SPECIES: Cirsium vulgare

INTRODUCTORY

SPECIES: Cirsium vulgare

AUTHORSHIP AND CITATION:
Zouhar, Kris 2002. Cirsium vulgare. 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/ [2007, September 24].

FEIS ABBREVIATION:
CIRVUL

SYNONYMS:
Carduus lanceolatus L. [119]

NRCS PLANT CODE [153]:
CIVU

COMMON NAMES:
bull thistle
spear thistle

TAXONOMY:
The currently accepted scientific name of bull thistle is *Cirsium vulgare* (Savi) Tenore (Asteraceae) [13,28,39,53,56,69,71,75,76,84,93,107,136,145,157,160,161,165,166].

Bull thistle exhibits variation in several morphological characteristics that have been described as subspecies by some authors; however, the Flora Europaea does not recognize these taxa because they lack sufficient morphological or geographical delimitation [50]. Several hybrids of bull thistle have been described in Europe, and 1 suggested in California. See reviews by Klinkhamer and deJong [80] and Forcella and Randall [50] for more information.

LIFE FORM:
Forb

FEDERAL LEGAL STATUS:
No special status

OTHER STATUS:
At the time of this writing (2002), bull thistle is classified as a noxious, restricted, or prohibited weed or weed seed in 10 states in the United States and 2 Canadian provinces [154]. See the Invaders or Plants databases for more information.

DISTRIBUTION AND OCCURRENCE

SPECIES: Cirsium vulgare

GENERAL DISTRIBUTION:
The origin, distribution and spread of bull thistle are reviewed by Beck [15], Mitich [106] and Forcella and Randall [50]. The following is a summary from these reviews. Bull thistle is native to Europe, from Britain and Iberia northward to Scandinavia, eastward to western Asia, and southward to northern Africa [50]. It is found on every continent except Antarctica, although its distribution is confined mostly to the northern and southern temperate zones. Bull thistle is not native to North America. It is thought to have been introduced to eastern North America during colonial times, and to western North America in scattered locations in the late 1800s and early 1900s. Bull thistle is now common throughout the Pacific States, and it is the most common and widespread of pasture and rangeland thistles in western North America. The Plants database provides a distribution map of bull thistle in the United States.

Although bull thistle has been reported in all 50 states and most Canadian provinces [75,153], it usually is not considered as problematic as musk thistle (*Carduus nutans*) or Scotch thistle (*Onopordum acanthium*) [15]. Bull thistle is most troublesome in recently or repeatedly disturbed areas such as pastures, overgrazed rangelands, forest clearcuts, and waste places; and along roads, ditches, and fences. It is also a problem in some natural areas such as Yosemite National Park, California [50].

The following lists reflect ecosystems and cover types in which bull thistle may be invasive. Because it is so widespread and has broad ecological tolerances, it is difficult to exclude many ecosystems as potential hosts of bull thistle plants or populations.

ECOSYSTEMS [52]:
FRES10 White-red-jack pine
FRES11 Spruce-fir
FRES12 Longleaf-slash pine
FRES13 Loblolly-shortleaf pine
FRES14 Oak-pine
FRES15 Oak-hickory
FRES16 Oak-gum-cypress
FRES17 Elm-ash-cottonwood
FRES18 Maple-beech-birch
FRES19 Aspen-birch
FRES20 Douglas-fir
FRES21 Ponderosa pine
FRES22 Western white pine
FRES23 Fir-spruce
FRES24 Hemlock-Sitka spruce
FRES25 Larch
FRES26 Lodgepole pine
FRES27 Redwood
FRES28 Western hardwoods
FRES29 Sagebrush
FRES30 Desert shrub
FRES33 Southwestern shrubsteppe
FRES34 Chaparral-mountain shrub
FRES35 Pinyon-juniper
FRES36 Mountain grasslands
FRES37 Mountain meadows
FRES38 Plains grasslands
FRES39 Prairie
FRES40 Desert grasslands
FRES41 Wet grasslands
FRES42 Annual grasslands
FRES44 Alpine

STATES [153]:

AL	AK	AZ	AR	CA	CO	CT	DE	FL	GA
HI	ID	IL	IN	IA	KS	KY	LA	ME	MD
MA	MI	MN	MS	MO	MT	NE	NV	NH	NJ
NM	NY	NC	ND	OH	OK	OR	PA	RI	SC
SD	TN	TX	UT	VT	VA	WA	WV	WI	WY
DC									

AB	BC	MB	NB	NT	NS	ON	PE	PQ	SK

BLM PHYSIOGRAPHIC REGIONS [18]:
1 Northern Pacific Border
2 Cascade Mountains

3 Southern Pacific Border
4 Sierra Mountains
5 Columbia Plateau
6 Upper Basin and Range
7 Lower Basin and Range
8 Northern Rocky Mountains
9 Middle Rocky Mountains
10 Wyoming Basin
11 Southern Rocky Mountains
12 Colorado Plateau
13 Rocky Mountain Piedmont
14 Great Plains
15 Black Hills Uplift
16 Upper Missouri Basin and Broken Lands

KUCHLER [83] PLANT ASSOCIATIONS:
K001 Spruce-cedar-hemlock forest
K002 Cedar-hemlock-Douglas-fir forest
K003 Silver fir-Douglas-fir forest
K004 Fir-hemlock forest
K005 Mixed conifer forest
K006 Redwood forest
K007 Red fir forest
K008 Lodgepole pine-subalpine forest
K009 Pine-cypress forest
K010 Ponderosa shrub forest
K011 Western ponderosa forest
K012 Douglas-fir forest
K013 Cedar-hemlock-pine forest
K014 Grand fir-Douglas-fir forest
K015 Western spruce-fir forest
K016 Eastern ponderosa forest
K017 Black Hills pine forest
K018 Pine-Douglas-fir forest
K019 Arizona pine forest
K020 Spruce-fir-Douglas-fir forest
K021 Southwestern spruce-fir forest
K022 Great Basin pine forest
K023 Juniper-pinyon woodland
K024 Juniper steppe woodland
K025 Alder-ash forest
K026 Oregon oakwoods
K027 Mesquite bosques
K028 Mosaic of K002 and K026
K029 California mixed evergreen forest
K030 California oakwoods
K031 Oak-juniper woodland
K032 Transition between K031 and K037
K033 Chaparral
K034 Montane chaparral
K035 Coastal sagebrush
K036 Mosaic of K030 and K035
K037 Mountain-mahogany-oak scrub

K038 Great Basin sagebrush
K039 Blackbrush
K040 Saltbush-greasewood
K041 Creosote bush
K042 Creosote bush-bursage
K043 Paloverde-cactus shrub
K044 Creosote bush-tarbush
K047 Fescue-oatgrass
K048 California steppe
K049 Tule marshes
K050 Fescue-wheatgrass
K051 Wheatgrass-bluegrass
K052 Alpine meadows and barren
K053 Grama-galleta steppe
K054 Grama-tobosa prairie
K055 Sagebrush steppe
K056 Wheatgrass-needlegrass shrubsteppe
K057 Galleta-threeawn shrubsteppe
K058 Grama-tobosa shrubsteppe
K059 Trans-Pecos shrub savanna
K063 Foothills prairie
K064 Grama-needlegrass-wheatgrass
K065 Grama-buffalo grass
K066 Wheatgrass-needlegrass
K067 Wheatgrass-bluestem-needlegrass
K068 Wheatgrass-grama-buffalo grass
K069 Bluestem-grama prairie
K070 Sandsage-bluestem prairie
K072 Sea oats prairie
K073 Northern cordgrass prairie
K074 Bluestem prairie
K075 Nebraska Sandhills prairie
K076 Blackland prairie
K077 Bluestem-sacahuista prairie
K081 Oak savanna
K082 Mosaic of K074 and K100
K083 Cedar glades
K084 Cross Timbers
K085 Mesquite-buffalo grass
K088 Fayette prairie
K089 Black Belt
K090 Live oak-sea oats
K093 Great Lakes spruce-fir forest
K094 Conifer bog
K095 Great Lakes pine forest
K096 Northeastern spruce-fir forest
K097 Southeastern spruce-fir forest
K098 Northern floodplain forest
K099 Maple-basswood forest
K100 Oak-hickory forest
K101 Elm-ash forest
K102 Beech-maple forest
K103 Mixed mesophytic forest

K104 Appalachian oak forest
K106 Northern hardwoods
K107 Northern hardwoods-fir forest
K108 Northern hardwoods-spruce forest
K109 Transition between K104 and K106
K110 Northeastern oak-pine forest
K111 Oak-hickory-pine
K112 Southern mixed forest
K113 Southern floodplain forest
K114 Pocosin
K115 Sand pine scrub
K116 Subtropical pine forest

SAF COVER TYPES [47]:
1 Jack pine
5 Balsam fir
12 Black spruce
13 Black spruce-tamarack
14 Northern pin oak
15 Red pine
16 Aspen
17 Pin cherry
18 Paper birch
19 Gray birch-red maple
20 White pine-northern red oak-red maple
21 Eastern white pine
22 White pine-hemlock
23 Eastern hemlock
24 Hemlock-yellow birch
25 Sugar maple-beech-yellow birch
26 Sugar maple-basswood
27 Sugar maple
28 Black cherry-maple
30 Red spruce-yellow birch
31 Red spruce-sugar maple-beech
32 Red spruce
33 Red spruce-balsam fir
34 Red spruce-Fraser fir
35 Paper birch-red spruce-balsam fir
37 Northern white-cedar
38 Tamarack
39 Black ash-American elm-red maple
40 Post oak-blackjack oak
42 Bur oak
43 Bear oak
44 Chestnut oak
45 Pitch pine
46 Eastern redcedar
50 Black locust
51 White pine-chestnut oak
52 White oak-black oak-northern red oak
53 White oak
55 Northern red oak

