Berberis vulgaris

INTRODUCTORY

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AUTHORSHIP AND CITATION:
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FEIS ABBREVIATION:
BERVUL

NRCS PLANT CODE [91]:
BEVU

COMMON NAMES:
common barberry
European barberry

TAXONOMY:
The scientific name of common barberry is *Berberis vulgaris* L. (Berberidaceae) [27,42].

Hybrid: *Berberis* × *ottawaensis* (Schneid.), a cross between common barberry and Japanese barberry (*B. thunbergerii*), occurs in Europe and North America [24,60,67].

SYNONYMS:
None

LIFE FORM:
Shrub

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: Berberis vulgaris

GENERAL DISTRIBUTION:
Common barberry is a nonnative plant in North America. Its native range is Asia's middle and western mountains, and it is widely introduced throughout Europe [44,77]. Common barberry was brought to North America in the 1600s by early New England settlers (Josselyn 1672 cited in [55]),[44], and soon after its introduction, common barrberry escaped from cultivation. Soon after its introduction and escape, common barberry was linked with failing wheat crops [27]. Programs to eliminate and restrict planting of common barberry in North America began in the 18th century, but large-scale cooperative eradication did not occur until the early 1900s. Widespread eradication led to a dramatic decline in common barberry abundance, and common barberry's distribution today is largely the result of successes and failures in eradication (Roelfs 1982 cited in [27]). Some suggest that common barberry has been "virtually exterminated in the United States" [77], but populations persist in the eastern Great Plains, Great Lakes states, northeastern United States, and southeastern Canada. Populations also remain in Idaho, Montana, British Columbia, and Colorado [27]. Large common barberry populations and infestations occur primarily in Ontario and Quebec in Canada [77] and are scattered through the northeastern United States [2,60,75]. Populations are especially persistent along the Atlantic Coast [62]. Flora of North America provides a distributional map of common barberry.

Introduction and spread in North America: European settlers likely brought common barberry to New England because of its ornamental, food, and medicinal uses [44,57]. Common barberry was growing in early New England settlements by 1671 (Josselyn 1672 cited in [55]). In the 18th and 19th centuries, common barberry was commonly planted as a hedge and as a source of jam and yellow dye. Plants frequently escaped cultivation and established in natural areas in eastern North America (Roelfs 1982 cited in [27]). Common barberry was considered a weed in Massachusetts by 1754 [77]. Below is a sporadic timeline that provides information about the spread of common barberry in North America:

- 19th-century catalogs offering common barberry seeds or cuttings were available in New York, Massachusetts, Pennsylvania, Maryland, North Carolina, Ohio, Illinois, Indiana, Wisconsin, and California; common barberry was sold in the United States by at least 1841 [56].
- Since at least 1821, common barberry occurred in Pennsylvania's Wyoming County (and perhaps others) [44].
- In 1850 in Iowa, common barberry was planted as an ornamental and as a hedge to contain livestock [22].
- In 1885, common barberry was considered abundant in Tottenville, New York [39].
- As of 1886, common barberry was reported in Summit County, Ohio [19].
- By 1902, common barberry was occasional along the Quinnipiac River sand plain from New Haven to Meriden, Connecticut [9].

- In a 1910 Nantucket flora, common barberry was noted along a roadside near Siasconset [6].
- By the early 1900s, common barberry was widespread in 13 north-central US states (Hutton 1927 cited in [57]).
- In 1914, common barberry was reported a "considerable distance from any habitation" in Rum Village woods in South Bend, Indiana [68].
- As of 1921 in Pennsylvania, common barberry was "thoroughly established" in "numerous natural areas"; escaped plants were "exceedingly numerous" in Susquehanna County [44].
- By 1925, common barberry was common throughout Michigan [100].
- In a 1937 flora of the Columbia Plateau, common barberry was listed, although not listed in earlier floras from 1892, 1901, or 1914 [54].

Eradication efforts and effects on local distributions: Soon after the introduction and escape of common barberry in New England, colonists determined it was responsible for dramatic reductions in wheat crop yields [28]. Common barberry is an alternate host for cereal stem rust (*Puccinia graminis*). As a host, common barberry provides an inoculum source and a sexual reproduction site for stem rust (Leonard 2001 cited in [71]). When common barberry grows near cereal crops (<330 feet (100 m) away) (Roelfs 1985 cited in [71]), it can support the development of new genotypes able to adapt and attack rust-resistant crops (Leonard 2001 cited in [71]). Earlier reports suggested that common barberry in urban areas was also able to spread stem rust to other grasses that eventually passed it on to wheat crops [80], suggesting there was no safe distance between common barberry and cereal crops. During epidemic stem rust outbreaks, wheat yield losses up to 70% were reported [71]. In 1916, stem rust was considered the principal reason for a 200 million bushel reduction in wheat yields for Minnesota, North Dakota, South Dakota, and Montana [80].

In the 18th century, the New England colonists of Connecticut, Massachusetts, and Rhode Island wrote laws restricting the planting and spread of common barberry. Over time many other states developed laws against the sale, transport, and planting of new barberry (*Berberis* spp.) plants and for the removal of established plants. It was not until 1918, after "devastating" wheat losses to stem rust, that federal laws and funding were devoted to eradication. Eradication projects and funding between 1918 and 1942 led to the destruction of 309,645,502 landscape, escaped, and nursery plants from the 964,000 mile² (2,497,000 km²) eradication area that included nearly all of the North American spring-wheat growing areas [28]. Between 1935 and 1950, there were 150,087,197 common barberry or American barberry (*B. canadensis*) shrubs destroyed in West Virginia [84]. By 1956, nearly 500 million barberry shrubs were killed on 149,318 properties in 19 states [12]. Widespread barberry eradication was "gradually phased out" by 1980 [71]. It is important to note that scattered common barberry populations persist in several areas of North America, and the potential for long-distance seed dispersal by birds makes monitoring and early detection of common barberry important to long-term control.

