwoods, hammocks, and other types of open woodlands (see Habitat Types and Plant Communities). However, it is unclear if chinaberry occurs as a shade intolerant overstory tree or as a shade tolerant mid-story or understory tree. In one instance, researchers from Louisiana reported chinaberry in the mid-story of the canopy [86].

Chinaberry sprouts on open sites (see Vegetative regeneration), and seedlings also likely establish in sunlight, but it is unknown whether the species reproduces in shade.

Successional stages: Chinaberry is a common associate of early successional species such as loblolly pine and sweetgum [40] and is associated with disturbed sites (see Vegetative regeneration and General Habitat and Moisture),

suggesting it may have a role in early succession. A few North American studies have noted chinaberry's occurrence on sites in early succession. In South Carolina, it established in an abandoned agricultural field [58]. In Alabama, patches of chinaberry trees occurred in a 7-year-old clearcut [48], and in Texas it occurred in a forest 10 years after intensive logging [53]. Chinaberry's establishment in early succession may occur from on or off-site seed sources, or it can persist by root or stump sprouting.

Chinaberry also occurs with a variety of shade tolerant oak species that establish after early succession [40], suggesting that it may persist past early succession in some forests, but for how long is unclear.

Chinaberry has been observed in late-successional forests in the southeastern United States. In Alabama, chinaberry occurred in a late-successional longleaf pine forest [74,129] and in South Carolina, chinaberry occurred in a late-successional floodplain forest [67]. Chinaberry's longevity (see General Botanical Characteristics), however, may preclude it from being a major component in late successional forests.

FIRE EFFECTS AND MANAGEMENT

SPECIES: Melia azedarach

FIRE EFFECTS

Immediate fire effect on plant: As of this writing (2009), information on the immediate effects of fire on chinaberry is limited. Fire likely top-kills chinaberry seedlings and small trees but may not top-kill mature trees, depending on the severity of the fire. Although chinaberry's root system may vary (see General Botanical Characteristics), available evidence (see Plant response to fire) indicates that chinaberry's roots are located deep enough in the soil to survive fire. Plants with perennating buds well below the soil surface are typically least affected by fire [24,42]. Roots are less likely to be damaged by low-severity fires than by severe fires (review by [19]).

Postfire regeneration strategy [116]:
Tree with adventitious buds, a sprouting root crown, sobols, 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: Chinaberry sprouts from roots and stumps when damaged (see Vegetative regeneration), suggesting it may sprout after fire. An abstract summarizing Menvielle and Scopel's [87] research suggests that vegetative regeneration is more likely than sexual reproduction in chinaberry after fire; however, chinaberry seedlings may establish from buried seed (see Seed banking) or from off-site seed sources soon after fire [87,117] (see Seed dispersal).

Plant response to fire: Chinaberry is likely to survive fire and can establish from seed on recently burned sites. Menvielle and Scopel [87] studied postfire regeneration of chinaberry in a South American forest and reported that burned chinaberry trees sprouted "vigorously" from stumps and roots and produced 2 to 6 times more root sprouts than chinaberry trees on unburned sites. In the same study, the surface seed bank of chinaberry was completely killed by fire, but some seedlings emerged from buried seed on burned sites. Seedling emergence was 5 to 20 times less on burned sites than on controls. Chinaberry's fruit production was reduced in trees exposed to fire compared to controls; however, by how much was not clear [87]. In Alabama, chinaberry occurred prior to and after 3 consecutive annual

prescribed fires in a longleaf pine forest [74,129]. However, it is unclear whether chinaberry's postfire occurrence was due to tree survival, sprouting, or seedling emergence.

Chinaberry may establish or perist following logging and slash burning. In an Australian rainforest, trees over 4 feet (1.2 m) in circumference were logged, remaining large trees were felled, and the site was cleared of small trees, shrubs, and vines by slashing. Three months later, debris was burned where it lay. A few (=10) chinaberry seedlings occurred within 23 months after treatments; however, no information was given on the characteristics of the fire or on chinaberry's prefire occurrence [117].

FUELS AND FIRE REGIMES:

Fuels: A publication from Virginia on firewise landscaping techniques gave chinaberry a low flammability rating [3]; however, no details were provided on how this determination was made.