57 Yellow-poplar
58 Yellow-poplar-eastern hemlock
59 Yellow-poplar-white oak-northern red oak
60 Beech-sugar maple
61 River birch-sycamore
62 Silver maple-American elm
63 Cottonwood
64 Sassafras-persimmon
65 Pin oak-sweetgum
66 Ashe juniper-redberry (Pinchot) juniper
68 Mesquite
69 Sand pine
70 Longleaf pine
71 Longleaf pine-scrub oak
72 Southern scrub oak
73 Southern redcedar
74 Cabbage palmetto
75 Shortleaf pine
76 Shortleaf pine-oak
78 Virginia pine-oak
79 Virginia pine
80 Loblolly pine-shortleaf pine
81 Loblolly pine
82 Loblolly pine-hardwood
83 Longleaf pine-slash pine
84 Slash pine
85 Slash pine-hardwood
87 Sweetgum-yellow-poplar
88 Willow oak-water oak-diamondleaf (laurel) oak
89 Live oak
91 Swamp chestnut oak-cherrybark oak
92 Sweetgum-willow oak
93 Sugarberry-American elm-green ash
94 Sycamore-sweetgum-American elm
95 Black willow
96 Overcup oak-water hickory
97 Atlantic white-cedar
98 Pond pine
100 Pondcypress
101 Baldcypress
102 Baldcypress-tupelo
103 Water tupelo-swamp tupelo
104 Sweetbay-swamp tupelo-redbay
105 Tropical hardwoods
106 Mangrove
107 White spruce
108 Red maple
109 Hawthorn
110 Black oak
111 South Florida slash pine
201 White spruce
202 White spruce-paper birch
203 Balsam poplar

204 Black spruce
205 Mountain hemlock
206 Engelmann spruce-subalpine fir
207 Red fir
208 Whitebark pine
209 Bristlecone pine
210 Interior Douglas-fir
211 White fir
212 Western larch
213 Grand fir
215 Western white pine
216 Blue spruce
217 Aspen
218 Lodgepole pine
219 Limber pine
220 Rocky Mountain juniper
221 Red alder
222 Black cottonwood-willow
223 Sitka spruce
224 Western hemlock
225 Western hemlock-Sitka spruce
226 Coastal true fir-hemlock
227 Western redcedar-western hemlock
228 Western redcedar
229 Pacific Douglas-fir
230 Douglas-fir-western hemlock
231 Port-Orford-cedar
232 Redwood
233 Oregon white oak
234 Douglas-fir-tanoak-Pacific madrone
235 Cottonwood-willow
236 Bur oak
237 Interior ponderosa pine
238 Western juniper
239 Pinyon-juniper
240 Arizona cypress
241 Western live oak
242 Mesquite
243 Sierra Nevada mixed conifer
244 Pacific ponderosa pine-Douglas-fir
245 Pacific ponderosa pine
246 California black oak
247 Jeffrey pine
248 Knobcone pine
249 Canyon live oak
250 Blue oak-foothills pine
251 White spruce-aspen
252 Paper birch
253 Black spruce-white spruce
254 Black spruce-paper birch
255 California coast live oak
256 California mixed subalpine

SRM (RANGELAND) COVER TYPES [140]:
101 Bluebunch wheatgrass
102 Idaho fescue
103 Green fescue
104 Antelope bitterbrush-bluebunch wheatgrass
105 Antelope bitterbrush-Idaho fescue
106 Bluegrass scabland
107 Western juniper/big sagebrush/bluebunch wheatgrass
108 Alpine Idaho fescue
109 Ponderosa pine shrubland
110 Ponderosa pine-grassland
201 Blue oak woodland
202 Coast live oak woodland
203 Riparian woodland
204 North coastal shrub
205 Coastal sage shrub
206 Chamise chaparral
207 Scrub oak mixed chaparral
208 Ceanothus mixed chaparral
209 Montane shrubland
210 Bitterbrush
211 Creosote bush scrub
212 Blackbush
213 Alpine grassland
214 Coastal prairie
215 Valley grassland
216 Montane meadows
217 Wetlands
301 Bluebunch wheatgrass-blue grama
302 Bluebunch wheatgrass-Sandberg bluegrass
303 Bluebunch wheatgrass-western wheatgrass
304 Idaho fescue-bluebunch wheatgrass
305 Idaho fescue-Richardson needlegrass
306 Idaho fescue-slender wheatgrass
307 Idaho fescue-threadleaf sedge
308 Idaho fescue-tufted hairgrass
309 Idaho fescue-western wheatgrass
310 Needle-and-thread-blue grama
311 Rough fescue-bluebunch wheatgrass
312 Rough fescue-Idaho fescue
313 Tufted hairgrass-sedge
314 Big sagebrush-bluebunch wheatgrass
315 Big sagebrush-Idaho fescue
316 Big sagebrush-rough fescue
317 Bitterbrush-bluebunch wheatgrass
318 Bitterbrush-Idaho fescue
319 Bitterbrush-rough fescue
320 Black sagebrush-bluebunch wheatgrass
321 Black sagebrush-Idaho fescue
322 Curlleaf mountain-mahogany-bluebunch wheatgrass
323 Shrubby cinquefoil-rough fescue
324 Threetip sagebrush-Idaho fescue
401 Basin big sagebrush

402 Mountain big sagebrush
403 Wyoming big sagebrush
404 Threetip sagebrush
405 Black sagebrush
406 Low sagebrush
407 Stiff sagebrush
408 Other sagebrush types
409 Tall forb
410 Alpine rangeland
411 Aspen woodland
412 Juniper-pinyon woodland
413 Gambel oak
414 Salt desert shrub
415 Curlleaf mountain-mahogany
416 True mountain-mahogany
417 Littleleaf mountain-mahogany
418 Bigtooth maple
419 Bittercherry
420 Snowbrush
421 Chokecherry-serviceberry-rose
422 Riparian
501 Saltbush-greasewood
502 Grama-galleta
503 Arizona chaparral
504 Juniper-pinyon pine woodland
505 Grama-tobosa shrub
506 Creosotebush-bursage
507 Palo verde-cactus
508 Creosotebush-tarbush
509 Transition between oak-juniper woodland and mahogany-oak association
601 Bluestem prairie
602 Bluestem-prairie sandreed
603 Prairie sandreed-needlegrass
604 Bluestem-grama prairie
605 Sandsage prairie
606 Wheatgrass-bluestem-needlegrass
607 Wheatgrass-needlegrass
608 Wheatgrass-grama-needlegrass
609 Wheatgrass-grama
610 Wheatgrass
611 Blue grama-buffalo grass
612 Sagebrush-grass
613 Fescue grassland
614 Crested wheatgrass
615 Wheatgrass-saltgrass-grama
701 Alkali sacaton-tobosagrass
702 Black grama-alkali sacaton
703 Black grama-sideoats grama
704 Blue grama-western wheatgrass
705 Blue grama-galleta
706 Blue grama-sideoats grama
707 Blue grama-sideoats grama-black grama
708 Bluestem-dropseed

709 Bluestem-grama
710 Bluestem prairie
711 Bluestem-sacahuista prairie
712 Galleta-alkali sacaton
713 Grama-muhly-threeawn
714 Grama-bluestem
715 Grama-buffalo grass
716 Grama-feathergrass
717 Little bluestem-Indiangrass-Texas wintergrass
718 Mesquite-grama
720 Sand bluestem-little bluestem (dunes)
721 Sand bluestem-little bluestem (plains)
722 Sand sagebrush-mixed prairie
723 Sea oats
724 Sideoats grama-New Mexico feathergrass-winterfat
725 Vine mesquite-alkali sacaton
727 Mesquite-buffalo grass
729 Mesquite
730 Sand shinnery oak
731 Cross timbers-Oklahoma
732 Cross timbers-Texas (little bluestem-post oak)
733 Juniper-oak
734 Mesquite-oak
735 Sideoats grama-sumac-juniper
801 Savanna
802 Missouri prairie
803 Missouri glades
804 Tall fescue
805 Riparian
808 Sand pine scrub
809 Mixed hardwood and pine
815 Upland hardwood hammocks
816 Cabbage palm hammocks
817 Oak hammocks

HABITAT TYPES AND PLANT COMMUNITIES:
Bull thistle is widespread and occurs in many types of plant communities in North America. A comprehensive treatment of plant communities in which it occurs is not available. The following discussion provides examples of plant communities associated with bull thistle that have been mentioned in the literature.

In the Pacific Northwest, bull thistle occurs on foothills and in dry meadows [69]. It occurs in riparian areas, clearcuts, and alder (*Alnus* spp.) flats in the western hemlock-Sitka spruce (*Tsuga heterophylla-Picea sitchensis*) zones on Olympic Peninsula in Washington [35]. Bull thistle also occurs in riparian areas and in ponderosa pine (*Pinus ponderosa*) communities on preserves in northeastern Oregon [129].