General effects of eradication efforts on common barberry distribution in North America are summarized below:

- In New Mexico in 1997, common barberry was far less common than it once was because of the USDA eradication program [15].
- Early USDA records reported common barberry scattered throughout Colorado, but by 1964, it was limited to the north-central part of the state [35]; as of 1996, common barberry occurred only on the Enchanted Mesa near Boulder because of "deliberate extermination" from wheat-growing areas [97].
- Although widely planted in the Great Plains, no common barberry plants were found by Stephens [82] while conducting plant surveys for a North Central Plains flora (covering North Dakota, South Dakota, Nebraska, and Kansas); common barberry was not reported in the Flora of the Great Plains printed in 1986 [31].
- As of 1985, common barberry was considered "largely eradicated" from Michigan [96].
- Although reported from 20 Ohio counties prior to USDA eradication efforts, common barberry was uncommon in the state in 1961 [8].
- As of 1959, common barberry still occurred in "fair numbers" in Wisconsin; disturbances associated with eradication were considered beneficial to common barberry seedling establishment [20].
- In the 1970s, common barberry was planted on acidic surface-mine spoils on 2 sites in eastern Kentucky; bareroot stock was obtained from an unidentified nursery [73].

Although common barberry populations were often reduced or eliminated by eradication efforts, some post-eradication surveys indicate substantial spread from untreated or surviving plants. In Minnesota, researchers surveyed 72 sites

treated by federal eradication teams. Surveyed sites had a "high potential" for reemergence, once supported large common barberry populations, and/or occurred in major grain production areas. Of the 72 sites, 32 had common barberry populations supporting 1 to 300 individuals [71]. In eastern Ontario and western Quebec, a 20-year eradication program (initiated in 1964) did not eliminate all common barberry. In the first 5 years of the program, population decreases of 90% or more were common. Eradication was successful at only a few sites where shrubs were initially rare and/or herbicide treatments were repeated for several successive years. Since 1980, there have been few treatments, and common barberry populations have increased "considerably" [18].

HABITAT TYPES AND PLANT COMMUNITIES:
Common barberry habitats in the United States are described before, during, and after eradication efforts; however, timing of habitat occupation is generally unimportant to possible future establishment and spread. Plant communities invaded by common barberry include grasslands, savannas, thickets, and dense woodlands or forests. These habitats are described for the Great Lakes area and northeastern United States where common barberry is persistent. Additional information on the importance of birds in common barberry's distribution is presented in Seed dispersal.

In the north-central United States, common barberry often invades prairies and savannas [21]. When eradication sites were revisited in Minnesota, most common barberry populations occurred in sparsely to densely wooded areas [71]. In Wisconsin, common barberry was typical in disturbed hardwood stands [20]. In southern Michigan, it was reported in upland oak (*Quercus* spp.) savannas [16]. In Pennsylvania, populations occurred in stream bank thickets, along roadsides, in open pastures, and on "half-wooded hillsides" [43]. Although most common in open-canopy forests in New England, common barberry is also reported in abandoned fields, coastal grasslands, early-seral forests, forest edges, floodplain forests, disturbed sites, pastures, roadsides, and shrubby wetlands [62]. In Connecticut's sand plains, common barberry occurred in the dense understory of black oak (*Q. velutina*) woodlands [70]. It was described within black locust (*Robinia pseudoacacia*) clones in inland pitch pine-scrub oak (*Pinus rigida-Q. ilicifolia*) barrens of the Albany Pine Bush Preserve in New York [25]. In Maine, common barberry occurred in red spruce-balsam fir (*Picea rubens-Abies balsamea*) forests [23].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Berberis vulgaris

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GENERAL BOTANICAL CHARACTERISTICS:

- **Botanical description**
- **Raunkiaer life form**

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., [27,29,79,84]).

Aboveground description: Common barberry is a deciduous shrub that may reach 10 feet (3 m) tall [27,79]. Shrubs often have 20 to 30 erect, widely spreading stems that droop at the ends, producing an arching form [17,24,35,86]. Simple or 3-pronged thorns occur at stem nodes [27,76]. Thorns measure 1 to 2 cm long [35]. Older stems have gray shredding bark, and individual stems may live up to 30 years [86].

Common barberry produces simple, alternate leaves that are often clustered on the stem [17,77]. Lance-shaped or egg-shaped leaves measure 0.4 to 2.2 inches (1-5.5 cm) long and are widest at or just above middle. Leaf margins are finely serrate with 8 to 30 spiny teeth [27,49,65,76,79]. Common barberry flowers occur in a drooping 0.8- to 2.4-inch (2-6 cm) long raceme. Inflorescences are typically comprised of 10 to 20 flowers [27,79]. Individual flowers are up to 8 mm across, with 6 petals and 6 stamens [81,84]. Stamens are contact-sensitive and "spring violently" against the stigma when touched [2]. Common barberry fruits are egg-shaped, 1- to 3-seeded berries that measure up to 0.5 inch (12 mm) long [24,35,77]. In the Tullgarn area of Sweden, fruits averaged 4.1 mm in diameter, 0.09 g when fresh, and produced an average of 1.3 seeds/fruit [26]. On Spain's Iberian Peninsula, common barberry averaged 1.6 seeds/fruit [36,37]. Common barberry seeds are about 6 mm long [77].

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Belowground description: Common barberry root and rhizome growth is often extensive. Surrounding the common barberry root crown is a "thick mass of fibrous roots". Large lateral roots occur several inches to more than a foot under ground. Lateral roots may be 1 to 2 inches (2.5-5 cm) in diameter near the root crown and extend 10 to 15 feet (3-4.6 m) from the root crown [86]. Common barberry root growth varies with site conditions. Shrubs in sandy, loose-textured soils produced long lateral roots. Shrubs growing on gentle slopes with deep loam soils did not produce long tap roots (review by [72]). The review did not indicate whether or not long common barberry tap roots were rare in all habitats.

