SPECIES: Cirsium arvense

INTRODUCTORY

SPECIES: Cirsium arvense

AUTHORSHIP AND CITATION:
Zouhar, Kris 2001. Cirsium arvense. 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].

ABBREVIATION:
CIRARV

SYNONYMS:
No entry

NRCS PLANT CODE [226]:
CIAR4

COMMON NAMES:
Canada thistle
Californian thistle
creeping thistle
field thistle

TAXONOMY:
The currently accepted scientific name for Canada thistle is *Cirsium arvense* (L.) Scop. (Asteraceae) [42,75,81,92,94,103,107,127,135,178,187,209,233,249]. Canada thistle is extremely variable with regard to leaf division and vestiture, and it has been treated as several species, numerous varieties, or as a single highly polymorphic species [81]. Several authors recognize different varieties based primarily on differences in leaf morphology [42,75,81,94,233,239]. Voss [233] says it is doubtful that the variety designations are meaningful, and Cronquist and

others [42] state that contemporary European botanists do not consider described variants of the species to be taxonomically significant.

LIFE FORM:
Forb

FEDERAL LEGAL STATUS:
No special status

OTHER STATUS:
As of this writing (2001), Canada thistle is listed as a noxious weed in at least 29 states in the U.S. and 7 Canadian provinces. See the Invaders or Plants databases for current information.

DISTRIBUTION AND OCCURRENCE

SPECIES: Cirsium arvense

GENERAL DISTRIBUTION:
Canada thistle is native to southeastern Europe and the eastern Mediterranean area, and was probably introduced to North America in the 1600s as a contaminant of crop seed and/or ship's ballast [153]. It is probably the most widespread of all thistle species [153]. In addition to North America, Canada thistle is invasive in northern and southern Africa, the Middle East, Japan, India, New Zealand, Australia, and South America. It infests at least 27 crops in 37 countries and thrives in temperate regions of the northern hemisphere [147]. In North America, Canada thistle occurs from Alaska east to the Northwest Territories, Quebec, and Newfoundland and south to California, New Mexico, Kansas, Arkansas, and North Carolina [107]. The PLANTS database provides a map of Canada thistle's distribution in the United States.

Canada thistle has been identified as a management problem in many national parks and on The Nature Conservancy preserves in the upper Midwest, the Great Plains states, and the Pacific Northwest [215]. It is an invader in Mesa Verde National Park, Colorado [67], Yellowstone National Park, Wyoming [4,48,219], Wood Buffalo National Park, Northwest Territories, Canada [83,238], Theodore Roosevelt National Park, North Dakota [32], and the Camas Swale Research Natural Area in the Willamette Valley, Oregon [43].

Although Canada thistle is not usually found in undisturbed forested areas, it has the potential to colonize a wide variety of forest habitats within its range following overstory removal and soil disturbance. The following listings take this potential into account.

ECOSYSTEMS [74]:
FRES10 White-red-jack pine
FRES11 Spruce-fir
FRES15 Oak-hickory
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
FRES34 Chaparral-mountain shrub
FRES35 Pinyon-juniper
FRES36 Mountain grasslands
FRES37 Mountain meadows
FRES38 Plains grasslands
FRES39 Prairie
FRES41 Wet grasslands
FRES42 Annual grasslands
FRES44 Alpine

STATES:

AK	AZ	AR	CA	CO	CT	DE	ID
IL	IN	IA	KS	KY	ME	MD	MA
MI	MN	MO	MT	NE	NV	NH	NJ
NM	NY	NC	ND	OH	OR	PA	RI
SD	TN	UT	VT	VA	WA	WV	WI
WY	DC						
AB	BC	MB	NB	NF	NT	NS	NU
ON	PE	PQ	SK	YK			