In the Intermountain region, bull thistle occurs primarily in disturbed habitats and in seepage areas or along streams [28]. It often establishes after disturbance (logging with and without burning) in grand fir (*Abies grandis*), Douglas-fir (*Pseudotsuga menziesii*), and ponderosa pine forests in Idaho [57,141], Oregon [27,45,104], and Montana [4,5]. Bull thistle often establishes after timber harvest with and without burning in western hemlock, western redcedar (*Thuja plicata*), and grand fir forests in northern Idaho [72]; and in grand fir and subalpine fir (*Abies lasiocarpa*) forests in western Montana [2,92,143]. Bull thistle is also invasive in grasslands on Thousand Springs Preserve in Idaho [129].

Bull thistle is found on tallgrass prairie sites on preserves in South Dakota [129]. In Michigan, bull thistle may establish after logging in oak-hickory (*Quercus-Carya* spp.) and maple (*Acer* spp.)-oak forests [29,85]. Here it may also establish after fire or ground disturbance such as bulldozing, and can also invade natural communities adjacent to disturbed habitats [157]. In Minnesota, bull thistle established after full-tree logging in a balsam fir-paper birch (*Abies balsamea-Betula papyrifera*) community [113].

Bull thistle often establishes in Sierra Nevada mixed-conifer forests after clearcutting [1,95,96,97]. It is also an important understory species in tanoak (*Lithocarpus densiflorus*) forests in California and Oregon [149].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Cirsium vulgare

GENERAL BOTANICAL CHARACTERISTICS:
The following description is based on reviews by Beck [15], Klinkhamer and de Jong [80] and Forcella and Randall [50]. It presents characteristics of bull thistle that may be relevant to fire ecology, and is not meant to be used for identification. Keys for identifying bull thistle are available (e.g. [28,53,56,84,161]). A detailed description of the biology of bull thistle is given by Klinkhamer and de Jong [80].

Bull thistle is a biennial, and sometimes annual or monocarpic perennial, forb. In the juvenile phase, individual bull thistle plants form a single rosette with a taproot up to 28 inches (70 cm) long. Rosettes may develop up to 3.3 feet (1 m) in diameter. The taproot does not spread, but develops several smaller lateral roots. Stems have spiny wings and grow 1 to 6.6 feet (0.3 to 2 m) tall, with many spreading branches, and sometimes a single stem. Bull thistle stem leaves are more or less lance-shaped and 3 to 12 inches (7.6-30 cm) long, prickly hairy on the top and very hairy underneath. Lobes on leaves are tipped with stout spines. Bull thistle flowerheads are 1.5 to 2 inches (3.8 to 5 cm) in diameter, 1 to 2 inches (2.5-5 cm) long, usually solitary, and more or less clustered at the ends of shoots and branches. Flowers are subtended by narrow, spine-tipped bracts. Bull thistle fruits are achenes, 1/16th-inch (0.15 cm) long, with a long, hairy plume that is easily detached.

The litter of *Cirsium* species is said to inhibit the growth of other plants. In bull thistle, this is probably a result of the immobilization of nutrients during the process of litter breakdown [80]. Descriptions of mycorrhizal associations in bull thistle [17,62] and their positive effects on its growth [163] are available.

RAUNKIAER [124] LIFE FORM:
Hemicryptophyte
Therophyte

REGENERATION PROCESSES:
A detailed description of reproductive and vegetative biology of bull thistle in New Zealand is provided by Michaux [103].

Breeding system: Bull thistle reproduces and spreads entirely from seeds [80]. Bull thistle flowers are bisexual [80,122]. While there is some evidence of self-pollination, selfing may result only in hollow seeds; therefore, bull thistle may require cross-pollination to set fertile seed. Only those plants that flower during the main flowering period, or where plants are growing in sufficient density, will contribute substantially to the following generation

[103]. Klinkhamer and de Jong [80] report that self-pollinated plants produce a smaller number of large seeds than do cross-pollinated individuals. A review by Forcella and Randall [50], however, indicates that heavy seeds may be produced through self-pollination, and that these seeds can establish at high rates and enable isolated plants to begin new populations.

Pollination: Bull thistle flowers produce abundant nectar [122] and require pollinators for effective pollination [103]. A wide variety of insects pollinate bull thistle [106]. Pollinators of bull thistle in New Zealand include honey bees, bumble bees, flower flies and various other adult Lepidoptera, Thysanoptera, and Hymenoptera [103].

Seed production:
Bull thistle plants produce about 100 to 300 or more seeds per flowerhead under favorable conditions, and anywhere from 1 to over 400 flowerheads per plant [50,79,80,103,122]. Variability in production of seeds per flowerhead and flowerheads per plant yields a wide range in number of seeds produced per plant. Bull thistle seed production can also vary considerably among years and within populations [79]. Size of mature bull thistle plants, timing of flowering and environmental conditions can influence seed production.

The number of viable seeds produced by a bull thistle plant varies with its overall size [50,103], which is, in turn, influenced by competition, site conditions, and herbivory [50]. Seed production and seedling establishment are often enhanced under disturbed conditions, which create open, habitable sites for invasive species [15]. A comparison of bull thistle demography in grazed and ungrazed pastures in Australia found that plants produced nearly 3 times as much seed on average in heavily grazed pasture (33 flowerheads per plant and 198 seeds per flowerhead) compared to ungrazed pasture (19 flowerheads per plant and 149 seeds per flowerhead) when averaged over 3 years [49]. Bull thistle seed production on Dutch coastal dunes was much lower than that recorded in an experimental garden, and was positively correlated with July rainfall. Seed and stem predation contributed to losses of 95% to over 99% in seed production on coastal dunes [79,80].

Time of flowering also affects total seed production in bull thistle. Seed production is highest in flowerheads that bloom during the peak of flowering at a particular location. At this time, more flowers are available for cross-pollination, and pollinators are most active [49,103]. Forcella and Randall [50] suggest that a lack of sufficient photosynthate and nutrients during aging can decrease seed production substantially.

Seed dispersal:
Bull thistle seeds are equipped with a feathery pappus that is suited to wind dispersal, although it is unclear how effective this dispersal mechanism is. Several researchers (e.g. [1,92,95,97,137,143,150]) cite instances where bull thistle established after disturbance, possibly from wind-dispersed seed, unless bull thistle plants established from seed carried by animals or human activities or from seed stored in soil (see "Seed banking" section below).

Michaux [103] notes that the pappus readily detaches from bull thistle seed at maturity, so a majority of seeds (91%) fall within a distance of 1.5 times the height of the parent plant. This explains the dense pattern of seedlings near the parent plant often observed in the field [103]. On coastal dunes in the Netherlands, seeds landing within 3, 7, and 106 feet (1, 2, and 32 m) of parent plants represented 50, 66, and 90% of those observed. The remaining 10% reached higher air levels and dispersed to unknown distances greater than 106 feet (32 m) [79]. Based on weight, size, shape, fall speed, and lateral movement of bull thistle achenes in still air, the estimated lateral dispersal distance in a 6-mile-per-hour (10 km/hour) breeze is 38 feet (11.6 m) [94]. These studies suggest that wind dispersal is an inefficient mechanism for the majority of bull thistle seed, even under ideal conditions. However, up to 10% of seeds produced may travel distances of more than 90 feet (27 m), even on days with little wind [122], thus providing opportunities for establishment of new populations.

Rapid migration of bull thistle across large geographical regions is probably the result of human activities including movement of livestock, vehicles, farm machines, and plant products (such as seed and hay) [15,50,103]. Reviews by Mitich [106] and Beck [15] also suggest that bull thistle seeds may be carried by water and animals.

Seed banking:
Evidence for seed banking in bull thistle varies. Numerous examples of bull thistle establishment following disturbance suggest either long-distance seed dispersal or seed stored in the soil. Reviews by Doucet and Cavers [41], Michaux [103], and Forcella and Randall [50] indicate that bull thistle is characterized as having either a transient or a very small persistent seed bank. Doucet and Cavers [41] note that studies concluding that bull thistle has a short-lived seed bank (e.g. [79]) only consider seeds located on or near the soil surface, and that seeds buried at least 6 inches (15 cm) may have over 50% viability 3 years after burial. Bull thistle seeds at or near the soil surface either germinate or are destroyed by rodents, insects, or microbes [79]. Those buried at greater depths appear to experience an induced dormancy, and decay more slowly with increasing depth [38,80,103]. A seed bank at 6 inches (15 cm) or deeper will not maintain a bull thistle population from year to year, but it could provide seeds that would re-establish the population after major physical disturbance of the soil [41]. In noncultivated areas, however, bull thistle seeds are not usually buried to great depths.

To form a persistent seed bank, bull thistle seeds would have to exhibit some form of dormancy that would enable them to remain viable at or near the surface of the soil without germinating [41]. Klinkhamer and de Jong [80] state that maintaining bull thistle seeds in an imbibed state in darkness induces dormancy. This suggests that in densely vegetated habitats it is possible that bull thistle seeds may become dormant and remain viable without germinating.