Fire regimes: Published information on fire regimes in chinaberry's native habitats was not available as of this writing (2009). In its North American range, chinaberry occurs in plant communities with historic fire regimes of varied frequency and severity, although chinaberry was not widespread when these reference fire regimes were functioning. Based on its ability to persist following annual prescribed fires a in longleaf pine forest [74,129], chinaberry may be adapted to high-frequency, low-severity fire regimes. In the southeastern United States, chinaberry may invade wet grasslands historically associated with frequent fire, when fire is excluded (review by [118]). As of this writing (2009) information pertaining to chinaberry's tolerance to low-frequency fire regimes is lacking. See the Fire Regime Table for further information on fire regimes of vegetation communities in which chinaberry may occur.

Fire regime change: As of this writing (2009) information pertaining to chinaberry's ability to alter fire regimes is lacking.

FIRE MANAGEMENT CONSIDERATIONS:

Prescribed fire is not likely to control current infestations of chinaberry or stop its spread. Fire may temporarily reduce chinaberry populations if seedlings and small trees are top-killed, but chinaberry is likely to sprout from intact root systems and/or stumps (see Plant response to fire). Additionally, chinaberry's ability to invade open, disturbed sites from off-site seed sources (see Site characteristics and Seed dispersal) suggests that fire may create favorable conditions for seedling establishment.

Fire exclusion: Chinaberry may invade wet grasslands on sites where fire has been excluded (review by [118]). However, chinaberry may respond favorably to fire (see Plant response to fire) and has not been recommended as a means to reduce chinaberry in any plant community.

Preventing postfire establishment and spread: In general, preventing invasive plants from establishing in weed-free burned areas is the most effective and least costly management method. Prevention of chinaberry's postfire establishment and spread on burned sites may be accomplished by limiting seed dispersal to burned sites, early detection and eradication of seedlings and sprouts, and careful monitoring and follow-up.

General recommendations for preventing postfire establishment and spread of invasive plants 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: [5,15,50,127].

Use of prescribed fire as a control agent: Prescribed fire is not likely to control chinaberry and may encourage its spread (see Fire adaptations and plant response to fire). In Alabama, chinaberry persisted in a longleaf pine forest after 3 consecutive annual prescribed fires (see Plant response to fire). According to a review by Tourn and others [124], attempts to control chinaberry in Argentina using treatments that included chemicals, tree felling, or prescribed fire induced "prolific" sprouting in chinaberry that likely contributed to its spread.

MANAGEMENT CONSIDERATIONS

SPECIES: Melia azedarach

IMPORTANCE TO WILDLIFE AND LIVESTOCK:
White-tailed dear [57], feral pigs [130], plain chachalaca [81], American robins [11], gray catbirds, northern mocking birds [83], and songbirds in the southeastern United States [57] eat chinaberry fruit to a limited extent. In Florida, songbirds sometimes gorge on chinaberry fruit to a point of intoxication [96]. In Texas, researchers found chinaberry plant material in the stomach of a ringtail [120].

Palatability and/or nutritional value: The fruit of chinaberry is poisonous [47,60,104] to humans ([31], review by [77]) and some other mammals (review by [77]), including livestock [31]. Chinaberry causes gastrointestinal problems in livestock [6]. The toxic substance in chinaberry may cause digestive, liver, and kidney problems in humans. Six to 8 chinaberry fruits have been reported to cause death in young children [31]. The fruit contains a narcotic capable of causing paralysis (review by [83]).

Chinaberry leaf litter is high in calcium (40.8 mg/g dried leaf) [101].

Cover value: On islands off the coast of Texas, cattle egrets used chinaberry trees for nesting sites in place of native vegetation that had been killed by guano deposited from breeding birds. Cattle egrets also used chinaberry's fruit-bearing twigs for nesting material. The continued accumulation of bird guano eventually killed chinaberry trees [121].

OTHER USES:
Chinaberry has many uses around the world. In the United States ([47,70,83], review by [78]) and in South America [4], chinaberry was primarily planted as an ornamental tree and for shade (reviews by [78,138]). It is likely so abundant it is seldom planted anymore [47]. In other parts of the world its wood is used for cabinets [55] and furniture (Dalton and others 1991 cited in [4]) and its seed for rosary beads ([70], review by [55]). In India, chinaberry is grown for fuel [97].