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
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 [119] 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
K028 Mosaic of K002 and K026
K029 California mixed evergreen forest
K030 California oakwoods
K032 Transition between K031 and K037
K034 Montane chaparral
K035 Coastal sagebrush
K036 Mosaic of K030 and K035
K037 Mountain-mahogany-oak scrub
K038 Great Basin sagebrush
K047 Fescue-oatgrass
K048 California steppe
K049 Tule marshes
K050 Fescue-wheatgrass
K051 Wheatgrass-bluegrass
K052 Alpine meadows and barren
K055 Sagebrush steppe
K056 Wheatgrass-needlegrass shrubsteppe
K063 Foothills prairie
K064 Grama-needlegrass-wheatgrass
K066 Wheatgrass-needlegrass
K067 Wheatgrass-bluestem-needlegrass
K068 Wheatgrass-grama-buffalo grass
K069 Bluestem-grama prairie
K070 Sandsage-bluestem prairie
K074 Bluestem prairie
K075 Nebraska Sandhills prairie
K081 Oak savanna
K082 Mosaic of K074 and K100
K084 Cross Timbers
K093 Great Lakes spruce-fir forest
K094 Conifer bog
K095 Great Lakes pine forest

K096 Northeastern 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

SAF COVER TYPES [59]:
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
75 Shortleaf pine
76 Shortleaf pine-oak
78 Virginia pine-oak
79 Virginia pine
80 Loblolly pine-shortleaf pine
81 Loblolly pine
87 Sweetgum-yellow-poplar
93 Sugarberry-American elm-green ash
95 Black willow
107 White spruce
108 Red maple
109 Hawthorn
110 Black oak
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
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 [200]:
101 Bluebunch wheatgrass
102 Idaho fescue
103 Green fescue
104 Antelope bitterbrush-bluebunch wheatgrass
105 Antelope bitterbrush-Idaho fescue
107 Western juniper/big sagebrush/bluebunch wheatgrass
109 Ponderosa pine shrubland
110 Ponderosa pine-grassland
201 Blue oak woodland
202 Coast live oak woodland
203 Riparian woodland
204 North coastal shrub
208 Ceanothus mixed chaparral
209 Montane shrubland
210 Bitterbrush
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
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
504 Juniper-pinyon pine woodland
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
722 Sand sagebrush-mixed prairie
801 Savanna
802 Missouri prairie
803 Missouri glades
804 Tall fescue
805 Riparian
808 Sand pine scrub
901 Alder
902 Alpine herb
903 Beach wildrye-mixed forb
904 Black spruce-lichen
905 Bluejoint reedgrass

906 Broadleaf forest
908 Fescue
909 Freshwater marsh
910 Hairgrass
912 Low scrub shrub birch-ericaceous
913 Low scrub swamp
914 Mesic sedge-grass-herb meadow tundra
915 Mixed herb-herbaceous
916 Sedge-shrub tundra
917 Tall shrub swamp
918 Tussock tundra
919 Wet meadow tundra
920 White spruce-paper birch
921 Willow

HABITAT TYPES AND PLANT COMMUNITIES:
Canada thistle is adaptable to a wide range of habitats. It occurs in nearly every upland herbaceous community within its range, particularly prairie communities and riparian habitats [162]. It is most commonly found in disturbed areas as part of the initial postdisturbance community along roadsides, railroads, streambanks, ditches, lakeshores, seashores, sand dunes and other open sandy areas [153], in clearcuts and forest openings, and in wet and wet-mesic grasslands and prairie potholes.

In Canada, Canada thistle frequently occurs in prairie marshes and sedge meadows, where it is often associated with sow thistle (*Sonchus* spp.), goldenrod (*Solidago* spp.), smartweeds (*Polygonum* spp.), mint (*Mentha arvensis*), rough bugleweed (*Lycopus asper*), marsh hedgenettle (*Stachys palustris*), and western germander (*Teucrium canadense* var. *occidentale*) in upland transition zones [98,160,170,214]. Canada thistle is also a component of the emergent vegetation after drawdown in marsh communities dominated by common reed (*Phragmites australis*), along with alkali bulrush (*Scirpus* spp.), cattail (*Typha* spp.), purple loosestrife (*Lythrum salicaria*), sow thistle, and stinging nettle (*Urtica dioica*) [143,214,230]. In a southern Ontario wet prairie, Canada thistle occurs with bluejoint reedgrass (*Calamagrostis canadensis*), prairie cordgrass (*Spartina pectinata*), and sedges (*Carex* spp.) [60]. On a seasonally flooded delta in Alberta, Canada thistle occurs with other xerophytic forbs such as sow thistle, largeleaf avens (*Geum macrophyllum*), willow shrubs (*Salix* spp.), Siberian yarrow (*Achillea sibirica*), threepetal bedstraw (*Galium trifidum*), and fringed willowherb (*Epilobium ciliatum*) [98].