Bull thistle seeds from 2 populations in Ontario established a persistent seed bank when buried 6 inches (15 cm). After storage on the soil surface or at 1-inch (3 cm) depth, bull thistle seeds in sandy soil on an open site did not persist beyond 6 months. In contrast, 2 to 14% of bull thistle seeds stored in shaded conditions in a clay loam soil maintained viability for 30 months at the surface and at 1 inch below the surface, with no decline in the number of viable seeds over time, suggesting an induced dormancy [41]. Induced dormancy might also explain why, although bull thistle was not present in the vegetation of 40- to 60-year-old, closed canopy forest understories in low-elevation forest on the Olympic Peninsula, it germinated from both litter and soil samples when placed in a greenhouse. This result suggests that bull thistle will establish on these sites following overstory removal [61].

Evidence provided by Doucet and Cavers [41,42], and by greenhouse studies in which bull thistle emerged from litter and soil samples from forested sites with little to no bull thistle cover [81,118,146], supports the possibility of a small persistent seed bank in bull thistle. There are also numerous examples of bull thistle's early seral dominance after disturbances such as harvesting [4,5,27,29,57,60,72,113,128,131], burning [10,16], or both [4,5,45,85,104,141], although it is not clear from these studies whether bull thistle established from buried seed or from seed dispersed from an off-site source.

Germination: Bull thistle seed viability is generally high, and may vary between 60 and 90% [80,103] or more [122]. Reviews by Michaux [103] and Klinkhamer and de Jong [80] indicate that bull thistle seeds have little innate dormancy and germinate rapidly after imbibition, while a review by Beck [15] indicates that 60 to 75% of bull thistle seeds may be dormant at maturity, but up to 90% may germinate within a year. A review by Forcella and Randall [50] indicates that the timing of emergence of bull thistle seedlings results from the interaction of dormancy mechanisms, soil temperature, and rainfall patterns and will, therefore, vary by site and regional characteristics. Cavers and others [24] discuss the pattern of germination in bull thistle over time. Germination of bull thistle seeds is affected by moisture, light availability, gap size, and temperature.

Germination of bull thistle seeds typically occurs in spring or fall in response to adequate soil moisture [49,103,106,122]. Bull thistle seed germination is less sensitive to low water potential than that of several other thistle species. The relative germination of bull thistle seeds decreased linearly from 100% at 0 MPa to 10% at -0.75 MPa [58]. In Dutch sand dunes the number of emerging seedlings in spring was related to both soil moisture and soil nitrate levels, implying that, combined with temperature, these 2 factors help to regulate seed germination [33]. Downs and Cavers [43] found that germination rate in bull thistle was reduced after exposure to 2 or more cycles of wetting and drying, and that total percent germination was reduced after exposure to 8 cycles of wetting and drying. This evidence supports the idea that bull thistle seeds may acquire an induced dormancy through exposure to cycles of wetting and drying such as can be experienced in the uppermost layers of soil.

Germination rate of bull thistle seeds tends to decrease as light decreases [80,103,118]. Doucet and Cavers [42] report that fresh bull thistle seeds are capable of germinating in either alternating light and dark or constant dark conditions under favorable diurnal temperatures of 77/50 degrees Fahrenheit (25/10 °C). In a laboratory study, seeds were stored over winter at 41 degrees Fahrenheit (5 °C) in either alternating light and dark, or in constant darkness. Seeds treated with alternating light and dark did not require light for germination when placed under optimal temperatures, whereas seeds treated with constant darkness did require additional light for germination. In the field, seeds that do not germinate in the fall and then spend the winter in darkness (e.g. in deep shade, under leaves, or buried by ants, earthworms or other animals) can acquire this induced dormancy and be prevented from germinating. Such seeds have the potential of forming a persistent seed bank [41,42]. Light requirement for germination of bull thistle seeds is also evidenced by higher germination rates in large (4-8 inches (10-20 cm)) gaps than in smaller gaps (Silvertown and Smith 1989, as cited by [80]). Bull thistle is dependent on canopy gaps for seedling emergence and establishment [20].

Bull thistle seeds germinate well over a wide range of temperatures [50]. Germination of bull thistle seeds is reduced if the temperature is outside the range of 50 to 86 degrees Fahrenheit (10-30 °C). Fresh seeds have higher optimum temperature for germination than stored seeds [80,103].

Seedling establishment/growth:
Bull thistle seedling establishment is favored by soil disturbance and seedling growth is favored by vegetation disturbance. The absolute growth of bull thistle seedlings is very low for 2 months after sowing, even under ideal conditions [50]. Transition from seedlings to rosettes is when the greatest attrition in bull thistle populations typically occurs [49,80,121]. Bull thistle seedlings have higher survival rates under high nutrient conditions [11,49].

Bull thistle establishes better in grazed versus ungrazed pasture. About 15% and 10% of seeds from grazed and ungrazed pastures, respectively, produced seedlings, and the average survival of seedlings in grazed and ungrazed pastures was 1% and 0.2% respectively. Fifty percent of rosettes in both pasture types survived and grew into adults [49]. An annual census of 2 bull thistle-infested meadows in Yosemite National Park found that seedlings accounted for about 85% of deaths observed, 13% of mortality was rosettes, and less than 2% of mortality was due to individuals that died after flowering [121]. On Dutch coastal dunes, bull thistle seedling mortality is related to soil moisture content and tends to be high, with only 23 to 47% of seedlings surviving from spring to autumn. Yearly death of rosettes varies between 10 and 69%, with the chance of dying inversely related to rosette size [80]. Bull thistle rosettes that are top-killed under dry or cold stress in the 1st season can grow again from the root crown during late winter or spring [106].

SITE CHARACTERISTICS:
Bull thistle is a very widespread weed that can grow in a wide range of environments but is most troublesome in recently or repeatedly disturbed areas such as pastures, overgrazed rangelands, recently burned forests and forest clearcuts, and along roads, ditches, and fences. Even small-scale disturbances such as gopher mounds promote bull thistle establishment and survival [122], and density tends to increase as grazing intensity increases. Bull thistle is seldom found in ungrazed prairies and pastures [15,49,111,159]. Similarly, in Yosemite National Park bull thistle germination was promoted by removal of vegetation and further promoted by soil disturbance [120]. Bull thistle can also colonize areas in relatively undisturbed grasslands, meadows and forest openings [122].

The distribution of bull thistle in Eurasia is closely linked to that of cultivated land. In the U.S., bull thistle is common in regions with intensive cattle commerce. In Canada, it is present in agricultural areas but absent from prairies [80]. In California, bull thistle is widespread and most common in coastal grasslands, along edges of fresh and brackish marshes, in meadows, and in mesic forest openings in the mountains [122]. Landscape patch types where bull thistle was found on the Olympic Peninsula in Washington include riparian cobble bars, riparian shrub communities, and clearcuts [35].

Bull thistle is found on dry and wet soils, but is most common on soils with intermediate moisture [80,120]. It is largely absent from deeply shaded and waterlogged habitats. Bull thistle tolerates a wide range of pH values, though it is rare on soils of pH <4.8-5.0 [80]. It proliferates in pastures subject to nitrogen fertilization [15,80], but has no apparent relationship with potassium or phosphorus content. Bull thistle is less common in sand and on soils of >30% humus content, and almost absent from pure clay [80].

Bull thistle is found as far north as 67°50' N latitude in Scandinavia. In shade, bull thistle is restricted to south-facing slopes. In dry habitats such as coastal dunes it is confined to north-facing slopes [80]. It has been suggested that bull thistle plants are not very invasive in the southern part of its North American range. This has been attributed to a peculiarity in their dispersal biology, where the achenes remain enclosed inside the seedheads after they are fully mature and are released only at the end of the season when the whole plant eventually falls over. Numerous achenes then germinate in situ in a cluster, but apparently only 1 of them survives to maturity [112].

Infestations of bull thistle in North America have been reported as high as 9,200 feet (2,800 m) [37]. Bull thistle was found on alpine sites in Utah [65], and on a subalpine riparian site in Montana [91]. The following table provides some elevational ranges for bull thistle by state:

Area	Elevational range	References
California	up to 7,600 feet (2,300 m)	[68]
Colorado	up to 9,000 feet (2,700 m)	[133]
New Mexico	4,500 to 7,500 feet (1,400-2,300 m)	[93]
Utah	4,420 to 9,060 feet (1,340-2,745 m)	[161]

SUCCESSIONAL STATUS:
Bull thistle is an early successional species that establishes well in open, disturbed sites, and is an important weed in clearcuts and conifer plantations in the western U.S. [128]. Examples where bull thistle is reported as an early successional component and sometimes dominant after timber harvest (with and without burning) include studies in California [95,97], Oregon [27,45,60,104], Idaho [57,72,141], Montana [4,5,137], and Michigan [29,85]. Bull thistle is 1 of several species of Asteraceae that often become prolific immediately after fire in southern Tasmania, Australia [10], and was a common component in study plots following wildfire and suppression efforts in Glacier National Park in the fall of 1988 [16]. Bull thistle was also among the pioneering species in primary successional habitats on Mount St. Helens following the eruption in 1980 [150]. It is a common component on repeatedly disturbed sites such as roadsides [114] and grazed pastures. In Australia bull thistle populations persisted for 4 years in grazed pasture but declined in ungrazed pasture, suggesting that grazing allowed bull thistle populations to thrive [49].