Rhizomes produced from the root crown typically grow a few inches below ground but may penetrate 2 to 3 feet (0.6-1 m). Rhizomes do not generally grow roots until aerial shoots emerge, at which time a mass of fibrous roots is produced at the point of emergence. Rhizome growth contributes to increasing shrub size, and severing rhizomes results in reproduction (see Vegetative Regeneration) [86].

Raunkiaer [74] life form:
Geophyte
Phanerophyte

SEASONAL DEVELOPMENT:
In North America and western Europe, common barberry flowers are common in May or June and fruits are generally ripe by August or September [27,64,69,77,79,84]. Seeds may mature by October [17]. In the fall, common barberry leaves turn a red, orange, or purple color [17,49]. Berries are persistent and remain on stems through winter [26,49,86].

REGENERATION PROCESSES:
Common barberry reproduces by seed and from rhizomes that are detached from the parent plant. Rhizome spread and sprouting are important to common barberry growth and persistence (see Vegetative regeneration).

Pollination and breeding system: Common barberry flowers are perfect [59] and primarily insect pollinated [79]. Nectaries occur at the base of flower petals, and bees, wasps, ants, flies, and beetles are common pollinators (review by [72]). Although cross pollination by insects is most common, in New Brunswick, New Jersey, 3 of 30 inflorescences produced fruits when protected from insects [32].

Seed production: Abundant fruit and seed crops are produced by common barberry nearly every year, but predation is common. Common barberry typically begins producing fruit at 4 to 7 years old, but fruit production has been observed on 1-year-old shrubs (Shepherd 1944 cited in [72]). A review reports that common barberry produces "good" fruit crops nearly every year [64]. On Spain's Iberian Peninsula, common barberry produced an estimated 1,000 to 2,500 fruits/plant [36,37]. During field studies conducted in southeastern Spain, 75.5% of common barberry flowers produced fruit, 70.6% of fruits ripened, and the average number of seeds/fruit was 1.66. Plants averaged 1,605 fruits, but production ranged from 100 to 5,000 fruits/plant [69].

Predation: Insects, birds, and small mammals can reduce common barberry seed production through predation. In southeastern Spain, tephritid fruit fly larvae affected an average of 41.6% of common barberry fruits. Predation ranged from 14.6% to 98.7% and was greatest on early-fruiting plants. Early-fruiting plants typically produced fewer seeds/fruit than late-fruiting plants. The researcher cautioned that predation was monitored for only 1 year and can vary dramatically between years and locations [69]. In Sierra Nevada National Park, southeastern Spain, 30.1% of common barberry seeds presented to predators were taken. Primary seed predators in the area were rodents. When compared with other seeds, common barberry was only moderately preferred [61]. When 1,875 dried common barberry fruits were fed to captive ring-necked pheasants, just 10 seeds were recovered intact. Ring-necked pheasants have powerful gizzards [48], but many smaller bird species pass whole common barberry seeds and are important to Seed dispersal. For more on animal use of common barberry, see Importance to Wildlife and Livestock.

Seed dispersal: Birds [36,37,70,79] and cattle are the most commonly discussed common barberry seed dispersers. However, small mammals such as field mice and other small rodents may also disperse seeds by caching common barberry fruits [62,63]. Seed dispersal in water is also likely, given the importance of river corridors in common barberry's distribution [52,67]. Seed movement by wind and in mud caught in shoes, hooves, or equipment is also possible. The use of fruiting common barberry branches in decorations could also result in seed dispersal [86].

Common barberry fruits are persistent and typically available to birds or browsers through winter and spring [49,77]. Birds generally scatter seeds over an extensive area, while cattle typically deposit numerous seeds over a limited area [86].

Birds: Many bird species eat common barberry fruits, including ruffed grouse, northern bobwhites, ring-necked pheasants, mockingbirds (review by [92]), cedar waxwings (Kelly cited in [44]), robins, catbirds, and blackbirds [63]. According to Thompson and Robbins [86], birds generally feed on common barberry fruits in winter or early spring when other foods are unavailable. Of 15 bird species reported to feed on berries, small birds often passed seeds whole through the digestive tract, and others removed the fruits and left intact seeds at the feeding site (review by [72]). Whole seeds were recovered from robin and waxwing feces, but blackbirds typically cracked seeds [63]. In May and June in Ithaca, New York, the frequency of barberry seeds in robin feces was 81.5%. Many feces collections came from sidewalks bordering barberry hedges [33]. Studies in Minnesota revealed that common barberry seeds were still viable after traveling through bird digestive tracts. Seeds were carried several kilometers by local birds, but dispersal distances by migratory birds may be much greater (Flake 1945 cited in [71]). Some have reported that barberry seeds that have passed through the digestive tracts of birds have a "hastened" period of germination (Kerner and Oliver cited in [44]).

Studies in Europe also highlight the importance of birds in common barberry dispersal. In Kaiserstahl, southwestern Germany, birds were the primary dispersers of fleshy-fruited plant species including common barberry. Seeds were collected from bird droppings and regurgitations. Most seeds were dropped in successionally mature vegetation dominated by sweet cherry (*Prunus avium*) and durmast oak (*Quercus petraea*), about half as many were dropped in vegetation dominated by shrubs and vines, and the fewest were dropped in pioneer vegetation. Findings suggested that birds preferred the structural diversity of scrub and woodland vegetation over grasslands, likely because of an abundance of perches [47]. In southeastern Spain, common barberry fruits were consumed and dispersed by thrushes (*Turdus* spp.). An average of 51.5% of common barberry fruits was consumed by birds. The number of seeds dispersed by thrushes was positively correlated with crop size ($P<0.05$). Fruit removal was greatest from plants that produced the largest fruits [69]. Information on Seed production from this study is available.

