Euonymus alatus

INTRODUCTORY

AUTHORSHIP AND CITATION:
Fryer, Janet L. 2009. Euonymus alatus. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2010, February 5].

FEIS ABBREVIATION:
EUOALA

NRCS PLANT CODE [46]:
EUAL13

COMMON NAMES:
winged burning bush
winged spindletree
winged euonymous
winged wahoo
burningbush

TAXONOMY:
The scientific name of winged burning bush is *Euonymus alatus* (Thunb.) Sieb. (Celastraceae) [4,15,16,19,27,42]. Worldwide, 5 poorly differentiated varieties are recognized by various systematists based on leaf color and relative hairiness (review by [4]). These varieties occur in North America [46,51]:

Euonymus alatus (Thunb.) Sieb. var. *alatus*
Euonymus alatus (Thunb.) Sieb. var. *apterus* Regel

SYNONYMS:
Euonymus alata (Thub.) Sieb. [34,49]

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: Euonymus alatus

GENERAL DISTRIBUTION:
North America: Winged burning bush is nonnative in North America, where it occurs from Ontario south to Missouri, Kentucky, and South Carolina and east to New Hampshire [27]. Booth and Wright [5] noted its presence in west-central Montana in 1962, but it was not listed in a 1991 flora of the same area [28]. Plants Database provides a distributional map of winged burning bush and varieties in North America.

Other continents: Winged burning bush's native distribution extends from central China to northeastern Asia [5,19,33,42,49]. Besides central and eastern China, winged burning bush occurs in Korea, the Sakhalin islands of eastern Russia, and Japan [15]. It was introduced in Europe and North America as an ornamental [10,15].

Invasion history in the United States: Winged burning bush was first introduced in the United States in the 1860s [10]. It has escaped cultivation or become invasive mostly in the northeastern United States.

Northeast: Winged burning bush was well established in some parts of the Northeast by the late 20th century. It had established near Palestine in Wirt County, West Virginia, by 1977 [42]. In a 1985 Michigan flora, winged burning bush was noted as rarely escaping cultivation but spreading "occasionally" into woodlands, thickets, and uncultivated urban and rural areas [49]. In 1991, Gleason and Cronquist [19] described it as widely cultivated but only "locally escaped from cultivation" in the Northeast. By the turn of the 21st century, winged burning bush was locally invasive in many northeastern states. A 2002 fact sheet describes winged burning bush as most invasive in Connecticut, Virginia, Pennsylvania, and Illinois [33]. A 2006 review describes 21 states as "invaded" [9].

Midwest: As of 2009, winged burning bush was noted as invasive in the Midwest only in Illinois, where it was first reported as "naturalized" in Coles County in 1973 [11]. By 1984, winged burning bush was reported from 13 Illinois counties [12]. In 1989, winged burning bush was the dominant woody species invading the Waterworks Ravine Hill Prairie, where woody species were historically rare. Most other invading woody species were native. Mean density (and frequency) of winged burning bush was 7,809 stem/ha (66%) [2].

HABITAT TYPES AND PLANT COMMUNITIES:
In the Northeast, winged burning bush is invasive in pastures, glacial drift hill prairies, woodlands, and mature second-growth forests [20,22,33]. It may be common in late-successional oak-hickory (*Quercus-Carya* spp.), maple-beech

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(*Acer-Fagus* spp.), and other mixed-hardwood forests [22,33,51]. It is noted in mixed-oak forests and swamp chestnut oak-swamp white oak-Shumard's oak (*Q. michauxii-Q bicolor-Q. shumardii*) swamps of Great Falls National Park, Virginia [23] and in oak-hickory-sugar maple (*Acer saccharum*) forests of Illinois. It also occurs in little bluestem-Indian grass (*Schizachyrium scoparium-Sorghastrum nutans*) prairie in Illinois [2]. In southern Connecticut, winged burning bush occurred in a mixed-hardwood forest with high densities of white-tailed deer. Due to browsing, woody understory vegetation was sparse except for sugar maple seedlings, winged burning bush, and other nonnative shrubs [51]. See Palatability and/or nutritional value for more information on this study.