Populations of bull thistle tend to be short lived, establishing after disturbance, dominating for a few years, and then declining as other vegetation recovers [27,33,41,95,96,155,167]. Few bull thistle plants can be found in undisturbed clearcuts and plantations older than 8 years [128], although some plants may remain for longer periods. After clearcutting of subalpine fir in western Montana, bull thistle cover peaked after 3 years, was still present after 17 years, but was not present on undisturbed sites or 1-year-old cuts [92]. Bull thistle was present 7 to 16 years after clearcutting in grand fir in western Montana, but absent from adjacent uncut forest [2]. Bull thistle was the most frequent species observed 6 to 9 years after clearcutting in Sierra Nevada mixed conifer [1]. The peak distribution of bull thistle in German old fields is 3 to 4 years following disturbance [80]. Specific patterns of succession are described for Douglas-fir and ponderosa pine forests in California and Oregon [98] and for burned Douglas-fir clearcuts in the Coast range of western Oregon, where bull thistle is the dominant species the 2nd year after clearcutting [131].

True biennials are uncommon or absent in late successional plant communities because they often need abundant light for establishment [50]. Doucet and Cavers [41] note that bull thistle is absent from densely shaded areas. A review by Klinkhamer and de Jong [80] indicates that bull thistle is almost absent if light is reduced to less than

40% of full sunlight. Bull thistle invasion is enhanced in pastures with decreased vegetative cover [49]. In a greenhouse experiment, bull thistle germination was not suppressed by sedge (*Carex* spp.) cover, but subsequent survival of seedlings was reduced and the percentage of seeds that germinated and survived decreased exponentially with increasing cover [121]. In Dutch coastal dunes, however, bull thistle was more restricted to shaded sites [34].

SEASONAL DEVELOPMENT:
Bull thistle plants usually release seed in late summer and early autumn. Germination may occur shortly after the onset of autumn rains or in spring when soil temperatures rise. An individual bull thistle plant produces a small rosette of spiny leaves and a fleshy taproot by the end of its 1st year, and generally overwinters in this form. In its 2nd growing season the rosette typically enlarges rapidly, bolts, and produces a flowering stalk. Flowering occurs from mid to late summer, but inflorescences can be seen until the 1st frost or snowfall in autumn [15,50]. Outer florets mature first, and the innermost last [103]. The time interval between bolting and seed maturation decreases as temperature increases [50].

Seed dispersal immediately follows maturation [49]. Individual flowers last for only a few days before the floral tissue wilts and the involucre bracts turn brown and open out -- the time taken depends on relative humidity. The pappus is thus exposed to air currents, and the innermost seeds are dispersed 1st as the receptacle arches upwards. A single plant may remain in a flowering state anywhere from 1 to 6 weeks, depending on the number of flowers. A population of bull thistle in New Zealand flowered for a total of 5 months [103]. Bull thistle plants are monocarpic, dying after they set seed [50]. Dead plants can remain standing for 1 or 2 years.

Bull thistle requires a vernalization
period before bolting. There is no size requirement for vernalization; however, plants need to attain a certain size after vernalization to bolt and flower. Some plants (about 1%) may flower without vernalization, and this may vary with location [80]. At Yosemite National Park, 2 individuals less than a year old flowered in September [121]. Evidence presented by Wesselingh and others [162] suggests a geographical variation in the vernalization requirement among European populations of bull thistle, based on observations of a latitudinal gradient in vernalization requirement in other biennials. In a common garden experiment, bull thistle plants from southern Europe tended to exhibit an annual habit, bolting and flowering without vernalization. Those from northern populations acted as biennials, flowering after vernalization in their 2nd year. It is unknown if these plants exhibit annual or biennial life cycles at their place of origin. Klinkhamer and others [79] indicate that bull thistle plants may behave as winter annuals if they germinate in fall, are vernalized over winter, and grow luxuriantly in early spring. Plants behave as monocarpic perennials when growth was stunted because of conditions such as infertile soils and inclement weather [50].

Typical flowering dates are reported by area as follows:

Area	Time of flowering	References
California	June/July, early August	[50,122]
Carolinas	June-frost	[119,165]
Florida	spring	[166]
Great Plains	July-September	[56]
Illinois	July-August	[107]
Intermountain region	July and August	[28]
Iowa	June/July	[50]
Kansas	June-October	[13]
Minnesota	July/August	[50]
New England	July-October	[136]

New Mexico	June-September	[93]
northeastern US	June-October	[53]
Tennessee	June-October	[165]
Texas	June-November	[39,112]
Virginia	June-October	[165]
West Virginia	July-November	[145]

FIRE ECOLOGY

SPECIES: Cirsium vulgare

- FIRE ECOLOGY OR ADAPTATIONS
- POSTFIRE REGENERATION STRATEGY

FIRE ECOLOGY OR ADAPTATIONS:
Bull thistle reproduces by abundant seed, some of which may disperse over moderate distances by wind and some of which may remain dormant in the soil for several years (research thus far suggests up to 5) . Fire creates conditions that are favorable for establishment (i.e. open canopy, reduced competition, areas of bare soil), so if bull thistle seeds are present and competition minimal, bull thistle may be favored in the postfire community. This is supported by several examples of bull thistles establishment within a few years after fire [4,5,10,16,137,141,143]. More research is needed regarding adaptations of bull thistle to fire.

Bull thistle is the most common and widespread thistle of pastures and rangelands in western North America, so it occurs in a large number of ecosystems with different fire regimes. Introduced species can alter the rate of fire spread, the probability of fire occurrence, and the intensity of fire in an ecosystem [30]. It is unclear how the presence of bull thistle alters the fire regime of a given site, and it is unclear how a historical fire regime might affect the presence or abundance of bull thistle at a given site. Dominant species of forest communities in which bull thistle has been noted as a primary or secondary colonizer after disturbance are described in Habitat Types and Plant Communities. Bull thistle also occurs in tallgrass prairie ecosystems, where fire can stimulate flowering of native grasses [31]. In Kansas, frequent burning of tallgrass prairie is said to be effective in keeping out exotic plants on sites where prairie grasses are vigorous [70]. Bull thistle did not occur in any of these communities at the time in which historic fire regimes were functioning, but has established since fire exclusion began. It is unclear how the presence of bull thistle might affect fire regimes in these communities.

Because it is so widespread and has broad ecological tolerances, it is difficult to exclude many ecosystems as potential hosts of bull thistle plants or populations. The following table provides fire regime intervals for several plant communities in which bull thistle may be found.

Community or Ecosystem	Dominant Species	Fire Return Interval Range (years)
silver fir-Douglas-fir	*Abies amabilis-Pseudotsuga menziesii* var. *menziesii*	> 200
grand fir	*A. grandis*	35-200 [6]
maple-beech-birch	*Acer-Fagus-Betula*	> 1000
silver maple-American elm	*A. saccharinum-Ulmus americana*	< 35 to 200
sugar maple	*A. saccharum*	> 1000
sugar maple-basswood	*A. s.-Tilia americana*	> 1000 [158]

California chaparral	*Adenostoma* and/or *Arctostaphylos* spp.	< 35 to < 100 [115]
bluestem prairie	*Andropogon gerardii* var. *gerardii-Schizachyrium scoparium*	< 10 [82,115]
Nebraska sandhills prairie	*A. g.* var. *paucipilus-Schizachyrium scoparium*	< 10
bluestem-Sacahuista prairie	*A. littoralis-Spartina spartinae*	< 10
sagebrush steppe	*Artemisia tridentata/Pseudoroegneria spicata*	20-70 [115]
basin big sagebrush	*A. t.* var. *tridentata*	12-43 [134]
mountain big sagebrush	*A. t.* var. *vaseyana*	15-40 [7,21,105]
Wyoming big sagebrush	*A. t.* var. *wyomingensis*	10-70 (40**) [156,168]
coastal sagebrush	*A. californica*	< 35 to < 100
plains grasslands	*Bouteloua* spp.	< 35
cheatgrass	*Bromus tectorum*	< 10
California montane chaparral	*Ceanothus* and/or *Arctostaphylos* spp.	50-100 [115]
sugarberry-America elm-green ash	*Celtis laevigata-Ulmus americana-Fraxinus pennsylvanica*	< 35 to 200 [158]
curlleaf mountain-mahogany*	*Cercocarpus ledifolius*	13-1000 [8,135]
mountain-mahogany-Gambel oak scrub	*C. l.-Quercus gambelii*	< 35 to < 100 [115]
Atlantic white-cedar	*Chamaecyparis thyoides*	35 to > 200 [158]
Arizona cypress	*Cupressus arizonica*	< 35 to 200
northern cordgrass prairie	*Distichlis spicata-Spartina* spp.	1-3 [115]
beech-sugar maple	*Fagus* spp.-*Acer saccharum*	> 1000 [158]
California steppe	*Festuca-Danthonia* spp.	< 35 [115]
black ash	*Fraxinus nigra*	< 35 to 200 [158]
juniper-oak savanna	*Juniperus ashei-Quercus virginiana*	< 35
Ashe juniper	*J. a.*	< 35
western juniper	*J. occidentalis*	20-70
Rocky Mountain juniper	*J. scopulorum*	< 35
cedar glades	*J. virginiana*	3-7
tamarack	*Larix laricina*	35-200 [115]
western larch	*L. occidentalis*	25-100 [6]
yellow-poplar	*Liriodendron tulipifera*	< 35 [158]
wheatgrass plains grasslands	*Pascopyrum smithii*	< 35 [115]
Great Lakes spruce-fir	*Picea-Abies* spp.	35 to > 200
northeastern spruce-fir	*P.-A.* spp.	35-200 [44]
southeastern spruce-fir	*P.-A.* spp.	35 to > 200 [158]
Engelmann spruce-subalpine fir	*P. engelmannii-A. lasiocarpa*	35 to > 200 [6]
black spruce	*P. mariana*	35-200 [44]