Cattle: Several observations indicate that cattle disperse common barberry seed. Cattle have been observed browsing ripe common barberry fruits, and seedlings grew from manure [86]. Surveys conducted during eradication efforts suggested that cattle were spreading common barberry throughout grazing allotments [63]. Numerous common barberry seedlings were observed in dung patties in pastures in Susquehanna County, Pennsylvania. In a single patty, there were 45 common barberry seedlings. Shady areas used heavily by resting cattle were covered with young common barberry shrubs. Beneath a single large tree, there were 145 common barberry shrubs [44].

Seed banking: Common barberry seeds may remain viable for 9 years or more in the soil. Studies conducted in North Dakota and Minnesota showed that seeds were viable after 9 and 7 years in the soil, respectively (Reddy 1929 cited in [72]), but no common barberry seedlings emerged from soil samples collected from an area where it occurred in Sweden [4]. Seeds stored in sealed containers at 34 to 37 °F (1-3 °C) were viable after 4 years (Heit 1967 cited in [64]). Seedlings emerged from common barberry seeds stored for up to 11 years. Storage conditions were not reported (review by [72]).

Germination: Common barberry seeds germinate best when shallowly buried in shaded areas where alternating temperatures exceed 50 °F (10 °C). In general, common barberry is described as germinating "readily" and producing "vigorous" seedlings [43]. Germination of seeds contained in intact fruits may be delayed compared to seeds without fleshy fruits. In field plots in southern Iowa, bare seeds generally germinated in the 1st year, while seeds in fruits germinated in the 2nd year. Germination occurred throughout the growing season [22].

Light: Germination of common barberry seeds is generally inhibited in full sun (Shepherd 1944 cited in [72]). Experiments designed to aid in the eradication of common barberry suggested that common barberry germination and seedling survival were best in shaded conditions (review by [71]).

Soils, burial: High levels of common barberry germination were reported in loose and recently cultivated soils (review by [72]). Another study reported that common barberry germination was best for seeds buried in 0.6 inch (1.5 cm) of soil. No seeds germinated from depths of 3 inches (8 cm) or more (Kempton 1922 cited in [72]).

Temperature: Field and laboratory experiments suggest that common barberry seed germination is best with

alternating temperatures [66,72]. Generally germination fails at constant temperatures of 90 °F (32 °C) or higher, 41 °F (5 °C) or lower [22,66], and is promoted with cold stratification [1].

In the field, common barberry seeds germinated best when soil temperatures were 50 °F (10 °C) for 18 hours and 72 °F (22 °C) for 6 hours (review by [72]). In the laboratory, alternating temperatures produced higher germination rates than constant temperatures. Common barberry germination failed at constant temperatures of 41 °F (5 °C) or 90 °F (32 °C). Germination ranged from 72% to 88% at alternating moderate (41-50 °F (5-10 °C)) and high (59-72 °F (15-22 °C)) temperatures. Germination was 4% at alternating temperatures of 72 and 100 °F (22 and 38 °C) and was 12% at temperatures of 32 and 72 °F (0 and 22 °C) [66]. In a greenhouse study, seeds collected from plants growing in natural areas of Iowa germinated better than those collected from cultivated plants. Germination was best (62%) at temperatures of 68 to 86 °F (20-30 °C). Germination was low (14-19%) at constant temperatures of 50 °F (10 °C) and failed at 95 °F (35 °C) [22].

Seedling establishment and plant growth: Common barberry seedling establishment is often best in shady conditions. Disturbed sites may promote seedling establishment, while flooding, desiccation, frost heaving, and predation may reduce establishment. In general, common barberry seedlings are considered "vigorous" [43]. Observations made during eradication efforts suggested that alkaline soils beneath tree canopies provided for high rates of seedling growth and survival (review by [72]).

Experiments conducted during the initiation of eradication programs suggested that common barberry seedling survival was best in shaded conditions (review by [71]), although another study suggested that deep shade could inhibit establishment [45]. In Pennsylvania, seedlings were often found near mature plants. Although site characteristics were variable, germination and seedling establishment were successful in the area [44]. In studies in Germany, common barberry seedlings were not considered especially shade tolerant. In the upper Rhine Valley, seedling establishment and survival were monitored in a field where shrubs were beginning to shade out grassland species. In one year, 4 of 6 monitored common barberry seedlings survived. In the next year, 3 of 3 monitored seedlings survived. Common barberry seedling numbers were low due to scarce seed rain. Researchers did not speculate on the reasons for low seed production. Based on laboratory studies that measured dark respiration rates, light compensation points, and photosynthetic capacity values, researchers suggested that common barberry seedlings had high light demands and were not "particularly adapted to establish in a strongly-shaded environment" [45].

Disturbances may favor common barberry establishment, but seedlings are sensitive to flooding, desiccation, frost heaving, heavy litter, and predation. Although an eradication target for years in Wisconsin, common barberry remained present in "fair numbers". Curtis [20] suggested that common barberry persisted because disturbances associated with eradication were well suited to seedling establishment. In a greenhouse study, continuous and temporary flooding reduced common barberry seedling growth. Flooded seedlings produced much lower dry weights than unflooded seedlings, but seedlings did survive 12 weeks of flooding [22]. Field studies in southern Iowa revealed high mortality in seedlings less than 1 year old. Seedling death was often due to dessication, but winter frost-heaving also contributed. Seedling survival was also low on sites with heavy litter. When 1-year-old greenhouse grown seedlings were planted in field plots in Iowa, predation by rabbits was severe [22].

Vegetative regeneration: Rhizome growth and sprouting are important to common barberry size increases and vegetative regeneration. Vegetative spread through rhizome growth can produce large-sized shrubs and thick clumps of shoots. Clumps of stems up to 16 feet (5 m) in diameter are possible through rhizomatous growth. Stem sprouts are possible from small rhizome fragments, and severing the rhizome between a parent plant and a new sprout rarely damages either the parent or the sprout [86]. Vegetative spread by layering was reported for common barberry in New England [62]. Individual stems may live up to 30 years [86].