Distribution of nonnative species is often difficult to accurately describe due to a lack of details survey information, gaps in understanding of nonnative species' ecological characteristics, and because nonnative species may still be expanding their North American range. Therefore, winged burning bush may occur in plant communities other than those discussed here and listed in the Fire Regime Table.

As of 2009, little English-language literature was available on winged burning bush's native habitats. In China, winged burning bush grows in forests, woodlands, and scrublands [15].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Euonymus alatus

Winged burning bush stem wings.
Photo courtesy Duke University.

GENERAL BOTANICAL CHARACTERISTICS:

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

Botanical description: This description provides characteristics that may be relevant to fire ecology and is not meant for identification. Keys for identification are available (for example, [19,34,42,49]).

Winged burning bush is a rounded shrub that grows to 8.2 feet (2.5 m) tall [5,19]. The branches typically have prominent, corky wings [5,19,34,42,49], although stem wings are reduced to ridges or absent on some plants [4,16,33,38]. Winged burning bush is deciduous [5,19,49], with

opposite leaves [34]. The inflorescence is a long-peduncled cyme with perfect flowers [34]. The fruit is a dehiscent capsule [19] containing up to to 4 seeds [33] that are enclosed in an aril [19]. A fact sheet describes winged burning bush's root system as deep and fibrous [38].

Split winged burning bush capsules, showing orange arils within.
Photo © Steve Baskauf.

Stand structure: Based on limited studies, winged burning bush may form shrublands or dense forest understories; it is uncertain whether this pattern is typical on winged burning bush-invaded sites. Winged burning bush has formed dense thickets in Pennsylvania [33]. In New York, winged burning bush was most common in the tall shrub layer of a yellow-poplar-red oak-American beech (*Liriodendron tulipifera-Quercus rubra-Fagus grandifolia*) forest [22]:

Cover (%) of winged burning bush in a mixed-hardwood forest in Long Island, New York [22]			
Tall shrub layer (2-3.5 m)	Medium shrub layer (1-2 m)	Herb layer (0-1 m)	All layers
1.86	0.60	0.53	0.53

Raunkiaer [37] **life form:**
Phanerophyte

SEASONAL DEVELOPMENT:
In general, winged burning bush flowers from May to June in the Northeast [19]. Late April to late June flowering is noted in Pennsylvania [33,38], while winged burning bush flowers in June and July in Illinois [34]. Fruit capsules ripen in September and October in the Northeast [33]. The capsules dehisce and seeds disperse in September and October in Pennsylvania [38]. Leaves turn a "brilliant" purplish red to scarlet before dropping in autumn [33]. Fall color is most intense in plants growing in sun [38].

Fall color; winged burning bush seedlings in foreground.
Photo © Barry A. Rice.

REGENERATION PROCESSES:

Winged burning bush regenerates from seed and vegetatively [33]. Little is known of winged burning bush's regeneration requirements in wildland ecosystems. Research is needed on all aspects of winged burning bush regeneration.

Pollination and breeding system: No information is available on this topic.

Seed production: A fact sheet described winged burning bush seed production as "prodigious" [33].

Seed dispersal: Seeds are dispersed by frugivorous birds [20,33].

Seed banking: No information is available on this topic.

Germination: Passage through a bird's digestive system may increase germination rates [33], although this has not been confirmed experimentally. Commercial winged burning bush seeds are stratified to increase germination rates in the nursery and in the field [48].

Seedling establishment and plant growth: As of 2009, no published information was available on requirements for winged burning bush establishment and growth. The photo on the right illustrates winged burning bush establishing in oak litter; the photo in Seasonal Development shows burning bush seedlings establishing beneath parent plants. Seedlings are shade tolerant (see Successional Status), but it is uncertain whether growth rates differ between open than with closed canopies. Fact sheets variously describe winged burning bush as a fast- [38] or slow-growing [13] species.