Chinaberry trees have been recommended for planting at landfills in developing countries to offset environmental problems caused by landfills [71]. In China, chinaberry as been studied for its ability to uptake selenium—an element that causes health problems in humans and other animals—on croplands that have high concentrations of this element

[30].

Extracts from chinaberry have been studied for potential medicinal applications including antibacterial, antimalarial, antifertility, and antiviral properties [131]. Its antiviral properties have led researchers to evaluate chinaberry as a potential treatment for the herpes simplex virus type 1 [8]. Extracts from chinaberry have been used as pesticides ([88,130], review by [89]). One study found that dried chinaberry leaves had limited inhibitory effects on weeds in croplands [62]. Dried chinaberry leaves have also been studied for their potential to augment soil nitrogen [111].

IMPACTS AND CONTROL:

Impacts: Reports on chinaberry's impacts in the United States vary, and it is not considered invasive in all states where it occurs. A study investigating characteristics of invasive plants placed chinaberry in a group of woody plants considered potentially invasive based on seed mass and other reproductive characteristics [107]. Dirr [33] described chinaberry as a "genuine weed tree" and a "true biological vagrant", and one of the most prevalent nonnative trees in southern forests. Although it commonly invades wildlands, little has been documented on its ecology and associated ecological impacts ([51], review by [10]). Most available information on chinaberry impacts in wildlands is anecdotal. A review by Woodcock [142] lists chinaberry with several nonnative woody plants that are considered among the greatest threats to native Hawaiian biota. It is ranked as a "severe threat" in South Carolina [114]. In Georgia, chinaberry is ranked as a Category 1 invasive species: nonnative plants that pose serious problems in Georgia natural areas by "extensively invading native plant communities and displacing native species" [46]. In Florida, it is ranked as a Category II nonnative invasive: species "that have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species" [43]. It has been banned from sale in some Florida counties [68]. According to Everitt and others [39], chinaberry is abundant in native riparian woodlands in parts of Texas, and "often forms dense stands that reduce light to other understory vegetation"; the source of this information was not given. Herbaria specimens from California indicate chinaberry has begun to invade wildlands in that state [20].

In one study, chinaberry's leaf litter had an inhibitory affect on weeds in a cropland [62] and may have a similar impact on native plants in wildlands. Chinaberry leaf litter may increase nitrogen [111] and pH, and reduce aluminum levels in the soil [101].

In Mississippi and Alabama, chinaberry saplings serve as a host for the ambrosia beetle, *Xylosandrus mutilatus*, an insect that may negatively impact forest ecosystems [119].

Control: This section is not intended to be comprehensive or prescriptive in nature but focuses on control methods for chinaberry in wildlands, and their potential to influence wildfire and or the use of fire as a management tool.

Control of biotic invasions is most effective when it employs a long-term, ecosystem-wide strategy rather than a tactical approach focused on battling individual invaders [80]. 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 [61]. Regardless what control methods are employed, the potential for other invasive species to replace chinaberry once it is controlled must be considered [16].

Fire: Prescribed fire is not recommended for controlling this species (see Fire Management Considerations).

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 [80,110] (e.g., avoid road building in wildlands [126]) and by monitoring several times each year [66]. Researchers in Texas [39] have developed a color-infrared aerial photography technique that may help to monitor population trends of chinaberry in wildlands. 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 [127]. See the Guide to noxious weed prevention practices [127] for specific guidelines in preventing the spread of weed seeds and propagules under different management conditions. For a widespread species like chinaberry, however, prevention alone will not stop its spread.

Cultural control: No information is available on this topic at the time of this publication (2009).

Physical or mechanical control: Physical or mechanical control of chinaberry is general only effective during the initial stages of invasion. Seedlings can be hand pulled ([68], review by [134]), but care must be taken to remove the entire root [49]. Physical controls that damage chinaberry's stem or root system will likely encourage sprouting (see Vegetative regeneration).

Biological control: Preliminary surveys have been conducted for biological controls of chinaberry (review by [29]), although at the time of this writing (2009), no biological control was available for chinaberry. In 2001, chinaberry was listed as 1 of the top 10 invasive plants from Asia that spread to North America, for which a biological control is needed. Chinaberry is considered a good candidate for biological control because it has no congeners in the United States [32].