Canada thistle emerges after drawdown in a northern marsh in Minnesota, along with sow thistle, willows, and sweet clover (*Melilotus* spp.) [87]. In a North Dakota meadow/riparian transition, Canada thistle is found with sedges, sow thistle, tall nettle (*U. procera*) and river-bulrush (*S. fluviatilis*) [136]. In the prairie pothole region of Iowa, Canada thistle occurs with Kentucky bluegrass (*Poa pratensis*), goldenrod, wild bergamot (*Monarda fistulosa*), and common milkweed (*Asclepias syriaca*) [146]. Canada thistle is found in the bottomland vegetation typical of perennial streams in eastern Colorado where silty and sandy terrace sediments are dominated by tall exotic herbs including rough pigweed (*Amaranthus retroflexus*), perennial pepperweed (*Lepidium latifolium*), saltbush (*Atriplex heterosperma*), lambsquarters (*Chenopodium album*) and Fuller's teasel (*Dipsacus fullonum*) [71]. Dense Canada thistle stands in undisturbed areas in Colorado are associated with American bulrush (*S. americanus*), creeping bentgrass (*Agrostis palustris*), longstem spikerush (*Eleocharis macrostachys*), and saltgrass (*Distichlis stricta*). In moderately dense stands of Canada thistle, associates include giant ragweed (*Ambrosia trifida*), horseweed (*Conyza canadensis*), common lambsquarters, rough pigweed, prairie sunflower (*Helianthus petiolaris*), smooth dock (*Rumex altissimus*), and foxtail barley (*Critestion jubatum*) [204]. In a riparian-wetland shrub community in Montana, Canada thistle is found with Sandbar willow (*Salix exigua*), rose (*Rosa* spp.), red-osier dogwood (*Cornus sericea*), other willows, redtop (*Agrostis gigantea*), and Kentucky bluegrass [86].

Midwest: In tallgrass prairies and upland openings in Wisconsin, Canada thistle may be found with big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), goldenrod, quackgrass (*Elytrigia repens*), Kentucky bluegrass, reed canarygrass (*Phalaris arundinacea*), aster (*Aster* spp.), Canada wildrye (*Elymus canadensis*), blackberry (*Rubus* spp.), sweet coneflower (*Rudbeckia subtomentosa*), and indiangrass (*Sorghastrum nutans*) [102,131,167]. In heavily grazed pastures in Iowa, Canada thistle is often found with Kentucky bluegrass and goldenrod [76], and in an abandoned field in Ohio it grows with fescue (*Festuca* spp.), bluegrass (*Poa* spp.), reed canarygrass, goldenrod, and

Fuller's teasel (*D. f.* ssp. *sylvestris*) [95].

Pacific Northwest: In the mountains of Washington and Oregon, Canada thistle is found along roadsides and in clearcuts on many forest types, but is usually absent from undisturbed forests [13,88,161,164,166,251]. It occurs in the beardless wildrye (*Leymus triticoides*) habitat type in mesic upland meadows in eastern Oregon with Douglas sedge (*C. douglasii*), Baltic rush (*Juncus balticus* var. *montanus*), and Sandberg bluegrass (*P. secunda*) [253]. On Mount St. Helens, Washington, Canada thistle occurs with fireweed (*Epilobium angustifolium*), pearly everlasting (*Anaphalis margaritacea*), cat's-ear (*Hypochareis radicata*), groundsel (*Senecio* spp.), velvet grass (*Holcus lanatus*), and blackberry on the regenerating blast zone and in clearcuts [145]. In the eastern Oregon desert Canada thistle occurs with stinging nettle, perennial pepperweed, chaparral willowherb (*Epilobium minutum*), short-rayed alkali aster (*Symphyotrichum frondosum*), western goldenrod (*S. occidentalis*), common silverweed (*Potentilla anserina*), and lambsquarters [242].