Photo by Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.

Vegetative regeneration: According to expert opinion [33] and fact sheets [13,38], winged burning bush sprouts from the root crown after top-kill from herbicides, so it is likely that it also sprouts following other top-killing events. Winged burning bush tolerates severe pruning [13].

SITE CHARACTERISTICS:

Winged burning bush appears adaptable to a variety of site conditions. As of 2009, few details were available regarding site conditions preferred by this species. Winged burning bush tolerates a variety of soil textures [33,36] and pH levels [33], and grows in dry to moist soils [10]. A fact sheet described winged burning bush as drought tolerant but intolerant of wet soils [13]. In oak-hickory-sugar maple forests in Illinois, winged burning bush dominated forest understories most often within small ravines. It also dominated shady valley floors and shady microsites on north-

facing hillslopes [11]. Research is needed on site conditions that may increase vulnerability of native plant communities to winged burning bush invasion.

In its native China, winged burning bush occurs in forests, woodlands, and scrublands from sea level to 8,900 feet (2,700 m) elevation [15]. Elevational ranges for winged burning bush in North America were not available of as 2009.

Winged burning bush may tolerate elevated levels of soil methane. In New York, it was planted on landfill sites, where methane concentration was 0.9%; and on control sites, where methane was not detected in the soil. Winged burning bush persisted in landfill soils, although its growth was significantly greater in control soils (P<0.05) [18].

SUCCESSIONAL STATUS:
Winged burning bush tolerates full sun [10] to nearly full shade [10,11,33] and has invaded closed-canopy, "relatively undisturbed" forest communities in Illinois [12]. Little research had been conducted on successional patterns in plant communities with winged burning bush as of 2009, and research is needed on winged burning bush's successional role in eastern mixed-hardwood and other plant communities where it is invasive. In the Northeast, winged burning bush may reach greatest coverage in late-successional hardwood forests. According to a fact sheet, winged burning bush has overgrown native shrub species and become dominant in the understories of closed-canopy, mixed-hardwood forests in Pennsylvania [38].

FIRE EFFECTS AND MANAGEMENT

SPECIES: Euonymus alatus

FIRE EFFECTS
Immediate fire effect on plant: There was no information on the direct effects of fire on winged burning bush as of 2009. According to expert opinion [33] and a fact sheet [38], herbicides may only top-kill winged burning bush, so it is likely that fire may also only top-kill winged burning bush.

Postfire regeneration strategy [41]:
Tall shrub, adventitious buds and/or a sprouting root crown
Small shrub, adventitious buds and/or a sprouting root crown
Initial off-site colonizer (off site, initial community)
Secondary colonizer (on- or off-site seed sources)

Fire adaptations and plant response to fire: Documentation of winged burning bush's adaptations and response to fire were lacking as of 2009. Since winged burning bush sprouts from the root crown after top-kill from herbicides [33,38], it is likely that it also sprouts from the root crown after top-kill by fire. Because birds disperse winged burning bush seed [20,33], postfire seedling establishment from off-site seed sources may occur. Research is needed on all aspects of winged burning bush's fire ecology.

FUELS AND FIRE REGIMES:
Fuels: According to a fact sheet, winged burning bush can successionally replace native shrubs and form a dense forest understory on some sites in the Northeast [38], so winged burning bush may increase fuel loads in plant communities it has invaded. However, data are lacking on how winged burning bush may alter horizontal and/or vertical fuel continuity and fuel loads from historical conditions.