Chemical control: According to reviews [21,49,68,134], triclopyr is the preferred method for chemical control of seed-producing chinaberry trees, and it controls root- and stem-sprouting [125]. Triclopyr applied to the base or foliage of chinaberry trees was recommended for chinaberry control [72]. Direct foliar application of triclopyr or imazapyr has been recommended to kill chinaberry sprouts and seedlings (review by [21]). Triclopyr and sodium chlorate produced partial or complete root mortality on containerized seedlings of chinaberry, which resulted in foliage damage [54]. Injecting triclopyr into chinaberry's stem [21,72] or applying triclopyr directly to its foliage or a freshly-cut stump in conjunction with a cut-surface treatment (e.g., girdle, cut-stump) kills chinaberry ([72], reviews by [21,49]).

Herbicides are typically 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 [18]. See the Weed control methods handbook [125] for considerations on the use of herbicides in natural areas and detailed information on specific chemicals.

Integrated management: No information is available on this topic at the time of this publication (2009).

APPENDIX: FIRE REGIME TABLE

SPECIES: Melia azedarach

The following table provides fire regime information that may be relevant to chinaberry habitats. Follow the links in the table to documents that provide more detailed information on these fire regimes. For information on fire regimes of plant communities not listed here, see the Expanded Fire Regime Table.

Fire regime information on vegetation communities in which chinaberry may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [76], 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.

Southwest	South-central US	Southern Appalachians	Southeast

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 forest with conifers	Replacement	100%	435	300	550
Riparian deciduous woodland	Replacement	50%	110	15	200
	Mixed	20%	275	25	
	Surface or low	30%	180	10	
South-central US • South-central US Woodland • South-central US Forested					
Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
South-central US Woodland					
Oak-hickory savanna	Replacement	1%	227		
	Surface or low	99%	3.2		
Interior Highlands dry oak/bluestem woodland and glade	Replacement	16%	25	10	100
	Mixed	4%	100	10	
	Surface or low	80%	5	2	7
Oak woodland-shrubland-grassland mosaic	Replacement	11%	50		
	Mixed	56%	10		
	Surface or low	33%	17		
Interior Highlands oak-hickory-pine	Replacement	3%	150	100	300
	Surface or low	97%	4	2	10
Pine bluestem	Replacement	4%	100		
	Surface or low	96%	4		
South-central US Forested					
Interior Highlands dry-mesic forest and	Replacement	7%	250	50	300
	Mixed	18%	90	20	150

woodland	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 floodplain	Replacement	42%	140		
	Surface or low	58%	100		
Southern floodplain (rare fire)	Replacement	42%	≥1,000		
	Surface or low	58%	714		
Cross Timbers	Replacement	3%	170		
	Mixed	2%	250		
	Surface or low	94%	6		

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
Oak (eastern dry-xeric)	Replacement	6%	128	50	100
	Mixed	16%	50	20	30
	Surface or low	78%	10	1	10
Appalachian oak forest (dry-mesic)	Replacement	6%	220		
	Mixed	15%	90		
	Surface or low	79%	17		

Southeast

- Southeast Woodland
- 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 Woodland					
Longleaf pine/bluestem	Replacement	3%	130		
	Surface or low	97%	4	1	5
Longleaf pine (mesic uplands)	Replacement	3%	110	40	200
	Surface or low	97%	3	1	5
Longleaf pine-Sandhills prairie	Replacement	3%	130	25	500
	Surface or	97%	4	1	10

	low				
Pine rocklands	Mixed	1%	330		
	Surface or low	99%	3	1	5
Pond pine	Replacement	64%	7	5	500
	Mixed	25%	18	8	150
	Surface or low	10%	43	2	50
South Florida slash pine flatwoods	Replacement	6%	50	50	90
	Surface or low	94%	3	1	6
Atlantic wet pine savanna	Replacement	4%	100		
	Mixed	2%	175		
	Surface or low	94%	4		
Southeast Forested					
Coastal Plain pine-oak-hickory	Replacement	4%	200		
	Mixed	7%	100		
	Surface or low	89%	8		
Maritime forest	Replacement	18%	40		500
	Mixed	2%	310	100	500
	Surface or low	80%	9	3	50
Mesic-dry flatwoods	Replacement	3%	65	5	150
	Surface or low	97%	2	1	8
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 [56,75].

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