SITE CHARACTERISTICS:
Throughout its range, common barberry is often described along roadsides and rivers, in old fields, pastures, clearings, thickets, and woodlands [35,59,84,96]. When eradication sites in Minnesota were monitored for reemergence, common barberry was most common in sparsely to densely wooded areas in the southeastern part of the state [71]. The Massachusetts Invasive Plant Advisory group reported that upland habitats were most commonly invaded [60]. In Maine, common barberry is most often reported in successional old fields and second-growth forests [53]. Common

barberry often spreads through pastures and along fencelines in Ontario [52,67]. Likely the establishment and spread of common barberry populations is largely related to Seed dispersal.

Climate: Common barberry's distribution suggests a preference for humid continental climates. Common barberry is considered hardy to low winter temperatures of -40 °F (-40 °C) or lower [24,81]. Based on its US distribution, common barberry likely requires at least 25 inches (630 mm) of annual precipitation. In southeastern Spain's Sierra Nevada National Park, common barberry occurs in the dense shrub layer beneath a (*Pinus sylvestris* var. *nevadensis*) canopy. In this area, summers are hot and dry, winters are cold and snowy, and the 15-year average annual rainfall is 32 inches (818 mm). Most rain comes in the fall and spring [61].

Elevation: Common barberry occurs from sea level up to 5,900 feet (1,800 m) in North America [27].

Soils: Although common barberry occurs on soils derived from a variety of parent materials with a variety of textures, pH levels, and moistures, it is often widespread or particularly prolific on limestone soils or other alkaline and/or calcareous soils. A review reports that common barberry often grows in acidic sandy clay loams but also grows in neutral or alkaline clays and nutrient poor soils [2]. In Pennsylvania in 1921, common barberry occurred on soils from a variety of parent materials, including sandstone, shale, limestone, igneous rock, and glacial till [43]. When eradication sites in Minnesota were surveyed for common barberry in early 2000, shrubs were most common in alkaline sandy loams in the southeast part of the state [71]. In many areas, common barberry is especially common or restricted to limestone and/or calcareous soils. These areas include Iowa (review by [22]), western and southern Ontario [52,79], New England [62], and Sierra de Cazorla, southeastern Spain [69].

Common barberry typically grows best on dry to moist soils (review by [2]). In an upland oak savanna in southern Michigan, common barberry was reported on slightly acidic soils with low water-holding capacity and low soil moisture [16]. During a 1951 survey in southwestern Ontario, common barberry was absent from flat, swampy lands, and when it occurred along streams, it often occupied well drained, steep-sloping banks [52].

SUCCESSIONAL STATUS:
As of 2009, few successional studies in common barberry-invaded habitats were available. Common barberry's tolerance of full sun [2] and full shade [60] and persistence in wooded areas [40] suggests early- to late-seral communities are potential common barberry habitat. Though reported in full sun and full shade conditions in western Ontario, common barberry was more common in partially cleared than deeply shaded, dense woodlands or forests [52]. In Pennsylvania, common barberry was considered rare in closed-canopy forests or woodlands [75].

Old field succession: On old fields in Stratfford County, New Hampshire, common barberry importance was greatest in mid- to late-seral communities. Researchers reported the importance (average relative density and relative basal area) of common barberry along a successional chronosequence from recently abandoned fields to mature forests. Common barberry importance was greatest in white pine (*Pinus strobus*) and eastern hemlock (*Tsuga canadensis*) forests dominating fields abandoned an average of 81 and 134 years previously, respectively. Importance was lowest in common juniper-Allegheny blackberry-sweetfern (*Juniperus communis-Rubus allegheniensis-Comptonia peregrina*) communities in fields abandoned 14 to 22 years earlier. Importance was intermediate in oak-virburnum (*Viburnum* spp.) communities in fields abandoned 45 to 196 years earlier. In habitats with common barberry, photosynthetically active radiation (PAR) averaged 4.3% at a height of 16 inches (40 cm). The range of PAR in common barberry habitats was 0.3% to 52.1% [40].

Grazing: In southeastern Sweden, common barberry appeared to grow best in more densely wooded areas. Without grazing and periodic firewood collection in dry alvar grasslands on Oland Island, grasslands succeed to closed-canopy common juniper woodlands in 100 years. In this area, common barberry was absent from grassland sites grazed by cattle, on sites ungrazed for 20 years, and on sites ungrazed for 55 years. Common barberry occurred only on a site ungrazed for 80 years. Common barberry seedlings did not emerge from soil samples collected at any site [4].

FIRE EFFECTS AND MANAGEMENT

SPECIES: Berberis vulgaris

FIRE EFFECTS:
Immediate fire effect on plant: Common barberry is likely only top-killed by fire [86].

Postfire regeneration strategy [83]:
Tall shrub, adventitious buds and/or a sprouting root crown
Rhizomatous shrub, rhizome in soil

Fire adaptations: As of 2009, only one study examined fire effects and the postfire response of common barberry. In this study, common barberry sprouted from the root crown or surviving rhizomes following fire [86]. Survival of buried seed on burned sites has not been studied (2009), although fire was thought to "destroy" seeds on the stems [86].

Plant response to fire: Established common barberry shrubs are likely to sprout following top-kill. Heat tolerance of seed is unknown. Seed dispersal by animals on burned sites is possible; however, common barberry seedling establishment is generally best in shaded sites, which may not occur on recently burned sites. In areas without mature common barberry shrubs, seedlings may not establish until other vegetation grows and produces shade.

Fire failed to control common barberry in studies conducted in conjunction with early eradication. When all common barberry stems, straw, and other brush were piled onto the root crown and burned, common barberry was rarely killed. Even when pile burning was done for 2 to 3 consecutive years, shrubs rarely died [86].