Fire regimes: Winged burning bush grows in plant communities that historically experienced both long and short fire-return intervals. The northeastern beech-maple communities that winged burning bush has invaded [33,51] historically experienced stand-replacement fires at long fire-return intervals, with an estimated range of 230 to 4,970 years in New Hampshire [14]. Oak-hickory communities historically had mostly short fire-return intervals. Some winged burning bush-invaded oak-hickory communities in Pennsylvania historically experienced low-severity surface fires at 4- to 7-year intervals. Short fire-return intervals kept stand structure open, usually maintaining the communities as woodlands [29]. Several authors have noted cooccurrence of sugar maple and winged burning bush in oak-hickory forests [2,11]. On many sites, presence of sugar maple in oak-hickory communities may indicate that these winged burning bush-invaded forests now have longer fire-return intervals than were typical in the past ([39], review by Pallardy and others [35]). Research on how winged burning bush affects fire regimes of plant communities it has invaded was lacking as of 2009. See the Fire Regime Table for further information on fire regimes of vegetation communities in which winged burning bush may occur.

FIRE MANAGEMENT CONSIDERATIONS:
Without information on how winged burning bush responds to fire or how it may affect fuel loads and fire regimes in plant communities it has invaded, it is impossible to make recommendations for its fire management. Studies on the sprouting ability of winged burning bush after fire; longevity of soil-stored seed; effects (if any) of fire and passage through animal digestive tracts on seed germination; and possible changes in fuels due to winged burning bush invasion are critically needed to understand the fire ecology winged burning bush. Postfire monitoring of winged burning bush can help managers access whether control measures are needed on burned sites.

MANAGEMENT CONSIDERATIONS

SPECIES: Euonymus alatus

IMPORTANCE TO WILDLIFE AND LIVESTOCK:
There was little information on wildlife or livestock use of winged burning bush as of 2009. Rabbits browse winged burning bush [3], and birds eat winged burning bush arils [20,38].

Palatability and/or nutritional value: A southern Connecticut study suggests winged burning bush is not palatable to white-tailed deer. Although winged burning bush was plentiful in the understory of a mixed-hardwood forest, white-tailed deer selected other browse species over winged burning bush. In a related greenhouse study, seedlings of 17 browse species emerged from white-tailed deer fecal samples collected in the forest. None of the samples contained winged burning bush seedlings [51].

Cover value: No information is available on this topic.

OTHER USES:
Winged burning bush is widely cultivated for its brilliant autumn foliage and distinctive winged branches [49].

IMPACTS AND CONTROL:
Impacts: According to a Pennsylvania fact sheet, winged burning bush may become invasive when planted near pastures, woodlands, and mature second-growth forests, but does not usually escape urban

plantings. It is most invasive in moist forest habitats [38]. Winged burning bush is often used in highway plantings [10], which may contribute to its seed spread.

Limited evidence suggests that in eastern mixed-hardwood forests, heavy white-tailed deer browsing of native shrubs may favor growth of winged burning bush and other nonnative shrubs [8] (see Palatability and/or nutritional value).

Winged burning bush infestation.
Photo by Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.

Control: Little published information on controlling winged burning bush was available as of 2009, and further research is needed on this topic. See The Nature Conservancy's Weeds Control Methods Handbook for general information on controlling nonnative invasive species.

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 [7]. 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 [32].

Fire: There was no published information on prescribed fire use for controlling winged burning bush as of 2009.

Prevention:

General prevention of invasives: Preventing invasive plants from establishing in weed-free burned areas is the most effective and least costly management method. This can be accomplished through early detection and eradication, careful monitoring, and by limiting invasive plant seed dispersal into burned areas by:

- incorporating cost of weed prevention and management into fire rehabilitation plans
- acquiring restoration funding
- including weed prevention education during fire training
- minimizing soil disturbance and vegetation removal during fire suppression and rehabilitation activities
- minimize the use of retardants containing nitrogen and phosphorus
- avoiding areas dominated by high priority invasive plants when locating firelines, monitoring camps, staging areas, and helibases
- cleaning equipment and vehicles prior to entering burned areas
- regulating or preventing human and livestock entry into burned areas until desirable site vegetation has recovered sufficiently to resist invasion by undesirable vegetation
- monitoring burned areas and areas of significant management activity
- detecting weeds early and eradicating before vegetative spread and/or seed dispersal
- eradicating small patches and containing or controlling large infestations within or adjacent to the burned area

For more detailed information on these topics see the following publications: [1,6,21,45].