Intermountain west: Canada thistle grows in a wide range of environmental types including those dominated by little bluestem (*Schizachyrium scoparium*), blue grama (*Bouteloua gracilis*), bluebunch wheatgrass (*Pseudoroegneria spicata*), ponderosa pine (*Pinus ponderosa*), and Douglas-fir (*Pseudotsuga menziesii*). Canada thistle is found in many forest types after disturbance [39,133], and it has the ability to invade undisturbed sites in Douglas-fir and subalpine fir (*Abies lasiocarpa*)/twinflower (*Linnaea borealis*) habitat types [68,141]. In Montana, Canada thistle may be found in ponderosa pine-Douglas fir communities with white spirea (*Spiraea betulifolia*), snowbrush ceanothus (*Ceanothus velutinus*), big huckleberry (*Vaccinium membranaceum*), and sticky currant (*Ribes viscosissimum*) [123], or on high river terraces with silver sagebrush (*Artemisia cana*), western snowberry (*Symphoricarpos occidentalis*), western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*), Kentucky bluegrass and smooth brome (*Bromus inermis*) under Russian-olive (*Elaeagnus angustifolia*) [130]. In Glacier National Park, it occurs in wetland communities with sedges (*Carex* spp.) [243]. In Yellowstone National Park, Canada thistle is found in a wide range of habitat types including big sagebrush (*Artemisia tridentata*)/Idaho fescue (*F. idahoensis*), Douglas-fir/common snowberry, Engelmann spruce (*Picea engelmannii*)/sweetscented bedstraw (*Galium triflorum*), Engelmann spruce/horsetail (*Equisetum* spp.), subalpine fir/grouse whortleberry (*Vaccinium scoparium*), and subalpine fir/pinegrass (*Calamagrostis rubescens*) habitat types [4]. Additional associated species include lodgepole pine (*Pinus contorta*), sedges, heartleaf arnica (*Arnica cordifolia*), silvery lupine (*Lupinus argenteus*), snowbrush ceanothus, quaking aspen (*Populus tremuloides*), and whitebark pine (*Pinus albicaulis*) [41,220].

Southwest: In New Mexico, Canada thistle was found in pinyon-juniper (*Pinus-Juniperus* spp.) woodland, on an abandoned uranium spoil, with broom snakeweed (*Gutierrezia sarothrae*), Indian ricegrass (*Achnatherum hymenoides*), winterfat (*Krascheninnikovia lanata*), hairy goldenaster (*Heterotheca villosa*), scarlet globemallow (*Sphaeralcea coccinea*), black grama (*Bouteloua eriopoda*), and tall dropseed (*Sporobolus asper*) [63]. At Mesa Verde National Park in Colorado, Canada thistle is found in Colorado pinyon (*Pinus edulis*)-juniper (*Juniperus* spp.) habitats where it is most common in riparian corridors with species such as boxelder (*Acer negundo*), Utah serviceberry (*Amelanchier utahensis*), fendlerbush (*Fendlera rupicola*), Gambel oak (*Quercus gambelii*), Wood's rose (*Rosa woodsii*), mountain snowberry (*Symphoricarpos oreophilus*), true mountain-mahogany (*Cercocarpus montanus*), chokecherry (*Prunus virginiana*), and antelope bitterbrush (*Purshia tridentata*) [64,65,66].