FUELS AND FIRE REGIMES:
Combustion characteristics of common barberry leaves and twigs were not different from the overall average of other woody native and nonnative species tested. Combustion was evaluated using a cone calorimeter. The average effective heat of combustion for common barberry was 14.02 MJ/kg, slightly greater than the average for all 42 eastern woody native and nonnative species tested (13.4 MJ/kg). Total heat release for common barberry was 13.11 MJ/kg, while the average for all species tested was 11.5 MJ/kg [23].

Common barberry is possible in a variety of habitats (see Habitat Types and Plant Communities and Site Characteristics). Altered fire frequency, severity, or behavior in habitats invaded by common barberry was not described in the available literature (2009). See the Fire Regime Table for information on fire regimes in plant communities where common barberry may occur.

FIRE MANAGEMENT CONSIDERATIONS:
Potential for postfire establishment and spread: On sites where common barberry is established, sprouting and regeneration should be expected after fire. Burned sites without established common barberry plants should be monitored for seedlings as vegetation recovers. The potential for long-distance seed dispersal suggests that recovering burned areas should be monitored for establishment even if adjacent areas are free of common barberry.

Preventing postfire establishment and spread: Preventing common barberry from establishing in weed-free burned areas is the most effective and least costly management method. This may be accomplished through early detection and eradication, careful monitoring and follow-up, and limiting dispersal of invasive plant seed into burned areas. 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 that may alter soil nutrient availability, such as those 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: [3,10,30,90].

Use of prescribed fire as a control agent: Fire alone is unlikely to control common barberry. Repeated pile burning on top of common barberry root crowns rarely killed established shrubs (see Plant response to fire). However, fire was recommended to kill plants and plant parts that were dug from the ground. Fire was considered effective in killing exposed rhizomes and seeds on stems [86]. Because seeds on cut stems are capable of producing seedlings, reestablishment may be limited by burning cut stems (Atwood 1930 cited in [72]).

MANAGEMENT CONSIDERATIONS

SPECIES: Berberis vulgaris

IMPORTANCE TO WILDLIFE AND LIVESTOCK:
Many bird species feed on common barberry fruits [86]; small mammals feed primarily on seedlings and stem bark [22,87]; livestock browse stems and fruits (Rhind 1857 cited in [44]),[86].

Birds: More than 12 species of birds feed on common barberry fruits in the United States. Birds consumed most fruits in winter or early spring when other foods were unavailable [86]. Common barberry has been recovered from the stomachs of 6 bird species, which included ruffed grouse and northern bobwhites (review by [92]). Ring-necked pheasants, mockingbirds (review by [92]), and cedar waxwings utilized common barberry fruits [99]. Common barberry seeds were recovered from the stomachs of American robins [5]. In May and June in Ithaca, New York, the frequency of barberry in robin feces was 81.5% [33]. In southeastern Spain, observations and fecal analyses revealed that common barberry fruits were consumed and seeds were dispersed primarily by thrushes. They fed on ripe fruits until October and consumed an average of 51.5% of common barberry fruits [69]. Information on seed predation and dispersal by birds was presented in earlier sections.

Small mammals: Common barberry seed predation by small mammals is likely less common than seedling and bark browsing. In Iowa, browsing of common barberry by rabbits was severe after 1-year-old greenhouse-grown seedlings were planted into field plots [22]. Observations made near Syracuse, New York, revealed that rabbits fed extensively on common barberry bark in the winter [87]. Winter feeding by cottontail rabbits in western Massachusetts resulted in moderate common barberry injury [85]. Field studies in southwestern Germany and southern England revealed that

mice often quit eating common barberry seeds presented without fruits after the seed coat was removed. Researchers suggested that toxins in the seeds were likely the reason for avoidance by mice [46]. Researchers did not speculate on possible outcomes if fleshy fruits had been presented.

Livestock: According to Rhind (1857 cited in [44]) cattle, sheep, and goats browse common barberry. Cattle browse common barberry and disperse viable seeds [44,86]. For more information, see Seed dispersal.

Palatability and/or nutritional value: Nutritional value of common barberry fruits is reported from Sweden [26] and Spain [37]. In the Tullgarn area of Sweden, common barberry fruits were 76% water [26]. On Spain's Iberian Peninsula, the average dry weight of common barberry fruit pulp was 25.6 mg [37].

Cover value: Although common barberry's use as cover was not addressed in the available literature (2009), its arching form may be useful for various ground-nesting birds and small mammals.

OTHER USES:
Common barberry fruits have been used in jams and jellies [59], and leaves, stems, and rhizomes have numerous medicinal uses. The Shinnecock tribe of Long Island boiled common barberry leaves into a tea to treat jaundice [14]. A review lists many other medicinal uses: preventing plague, reducing high blood pressure, relieving inflammation, reducing fevers, improving appetites, soothing upset stomachs, and the treatment of diarrhea, dysentery, malaria, ulcers, heart burn, and liver and gallbladder ailments. Today common barberry is used to treat throat, urinary tract, gastrointestinal, lung, and yeast infections. For more about the potential medicinal uses and precautions with use of common barberry, see the complete review by Arayne and others [2].

Research shows that common barberry roots, stems, and leaves have antimicrobial and anti-inflammatory properties. Roots are rich in alkaloids including berberine and berbamine (review presented in [95]). Twenty-two alkaloids with medicinal properties have been identified in common barberry roots, leaves, and fruits (review by [2]).

IMPACTS AND CONTROL:
Impacts: The most widespread and commonly described impact of common barberry's invasion is its ability to act as an alternate host for cereal stem rusts. As an alternate host, common barberry can support the development of new genotypes able to attack rust-resistant crops (Leonard 2001 cited in [71]). The wheat rust (*Puccinia graminis*) can severely reduce the yield of wheat, oat, and barley crops [77]. Once common barberry was removed from oat production areas of Pennsylvania and wheat production areas of Virginia, crop yields increased by an average of 123% and 68%, respectively [12]. For more on stem rust and common barberry eradication, see Eradication efforts and effects on local distributions.