blue spruce*	*P. pungens*	35-200 [6]
red spruce*	*P. rubens*	35-200 [44]
pine-cypress forest	*Pinus-Cupressus* spp.	< 35 to 200 [6]
pinyon-juniper	*P.-Juniperus* spp.	< 35 [115]
whitebark pine*	*P. albicaulis*	50-200 [6]
jack pine	*P. banksiana*	<35 to 200 [44]
Mexican pinyon	*P. cembroides*	20-70 [108,148]
Rocky Mountain lodgepole pine*	*P. contorta* var. *latifolia*	25-300+ [3,6,132]
Sierra lodgepole pine*	*P. c.* var. *murrayana*	35-200 [6]
shortleaf pine	*P. echinata*	2-15
slash pine	*P. elliottii*	3-8 [158]
Jeffrey pine	*P. jeffreyi*	5-30
western white pine*	*P. monticola*	50-200 [6]
longleaf-slash pine	*P. palustris-P. elliottii*	1-4 [110,158]
Pacific ponderosa pine*	*P. ponderosa* var. *ponderosa*	1-47 [6]
interior ponderosa pine*	*P. p.* var. *scopulorum*	2-30 [6,12,86]
Arizona pine	*P. p.* var. *arizonica*	2-10 [6]
Table Mountain pine	*P. pungens*	< 35 to 200 [158]
red pine (Great Lakes region)	*P. resinosa*	10-200 (10**) [44,51]
red-white-jack pine*	*P. r.-P. strobus-P. banksiana*	10-300 [44,66]
pitch pine	*P. rigida*	6-25 [19,67]
pocosin	*P. serotina*	3-8
eastern white pine	*P. strobus*	35-200
eastern white pine-eastern hemlock	*P. s.-Tsuga canadensis*	35-200
eastern white pine-northern red oak-red maple	*P. s.-Quercus rubra-Acer rubrum*	35-200
loblolly pine	*P. taeda*	3-8
loblolly-shortleaf pine	*P. t.-P. echinata*	10 to < 35
Virginia pine	*P. virginiana*	10 to < 35
Virginia pine-oak	*P. v.-Quercus* spp.	10 to < 35
sycamore-sweetgum-American elm	*Platanus occidentalis-Liquidambar styraciflua-Ulmus americana*	< 35 to 200 [158]
galleta-threeawn shrubsteppe	*Pleuraphis jamesii-Aristida purpurea*	< 35 to < 100
eastern cottonwood	*Populus deltoides*	< 35 to 200 [115]
aspen-birch	*P. tremuloides-Betula papyrifera*	35-200 [44,158]
quaking aspen (west of the Great Plains)	*P. t.*	7-120 [6,59,101]
mesquite	*Prosopis glandulosa*	< 35 to < 100 [100,115]
black cherry-sugar maple	*Prunus serotina-Acer saccharum*	> 1000 [158]

mountain grasslands	*Pseudoroegneria spicata*	3-40 (10**) [3,6]
Rocky Mountain Douglas-fir*	*Pseudotsuga menziesii* var. *glauca*	25-100 [6]
coastal Douglas-fir*	*P. m.* var. *menziesii*	40-240 [6,109,130]
California mixed evergreen	*P. m.* var. *m.-Lithocarpus densiflorus-Arbutus menziesii*	< 35
California oakwoods	*Quercus* spp.	< 35 [6]
oak-hickory	*Q.-Carya* spp.	< 35[158]
oak-juniper woodland (Southwest)	*Q.-Juniperus* spp.	< 35 to < 200 [115]
northeastern oak-pine	*Q.-Pinus* spp.	10 to < 35 [158]
oak-gum-cypress	*Q.-Nyssa*-spp.-*Taxodium distichum*	35 to > 200 [110]
coast live oak	*Q. agrifolia*	<35 to 200 [6]
white oak-black oak-northern red oak	*Q. alba-Q. velutina-Q. rubra*	< 35 [158]
canyon live oak	*Q. chrysolepis*	<35 to 200
blue oak-foothills pine	*Q. douglasii-Pinus sabiana*	<35 [6]
northern pin oak	*Q. ellipsoidalis*	< 35 [158]
Oregon white oak	*Q. garryana*	< 35 [6]
bear oak	*Q. ilicifolia*	< 35 >[158]
California black oak	*Q. kelloggii*	5-30 [115]
bur oak	*Q. macrocarpa*	< 10 [158]
oak savanna	*Q. m./Andropogon gerardii-Schizachyrium scoparium*	2-14 [115,158]
chestnut oak	*Q. prinus*	3-8
northern red oak	*Q. rubra*	10 to < 35
post oak-blackjack oak	*Q. stellata-Q. marilandica*	< 10
black oak	*Q. velutina*	< 35
live oak	*Q. virginiana*	10 to< 100 [158]
interior live oak	*Q. wislizenii*	< 35 [6]
blackland prairie	*Schizachyrium scoparium-Nassella leucotricha*	< 10
Fayette prairie	*S. s.-Buchloe dactyloides*	< 10
little bluestem-grama prairie	*S. s.-Bouteloua* spp.	< 35 [115]
redwood	*Sequoia sempervirens*	5-200 [6,48,147]
western redcedar-western hemlock	*Thuja plicata-Tsuga heterophylla*	> 200 [6]
eastern hemlock-yellow birch	*Tsuga canadensis-Betula alleghaniensis*	> 200 [158]
western hemlock-Sitka spruce	*T. heterophylla-Picea sitchensis*	> 200
mountain hemlock*	*T. mertensiana*	35 to > 200 [6]
elm-ash-cottonwood	*Ulmus-Fraxinus-Populus* spp.	< 35 to 200 [44,158]

*fire return interval varies widely; trends in variation are noted in the species summary
**mean

POSTFIRE REGENERATION STRATEGY [144]:

Initial off-site colonizer (off-site, initial community)
Secondary colonizer (on-site or off-site seed sources)

FIRE EFFECTS

SPECIES: Cirsium vulgare

IMMEDIATE FIRE EFFECT ON PLANT:
More research is needed to determine the immediate effects of fire on bull thistle plants and seeds. Bull thistle may or may not be killed by fire. In south-central Idaho on a Douglas-fir site where bull thistle was present before prescribed burning, bull thistle frequency declined immediately following burning, then increased 3 years after the burn [90]. Musk thistle, a biennial thistle with a similar life history, may be killed by high-severity fires that kill the root crown, but may survive low-severity fires (see musk thistle). It has been suggested that combustion would only readily take place on mature thistle plants, from which seed would have already dispersed [116].

It is also unclear what effects fire has on bull thistle seeds in the soil. Incidents of rapid colonization after fire [4,5,10,16,102] suggest that either bull thistle seeds were present in the soil at the time of the fire and survived to germinate after the overstory was removed, or that bull thistle seeds were dispersed after fire from off-site seed sources. However, when experimental heat treatments including 6 combinations of temperature, duration, and soil moisture were applied to bull thistle seeds from an old-growth Douglas-fir forest seed bank, researchers concluded that even low-severity fire could kill bull thistle seeds. Seed survival was lower in wet soil than in dry soil. In wet soil, 35% of the bull thistle seeds tested survived 122 degrees Fahrenheit (50 °C) for 60 minutes, and 0 seeds survived 167 degrees Fahrenheit (75 °C) or 212 degrees Fahrenheit (100 °C) for 15 minutes. In dry soil, 44% survived 122 degrees Fahrenheit (50 °C) for 60 minutes, 32% survived 167 degrees Fahrenheit (75 °C) for 15 minutes, and 6% survived 212 degrees Fahrenheit (100 °C) for 15 minutes [25].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT:
No information

PLANT RESPONSE TO FIRE:
Bull thistle colonization may be enhanced [4,5,10,16,87,99,102,129] or depressed [31,70] by fire. Observations at preserves in northeastern Oregon suggest that bull thistle establishment is encouraged by wildfire [129]. Conversely, prescribed burning on tallgrass prairie sites in South Dakota discourages bull thistle and encourages native plants [31,129]

Fire creates conditions that are favorable to the establishment of bull thistle (i.e. open canopy, reduced competition, areas of bare soil), so if bull thistle seeds are present and competition is minimal, bull thistle may be favored in the postfire community. Bull thistle densities increased dramatically after a prescribed burn in Yosemite Valley, leading managers to believe that burning promotes thistle populations. It is unclear, however, whether prescribed burning alone caused the increase in bull thistle cover [121].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE:
Response of bull thistle to fire depends on the conditions of the fire such as fire severity, time of burning, prior and subsequent weather conditions [30], site conditions (e.g. soil moisture content) and composition of the preburn community and seedbank.

Observations in tallgrass prairie sites in South Dakota indicate that late spring prescribed burning on a 4- to 5-year rotation encourages the growth of native plants and discourages the growth of Canada thistle (*Cirsium arvense*), musk thistle, and bull thistle [31,129]. Additionally, Hulbert [70] suggests that late spring burning in these ecosystems results in fewer forbs but greater grass production than fall or early spring burning.