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 [32,40] (for example, avoid road building in wildlands [44]) and by conducting monitoring several times each year [26]. Managing to maintain the integrity of native plant communities and identifying causal factors enhancing ecosystem invasibility are likely to be more

effective than an emphasis on controlling the invader [25].

Weed prevention and control can be incorporated into all types of management plans, including logging and site preparation, management of grazing allotments, recreation management, research projects, road building and maintenance, and fire management [45]. See the "Guide to noxious weed prevention practices" [45] for specific guidelines on preventing the spread of weed seeds and propagules under various management conditions.

Preventing winged burning bush invasion: Winged burning bush's escape from cultivation could be slowed or prevented if fertile winged burning bush plants were no longer commercially available and/or if native species were substituted in landscaping projects. However, frugivorous birds may disperse fertile winged burning bush seed into uninvaded areas (see Seed dispersal). Studies to develop sterile winged burning bush cultivars were in progress in 2008 [8,17]. Lists of alternative native species that provide bright red or pruple fall color are available in these sources: [33,38].

Cultural: No information is available on this topic.

Physical and/or mechanical: Mechanical treatments are generally preferred over other methods for controlling small infestations of invasive species [43]. Winged burning bush seedlings up to 2 feet (0.6 m) tall can be hand-pulled, especially in moist soils. Larger plants require cutting and are likely to sprout unless the stumps are removed or painted with herbicide [33,38].

Biological: As of 2009, biological agents for winged burning bush control were not available [38]. A review identifies 13 potential biological control agents from China that may help control winged burning bush in North America [9]. Biological control of invasive species has a long history, and many factors must be considered before using biological controls. Refer to the Weeds Control Methods Handbook [43] and these sources: [47,52] for background information and important considerations for developing and implementing biological control programs.

Chemical: Glyphosate may be effective on extensive stands, especially when applied in early summer [33,38].

Integrated management: As of 2009, published studies on using multiple control methods on winged burning bush were lacking. According to a fact sheet, glyphosate application to cut stumps can help prevent cut stumps from sprouting [38].

APPENDIX: FIRE REGIME TABLE

SPECIES: Euonymus alatus

The following table provides fire regime information that may be relevant to winged burning bush habitats. Follow the links in the table to documents that provide more detailed information on these fire regimes. If you are interested in fire regimes of plant communities not listed here, see the Expanded FEIS Fire Regime Table.

Fire regime information on vegetation communities in which winged burning bush may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [30], 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.		
Northern Great Plains	Great Lakes	Northeast

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					
Northern tallgrass prairie	Replacement	90%	6.5	1	25
	Mixed	9%	63		
	Surface or low	2%	303		
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		
Northern Great Plains wooded draws and ravines	Replacement	38%	45	30	100
	Mixed	18%	94		
	Surface or low	43%	40	10	

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					
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		
Maple-basswood	Replacement	33%	≥1,000		
	Surface or low	67%	500		
Maple-basswood mesic hardwood forest (Great Lakes)	Replacement	100%	>1,000	≥1,000	>1,000
Maple-basswood-oak-aspen	Replacement	4%	769		
	Mixed	7%	476		
	Surface or low	89%	35		
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		
Northeast • Northeast Woodland • Northeast Forested					
Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northeast Woodland					
Eastern woodland mosaic	Replacement	2%	200	100	300
	Mixed	9%	40	20	60
	Surface or low	89%	4	1	7
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		
	Replacement	50%	≥1,000		

Northern hardwoods-eastern hemlock	Surface or low	50%	≥1,000		
Appalachian oak forest (dry-mesic)	Replacement	2%	625	500	≥1,000
	Mixed	6%	250	200	500
	Surface or low	92%	15	7	26
Beech-maple	Replacement	100%	>1,000		

*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 [24,30].

Euonymus alatus: REFERENCES

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FEIS Home Page