Discussions and studies on the impacts of common barberry populations in natural areas were generally lacking as of 2009. The Massachusetts Invasive Plant Advisory Group reports that common barberry has a high potential for spread [60], and Vermont's Agency of Natural Resources suggests that common barberry could displace native vegetation on a localized or widespread scale [94]. See the following sections for additional information on common barberry's potential for spread: Seed dispersal, Seedling establishment, and Vegetative regeneration.

Studies conducted in Ontario indicate that common barberry is often spread along fence rows, throughout pastures, and along river corridors. During a 1951 survey of southwestern Ontario, large and spreading common barberry populations were reported in Elgin, Grey, Kent, Waterloo, and Wellington counties. In Waterloo and Wellington counties, thousands of common barberry shrubs occurred along the Grand and Eramosa rivers, respectively. Along the Grand River, populations were scattered along a 30-mile stretch. In Grey County, populations were spreading "rapidly" in "rough pasture land". In these pastures, common barberry stands covered several hundred acres [52]. During a 1952 survey in eastern Ontario, large common barberry populations occurred in Grenville, Lanark, Leeds, and Prescott counties. Common barberry populations were most common in pastures, along fence rows, along the St Lawrence and Ottawa rivers, and in open woodlands [67]. Dispersal of common barberry seeds by birds and cattle is likely important to the distribution of shrubs in pastures, along fence lines, and in open woods and riparian areas (see Seed dispersal).

Control: With widespread eradication efforts targeting common barberry, well established and successful control

methods may be expected. However, many of the early methods used to reduce common barberry populations were time consuming, labor intensive (see Physical or mechanical control), and/or involved chemical experimentation. Most early eradication methods are not feasible or legal today.

In all cases where invasive species are targeted for control, no matter what method is employed, the potential for other invasive species to fill their void must be considered [11]. 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 [58].

Fire: For information on the use of prescribed fire to control 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 [58,78] (e.g., avoid road building in wildlands [89]) and by monitoring several times each year [41]. 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 [38].

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 [90]. See the Guide to noxious weed prevention practices [90] for specific guidelines in preventing the spread of weed seeds and propagules under different management conditions.

Physical or mechanical control: Digging and hand-grubbing were used extensively in early eradication efforts. Effective control using these methods required complete root and rhizome removal. If root and rhizome removal was not done carefully and meticulously, sprouts were "almost sure to develop". Roots or rhizomes 1 foot (0.3 m) or more below ground rarely sprouted, but those near the surface sprouted "readily" [86]. Because sprouting was often abundant in areas where barberry was cut, pulled, or dug, eradication officials poured salt in and around the treated areas, which minimized sprouting, but high levels of seedling production often occurred in treated sites (review by [72]).

Common barberry sprouts following cutting [86], and berries from cut stems can still produce seedlings (Atwood 1930 [72]).

Biological control: Currently (2009) there have been no insects or pathogens released to control common barberry. Control by mammalian herbivores (especially cattle) is unlikely, since common barberry seed is dispersed in feces (see Seed dispersal).

Biological control of invasive species has a long history that indicates many factors must be considered before using biological controls. Refer to these sources: [93,98] and the Weed control methods handbook [88] for background information and important considerations for developing and implementing biological control programs.

Chemical control: 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 [13]. See the Weed control methods handbook [88] for considerations on the use of herbicides in natural areas and detailed information on specific chemicals.

In eastern Ontario and western Quebec, a common barberry eradication program using primarily herbicides was initiated in 1964. After 20 years, common barberry was not eradicated. Eradication occurred at only a few sites where shrubs were scarce initially and herbicide treatments were repeated for several years. There have been few herbicide treatments since 1980, and populations have increased "considerably" [18]. In earlier eradication programs, researchers suggested that chemicals applied to the base of the plant where fine, fibrous roots were concentrated would be most effective [86]. However, the effectiveness of this practice in the field was not reported.

Integrated management: Although using a combination of control methods often produces better results, integrated

management in common barberry populations was rarely described in the available literature (2009) (see Use of prescribed fire as a control agent).

APPENDIX: FIRE REGIME TABLE

SPECIES: Berberis vulgaris

The following table provides fire regime information that may be relevant to common barberry habitats. Follow the links in the table to documents that provide more detailed information on these fire regimes.

Fire regime information on vegetation communities in which common barberry may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [51], 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	Northern and Central Rockies	Northern Great Plains
Great Lakes	Northeast	Southern Appalachians

Southwest

- Southwest Grassland
- Southwest Shrubland
- Southwest Woodland
- 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 Grassland					
Desert grassland with shrubs and trees	Replacement	85%	12		
	Mixed	15%	70		
Plains mesa grassland with shrubs or trees	Replacement	76%	20		
	Mixed	24%	65		
Southwest Shrubland					
Gambel oak	Replacement	75%	50		
	Mixed	25%	150		
Mountain-mahogany shrubland	Replacement	73%	75		
	Mixed	27%	200		

Southwest Woodland					
Pinyon-juniper (mixed fire regime)	Replacement	29%	430		
	Mixed	65%	192		
	Surface or low	6%	>1,000		
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	
Ponderosa pine-Douglas-fir (southern Rockies)	Replacement	15%	460		
	Mixed	43%	160		
	Surface or low	43%	160		
Stable aspen without conifers	Replacement	81%	150	50	300
	Surface or low	19%	650	600	>1,000
Lodgepole pine (Central Rocky Mountains, infrequent fire)	Replacement	82%	300	250	500
	Surface or low	18%	>1,000	>1,000	>1,000
Northern and Central Rockies • Northern and Central Rockies Grassland • Northern and Central Rockies Shrubland • Northern and Central Rockies Forested					
Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northern and Central Rockies Grassland					
Northern prairie grassland	Replacement	55%	22	2	40
	Mixed	45%	27	10	50
Mountain grassland	Replacement	60%	20	10	
	Mixed	40%	30		
Northern and Central Rockies Shrubland					
	Replacement	80%	100	20	150