A spring prescribed fire following clearcutting in 1968 on Miller Creek in western Montana (when the lower half of the duff was still wet from snowmelt and rain) left a continuous, intact duff mantle as a seedbed and killed the aerial portions of understory herbs and shrubs. Forest succession then began with regrowth of heartleaf arnica (*Arnica cordifolia*) and beargrass (*Xerophyllum tenax*) and establishment of the offsite colonizers fireweed (*Epilobium angustifolium*) and bull thistle. Other sites in the area that were harvested during the same time period but either unburned or burned in summer or fall did not have bull thistle in the postdisturbance plant community [137].

The Research Project Summary
Vegetation response to restoration treatments in ponderosa pine-Douglas-fir forests of western Montana provides information on prescribed fire and postfire response of plant community species including bull thistle.

More research is needed on short- and long-term secondary effects of fire on bull thistle. See "Postfire colonization potential" below for more details.

FIRE MANAGEMENT CONSIDERATIONS:
Fire as a control agent: Research is needed regarding the potential of prescribed burning to control bull thistle. Observations in tallgrass prairie sites in South Dakota indicate that a program of prescribed burning designed to simulate the historic fire regime encourages the growth of native plants and discourages the growth of invasive thistles [31,129]. However, poorly timed grazing (i.e. early in the growing season) can potentially negate beneficial effects of prescribed fire on these sites [31].

Postfire colonization potential: General precautions should be followed to prevent bull thistle establishment after fire. The USDA Forest Service's "Guide to noxious weed prevention practices" [152] provides several fire management considerations for weed prevention in general that can be applied to bull thistle. Fire managers might consider including weed prevention education and providing weed identification aids during fire training; avoiding known weed infestations when locating firelines, monitoring camps, staging areas, and helibases to be sure they are kept weed free; taking care that equipment is weed free; incorporating cost of weed prevention and management into fire rehabilitation plans; and acquiring restoration funding [152]. Careful postfire vigilance to identify and record the establishment of new populations is critical. About 1 month after fire, survey for signs of new or resprouting weeds. Repeated surveys will be needed, with the frequency and intensity guided by local conditions [9].

Potential weed problems must be addressed during prefire planning of prescribed burns, and following both wild and prescribed fires. When planning a prescribed burn, preinventory the project area and evaluate cover and phenology of any bull thistle present on or adjacent to the site, and evaluate the potential for increased bull thistle populations in the area [9]. Avoid ignition and burning in areas at high risk for weed establishment or spread, and/or plan for follow-up treatments in succeeding years. Avoid creating soil conditions that promote weed germination and establishment. Discuss weed status and risks in burn rehabilitation plans [152]. To prevent infestations, re-establish vegetation on bare ground as soon after fire as possible, using either natural recovery or artificial techniques as appropriate to site conditions and objectives. When reseeding after wildfires and prescribed burns, use only certified weed-free seed. Monitor the burn site and associated disturbed areas after the fire and the following spring for emergence of bull thistle, and treat to eradicate any emergent bull thistle plants. Regulate human, pack animal, and livestock entry into burned areas at risk for weed invasion until desirable site vegetation has recovered sufficiently to resist weed invasion. Additional guidelines and specific recommendations and requirements are available [9,54,152].

MANAGEMENT CONSIDERATIONS

SPECIES: Cirsium vulgare

- IMPORTANCE TO LIVESTOCK AND WILDLIFE
- OTHER USES
- IMPACTS AND CONTROL

IMPORTANCE TO LIVESTOCK AND WILDLIFE:
Bull thistle is usually avoided by grazing animals because of its spines, and thus its proliferation is encouraged by heavy gazing on rangeland and in pastures. Additionally, rosettes that were damaged during heavy grazing on a pasture in New Zealand were stimulated by the damage to regrow [103]. Domestic goats and sheep eat bull thistle seedlings [50,80]. Pasture grazing by domestic sheep can reduce competition from neighboring plants and increase growth, flowering, and seed production, and promote survival of bull thistle seedlings [49]. This may be an issue of timing: spring grazing may encourage bull thistle, while later in the season, sheep may eat bull thistle seedlings or small rosettes [50,80].

Studies in the Netherlands indicate that rabbits eat bull thistle leaves, especially in winter and early spring. The flowering stem may be attacked by a variety of herbivores, which can result in a reduced seed output. If the main stem is severed or damaged by herbivores, secondary flowering stems can form. Recovery of bull thistle after herbivore damage is dependent on moisture availability. Bull thistle seeds are eaten by mice and voles. Birds sometimes eat seeds in the Dutch coastal dune area [80]. Goldfinches eat bull thistle seeds and use the thistledown to build their nests [106]. Bull thistle is included in a list of known grizzly bear food plants [32]. Bull thistle is eaten by Mazama pocket gophers in south-central Oregon [22], and high bull thistle densities were observed in Yosemite National Park in sites of intense pocket gopher digging. Pocket gophers consume taproots from below, and their digging provides sites for further thistle establishment, so that they are effectively "farming" thistles [121]. Bull thistle flower nectar is a favorite of bees and butterflies [84].

Palatability/nutritional value: No information

Cover value: No information

OTHER USES:
The thistles have long been associated with humans [106]. "Thistles have been used medicinally as well as for food. However, they are also notoriously associated with unkempt agricultural land. While this may be true of invasive thistles that are not native to North America, the vast majority of native thistles fill specific ecological niches and have traits useful to humans" [15]. The young stems and roots of bull thistle are edible [46]. Native North Americans used the roots and young leaves and newly bolted stems of *Cirsium* species for food. *Cirsium* roots have been sold commercially for use as rabbit bait in Australia [106]. In a review by Klinkhamer and de Jong [80], it is suggested that bull thistle may be easily processed for rubber using standard equipment.

IMPACTS AND CONTROL:
Impacts:
Bull thistle is a problem in pastures because it competes with and decreases desirable forage and has no significant nutritive value for livestock [106]. Sharp spines deter livestock, and presumably wildlife, from grazing. One adult bull thistle plant per square yard decreased spring or summer live weight gains of sheep by about 3.8 lb (1.7 kg) per animal in New Zealand pastures [64]. Bull thistle is a range weed in 20 countries and is more frequent in grazed than in ungrazed pastures. It is regarded as a serious pest in protected areas and parks such as Yosemite, Yellowstone, Teton and Glacier National Parks [50]. Bull thistle may also interfere with growth of Douglas-fir transplants in the Oregon Coast Range as indicated by results presented by Gourley and others [55], where tree growth was improved by control of various weeds, including but not limited to bull thistle.

Bull thistle often dominates recently clearcut forest areas in the Sierra Nevada of California, and infestations may limit growth of replanted tree seedlings. Work in a replanted Sierra clearcut forest indicated that stem growth of ponderosa pine saplings was negatively correlated with density of thistles within about 7 feet (2 m) of pines [123]. Bull thistle also colonizes and maintains high population densities for up to 6 years in clearcuts in redwood and mixed evergreen forests in northwestern California [122].

Control:
Bull thistle should be accurately identified before attempting any control measures, since several native species of thistles have a similar appearance. See Klinkhamer and de Jong [80] and General Botanical Characteristics for information on proper identification.

The key to successful management of bull thistle is to prevent seed production. Combining control methods into an integrated management system will result in the best long-term population decreases. Control data suggest that viable seed production by biennial thistles must be eliminated to achieve long-term population decreases, although zero seed production may not be a realistic goal. The transition from seedling to rosette in bull thistle may be the most precarious stage in its life cycle. Seedling and rosette growth stages are the most logical to target for control efforts in biennial thistles.

Desirable plant competition to deter establishment of bull thistle seedlings is a critical part of any biennial thistle management strategy. Recovery of infested areas should not be considered complete until a diverse population of desirable plants has replaced invasive biennial thistles, and bull thistles are a minor to nonexistent component of the plant community. Always monitor and evaluate weed management programs to determine whether and when to repeat and/or modify control treatments [15].

Prevention: Prevention is the most effective method for managing invasive species, including bull thistle [15,139]. Preventing or dramatically reducing seed production will help decrease the spread of infestations. This is accomplished by cleaning mowers, vehicles, and tillage equipment after operation in an infested area. When seeding is necessary, use clean, certified weed-free seed and mulch to ensure that bull thistle or other weeds are not being sown. Preventing the establishment of weeds in natural areas is achieved by maintaining healthy natural communities and by conducting aggressive monitoring several times each year. Monitoring efforts are best concentrated on the most disturbed areas in a site, particularly along roadsides, parking lots, fencelines, and waterways. When an infestation is found, the location can be recorded and the surrounding area surveyed to determine the size and extent of the infestation, so these sites can be revisited on follow-up surveys. For more on monitoring see Johnson [74]. Place a priority on controlling small infestations so they do not expand [15,74].

Good grazing management will stimulate grass growth and keep pastures and rangelands healthy. Healthy pastures and rangeland may be more resistant to biennial thistle invasion. Bare spots caused by overgrazing are prime habitable sites for biennial thistles. In many instances, grazing lands will have to be rested from grazing for grasses to recover. This should be coupled with precipitation cycles, so adequate soil moisture will be available to stimulate grass growth. Grazed pastures that are managed carefully may enhance grass competition and deter thistle survival from seedlings to rosettes [15].

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 [152]. See the "Guide to noxious weed prevention practices" [152] for specific guidelines in preventing the spread of weed seeds and propagules under different management conditions.