Mountain shrub, nonsagebrush	Mixed	20%	400		
Northern and Central Rockies Forested					
Ponderosa pine (Northern and Central Rockies)	Replacement	4%	300	100	≥1,000
	Mixed	19%	60	50	200
	Surface or low	77%	15	3	30
Ponderosa pine-Douglas-fir	Replacement	10%	250		≥1,000
	Mixed	51%	50	50	130
	Surface or low	39%	65	15	
Western redcedar	Replacement	87%	385	75	≥1,000
	Mixed	13%	>1,000	25	
Douglas-fir (xeric interior)	Replacement	12%	165	100	300
	Mixed	19%	100	30	100
	Surface or low	69%	28	15	40
Douglas-fir (warm mesic interior)	Replacement	28%	170	80	400
	Mixed	72%	65	50	250
Grand fir-Douglas-fir-western larch mix	Replacement	29%	150	100	200
	Mixed	71%	60	3	75
Mixed conifer-upland western redcedar-western hemlock	Replacement	67%	225	150	300
	Mixed	33%	450	35	500
Western larch-lodgepole pine-Douglas-fir	Replacement	33%	200	50	250
	Mixed	67%	100	20	140
Grand fir-lodgepole pine-larch-Douglas-fir	Replacement	31%	220	50	250
	Mixed	69%	100	35	150
Persistent lodgepole pine	Replacement	89%	450	300	600
	Mixed	11%	>1,000		
Northern Great Plains • Northern Plains Grassland • Northern Plains Woodland					
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					
Central tallgrass prairie	Replacement	75%	5	3	5
	Mixed	11%	34	1	100
	Surface or low	13%	28	1	50
Northern tallgrass prairie	Replacement	90%	6.5	1	25
	Mixed	9%	63		
	Surface or low	2%	303		
Southern tallgrass prairie (East)	Replacement	96%	4	1	10
	Mixed	1%	277		
	Surface or low	3%	135		
Oak savanna	Replacement	7%	44		
	Mixed	17%	18		
	Surface or low	76%	4		
Northern Plains Woodland					
Oak woodland	Replacement	2%	450		
	Surface or low	98%	7.5		
Great Plains floodplain	Replacement	100%	500		

Great Lakes

- Great Lakes Grassland
- 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 Grassland					
Mosaic of bluestem prairie and oak-hickory	Replacement	79%	5	1	8
	Mixed	2%	260		
	Surface or low	20%	2		33
Great Lakes Woodland					
	Replacement	8%	41	10	80

Great Lakes pine barrens	Mixed	9%	36	10	80
	Surface or low	83%	4	1	20
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		
Conifer lowland (embedded in fire-prone system)	Replacement	45%	120	90	220
	Mixed	55%	100		
Conifer lowland (embedded in fire-resistant ecosystem)	Replacement	36%	540	220	≥1,000
	Mixed	64%	300		
Great Lakes floodplain forest	Mixed	7%	833		
	Surface or low	93%	61		
Great Lakes spruce-fir	Replacement	100%	85	50	200
Minnesota spruce-fir (adjacent to Lake Superior and Drift and Lake Plain)	Replacement	21%	300		
	Surface or low	79%	80		
Northern hardwood-eastern hemlock forest (Great Lakes)	Replacement	99%	>1,000		
Oak-hickory	Replacement	13%	66	1	
	Mixed	11%	77	5	
	Surface or low	76%	11	2	25
Pine-oak	Replacement	19%	357		
	Surface or low	81%	85		
Great Lakes pine forest, eastern white pine-eastern hemlock (frequent fire)	Replacement	52%	260		
	Mixed	12%	>1,000		
	Surface or low	35%	385		
Eastern white pine-eastern hemlock	Replacement	54%	370		
	Mixed	12%	>1,000		
	Surface or				

	low	34%	588		

Northeast

- Northeast Grassland
- 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 Grassland					
Northern coastal marsh	Replacement	97%	7	2	50
	Mixed	3%	265	20	
Northeast Woodland					
Eastern woodland mosaic	Replacement	2%	200	100	300
	Mixed	9%	40	20	60
	Surface or low	89%	4	1	7
Pine barrens	Replacement	10%	78		
	Mixed	25%	32		
	Surface or low	65%	12		
Oak-pine (eastern dry-xeric)	Replacement	4%	185		
	Mixed	7%	110		
	Surface or low	90%	8		
Northeast Forested					
Northern hardwoods (Northeast)	Replacement	39%	≥1,000		
	Mixed	61%	650		
Eastern white pine-northern hardwoods	Replacement	72%	475		
	Surface or low	28%	>1,000		
Northern hardwoods-eastern hemlock	Replacement	50%	≥1,000		
	Surface or low	50%	≥1,000		
Northern hardwoods-spruce	Replacement	100%	≥1,000	400	>1,000
	Replacement	2%	625	500	≥1,000

Appalachian oak forest (dry-mesic)	Mixed	6%	250	200	500
	Surface or low	92%	15	7	26
Beech-maple	Replacement	100%	>1,000		
Northeast spruce-fir forest	Replacement	100%	265	150	300
Southeastern red spruce-Fraser fir	Replacement	100%	500	300	≥1,000
Southern Appalachians • Southern Appalachians Grassland • 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 Grassland					
Bluestem-oak barrens	Replacement	46%	15		
	Mixed	10%	69		
	Surface or low	44%	16		
Eastern prairie-woodland mosaic	Replacement	50%	10		
	Mixed	1%	900		
	Surface or low	50%	10		
Southern Appalachians Woodland					
Oak-ash woodland	Replacement	23%	119		
	Mixed	28%	95		
	Surface or low	49%	55		
Southern Appalachians Forested					
Mixed mesophytic hardwood	Replacement	11%	665		
	Mixed	10%	715		
	Surface or low	79%	90		
Eastern hemlock-eastern white pine-	Replacement	17%	≥1,000	500	>1,000

hardwood	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 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 [34,50].

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