Integrated management:
The goal of any management plan should be not only controlling invasive plants, but also improving the affected community, maximizing forage quality and quantity and/or preserving ecosystem integrity, and preventing reinvasion or invasion by other invasive species, in a way that is complementary to the ecology and economics of the site [40,73]. Effective long-term control requires that invasive plants be removed and replaced by more desirable and weed-resistant plant communities [73]. Once the desired plant community has been determined, an

integrated weed management strategy can be developed to direct succession toward that plant community by identifying key mechanisms and processes directing plant community dynamics (site availability, species availability, and species performance) and predicting plant community response to control measures [138]. This requires a long-term integrated management plan [15].

Most often, a single method is not effective for controlling an invasive plant, and many possible combinations of methods can achieve the desired objectives. Methods selected for removal or control of bull thistle on a specific site will be determined by land use objectives, desired plant community, extent and nature of the infestation(s), environmental factors (nontarget vegetation, soil types, climatic conditions, important water resources), economics, and effectiveness and limitations of available control techniques [126]. Killing thistles and decreasing weed populations must be followed by the establishment of desirable vegetation in the newly opened niches; herbicide applications in spring followed by dormant seeding of competitive perennial grasses in the fall is an example of an effective management system for biennial thistles in the western U.S. Similarly, integrating herbicides and biological control agents is likely to be more effective than insects alone [15] (see "Biological control" below, for more information). For information on integrated weed management without herbicides, see the Bio-Integral Resource Center (BIRC) website.

Some examples of combined approaches and considerations for managing bull thistle infestations are presented within the following sections. Managers are encouraged to use combinations of control techniques in a manner that is appropriate to the site objectives, desired plant community, available resources, and timing of applications.

Physical/mechanical:
Any mechanical or physical method that severs the root below the soil surface will kill bull thistle plants. However, it is essential to re-vegetate the site with desirable plants to compete with bull thistle that may reinvade from seeds left in the soil. Tillage, hoeing, and hand pulling may provide effective control, providing these operations are done before the reproductive growth stages to prevent seed production. Mowing alone is not an effective control measure for biennial thistles, because some seed will still be produced. Mechanical methods may not be practical on rangeland and natural areas, but could be useful in improved pastures or roadsides [15]. The long duration of flowering in bull thistle increases the importance of timely control operations and may make repeated treatments necessary [49,122].

A single mowing will not control a bull or musk thistle infestation, because infestations often consist of plants of various ages, and stands therefore have nonuniform development and flowering. Bull thistle plants mowed just before seed dispersal do not produce seed or recover well [50,80,122]. If mowed too early, bull thistle plants resprout and flower. About 4% of bull thistles cut 2 to 4 inches (5-10 cm) above the soil surface a month before flowering resprout [121,122].

Bull thistle will not withstand cultivation; however, tillage is not appropriate in wildlands and rangelands since it can damage important desirable species, increase erosion, alter soil structure, and expose the soil for rapid reinfestation by bull thistle and other invasive species [88]. Slicing off the root crown of bull thistle plants is time consuming, but very effective [129]. At Yosemite National Park, less than 5% of adult bull thistles cut at the soil surface resprouted, while over 80% of adult bull thistles in control plots survived and flowered [120,121]. Of the bull thistle plants that resprouted, mean height and number of inflorescences were lower (25 inches or 63 cm and 3.7 flowerheads) than for adults in control plots (33 inches or 85 cm and 15.8 flowerheads) [121,122]. Plants that were cut at the root crown a few days after their 1st flowers appeared and then laid on the ground produced abundant viable seed, so removing cut stems from areas being cleared may be important [50,122].

Even if bull thistle plants resprout after mechanical control, populations may be reduced by limiting seed production [122]. Removal of adult bull thistle plants must be repeated annually for 4 years or more, since some plants will stay in the rosette form for up to 5 years [121]. Mechanical control may be labor intensive; however, sometimes volunteer groups are available. The Salmon River Restoration Council (SRRC) provides an example of watershed-scale weed control using primarily mechanical control methods.

Fire: See Fire Management Considerations.

Biological:
Biological control of invasive species has a long history, and there are many important considerations to be made before the implementation of a biological control program. The reader is referred to other sources [126,164] and the Weed Control Methods Handbook [151] for background information on biological control. Additionally, Cornell University, Texas A & M University, and NAPIS websites offer information on biological control.

In its native range, number of viable seeds produced by bull thistle plants can be greatly reduced by insects feeding on the stem, flowerheads, or seeds [80]. Several agents have been considered and tested for bull thistle control, and those in the following table have been introduced in North America:

Biological control agent	Mode of action	Areas established	References
thistle head weevil *Rhinocyllus conicus*	larvae eat seed-producing tissue	well established in most northwestern and northern plains states; GA, TN, TX, VA	[15,36,63,77,125,127]
thistle crown weevil (*Trichosirocalus horridus*)	larvae feed on the growing points of thistle rosettes and developing shoots	CO, KS, MO, MT, OR, VA, WA, WY	[15,125]
bull thistle gall fly (*Urophora stylata*)	larvae feed within seed producing tissues of developing seedheads	CO, MD, OR, WA, BC, NS, PQ	[15,26]

Rhinocyllus conicus
was introduced from Europe to Montana and Virginia in 1969 to control musk thistle, but it also uses bull thistle. *Rhinocyllus conicus* will use *Carduus*, *Cirsium*, *Silybum*, and *Onopordum* genera as hosts but prefers the musk thistle group [127]. In areas where the plant and insect life cycles are synchronized, *R. conicus* is extremely effective in reducing seed production in musk thistle [125]. It is unclear if it is as effective on bull thistle. Several strains of *R. conicus*
have been identified and they vary in their utilization of various thistle species. At least 1 of these strains does attack some native *Cirsium* species [89,125], and reviews by Randall [122], Beck [15] and Wilson and McCaffrey [164] indicate that it is known to attack native and rare thistles. Therefore, before releasing insects in a new area containing native *Cirsium* species, investigate whether any of the local species may be attacked [125]. A detailed discussion of the biology of *R. conicus* is given by Harris and Shorthouse [63].

Urophora stylata
feeds on developing seeds in bull thistle flowerheads and decreases seed production up to 60% [26].
Trichosirocalus horridus
was introduced to the U.S. in 1974. This weevil uses thistles of the subtribe Carduinae, including bull thistle, musk thistle, plumeless thistle (*Carduus acanthoides*), Italian thistle (*C. pycnocephalus*), Canada thistle, and Scotch thistle. Reports of suppression vary from slight to great. *Trichosirocalus horridus* is more effective when used in conjunction with *R. conicus* [125]. In areas of Missouri where *R. conicus* and *T. horridus* have been present for over 15 years, an 80 to 90% reduction in thistle populations has occurred [142].

Chemical:
Herbicides are effective in gaining initial control of a new invasion or a severe infestation, but are rarely a complete or long-term solution to weed management [23]. Herbicides are more effective on large infestations when incorporated into long-term management plans that include replacement of weeds with desirable species, careful land use management, and prevention of new infestations. Control with herbicides is temporary, as it does not change conditions that allow infestations to occur [169]. See the Weed Control Methods Handbook for considerations on the use of herbicides in natural areas and detailed information on specific chemicals.

Chemical control of bull thistle is reviewed by Beck [15], Forcella and Randall [50], and Randall [122].

Clopyralid, dicamba, MCPA, picloram, 2,4-D, metsulfuron, and chlorsulfuron will all kill bull and musk thistles. Timing of application is important. Autumn is a good time to control biennial thistles with herbicides because all live plants will be seedlings or rosettes, and plants are easiest to control in the seedling and rosette stages. Plants are, however, more difficult to locate at this stage, and cold weather may decrease the effectiveness of some chemicals. Herbicide choice and rates are influenced by growth stage, stand density, and environmental conditions (e.g. drought or cold temperatures). Check with state or county weed specialists for appropriate local use rates and timing. Bull thistle is less aggressive and easier to control than other biennial thistles [14].

In pastures and range containing appreciable quantities of broadleaf forage species, application of any of the herbicides listed above may damage valuable plants and reduce forage production and livestock weight gain as much as that caused by thistle interference [64], so it is important to prevent these and other non-target effects of chemical control.

Cultural: Bull thistle germination and establishment is favored in open areas and by disturbance [15]. No matter what method is used to kill weeds, reestablishment of competitive, desirable plant cover is imperative for long-term control. Fertilization and reseeding with competitive, adapted species is often necessary in areas without a residual understory of desirable plants [126].

Revegetation with aggressive desirable species has been shown to inhibit reinvasion of bull thistle, especially with the help of effective biological control agents and carefully prescribed grazing practices. Promoting desirable competitors is important both after weed control and before weed establishment. Choice of species to sow will depend upon climate, location, and management objectives. The Natural Resource Conservation Service and land grant universities are good sources of information about appropriate perennial grass species for a particular locale. Management that allows grasses to grow taller in spring to shade bull thistle seedlings may decrease seedling establishment and growth [15].

At Thousand Springs Preserve in Idaho, bull thistle invades native grasslands. Where healthy native grasses have re-established, they outcompete bull thistle and their litter prevents bull thistle seeds from reaching the ground and germinating [129]. On a reclaimed parking lot in Illinois that was planted by broadcast seeding and seedling transplants, then burned 5 years later and on an annual basis thereafter, bull thistle decreased over time and was virtually absent by year 7 [78].

Cirsium vulgare: References

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