In California, Canada thistle infests middle-elevation Sierran meadows, including those in Yosemite Valley, as well as clear-cuts in the El Dorado National Forest and riparian zones throughout the state, and is general to many disturbed habitats [197]. In the annual grassland of northern California, Canada thistle may be found with coyotebrush (*Baccharis pilularis*), Italian ryegrass (*Lolium multiflorum*), soft chess (*Bromus hordeaceus*), ripgut brome (*Bromus rigidus*), wild oat (*Avena fatua*), blue fieldmadder (*Sherardia arvensis*), foxtail fescue (*Vulpia myuros*) and purple tussock grass (*Nassella pulchra*) [96]. In the coastal redwood (*Sequoia sempervirens*) zone in California, Canada thistle may be found in cottonwood (*Populus* spp.)-ash (*Fraxinus* spp.) habitats [235].

MANAGEMENT CONSIDERATIONS

SPECIES: Cirsium arvense

IMPORTANCE TO LIVESTOCK AND WILDLIFE:
Livestock tend to dislike and avoid Canada thistle and may also reduce their consumption of desirable plants in the vicinity of Canada thistle colonies [129,147]. Canada thistle can be a minor component in the winter and spring diet of mule deer [12,120]. White-tailed deer forage on Canada thistle in marsh meadows [73]. Thistles (*Cirsium* spp.) are sometimes eaten by grizzly bear [46]. There are more than 130 species, including pathogens, birds, and over 80 insects, known to feed on Canada thistle [137,162]. Larvae of the painted lady butterfly feed on Canada thistle, but only on an intermittent basis [182,208]. Seeds of Canada thistle are eaten by goldfinches, whose diet consists largely of thistle seeds. Many of the seeds are destroyed this way, but some may pass through the birds unharmed [186].

PALATABILITY:
Canada thistle is not considered palatable to most livestock. It was rejected by grazing lambs, probably because of the spines [134].

NUTRITIONAL VALUE:
Crude protein, in-vitro digestible dry matter, micro-, and macromineral concentrations of Canada thistle are comparable to or greater than those of alfalfa (*Medicago sativa*) [134].

COVER VALUE:
There is little information on whether Canada thistle provides cover for wildlife species. Canada thistle provided cover for endangered Columbian white-tailed deer in Washington in the summer, allowing deer to utilize previously unused areas [211].

VALUE FOR REHABILITATION OF DISTURBED SITES:
No entry

OTHER USES:
The fragrant flowers of Canada thistle attract honeybees, the primary pollinator for this species. Thistles (*Cirsium* spp.) are reported to be both edible [177] and medicinal [83]. Canada thistle has been used by native peoples in the northeastern United States in remedies for worms and poison-ivy (*Toxicodendron radicans*) and was used to make a mouthwash for children, a treatment for tuberculosis (Duke 1986, cited in [83]), and a tonic for gastrointestinal ailments [148]. The roots and shoots of Canada thistle are said to be tender and tasty when taken early in the spring, and were reportedly used as a food in Russia and by North American natives [186]. The roots of Canada thistle, however, may be emetic when consumed (Lewis and Elvin-Lewis 1977, cited in [153]). "Cirsium" comes from the Greek "cirsos," meaning "swollen vein," for which the thistle was considered a remedy [237].

OTHER MANAGEMENT CONSIDERATIONS:
After its introduction to North America in the 1600s, the rapid spread of Canada thistle led to the enactment of control legislation as early as 1795 in Vermont and 1831 in New York [147]. Since that time it has spread throughout most of Canada and the United States, north of the 35th parallel, where it is considered one of the most tenacious and economically important agricultural weeds. It is also known to invade native plant communities in forest and range sites [49].

Canada thistle has the potential to rapidly form dense infestations through vegetative reproduction, and the spread of these clones may continue indefinitely, crowding out and displacing native grasses and forbs through shading, competition, and possibly allelopathy [85,105]. Its spread can change the structure and species composition of natural areas and reduce plant and animal diversity [105,153]. Infestations of Canada thistle may contribute to the elimination of endangered and/or endemic plant species such as the Colorado butterfly plant in Wyoming [38]. Canada thistle can decrease or limit forage and livestock production on rangelands and can limit the use of recreational areas, as it is annoying to hikers [85,153,238]. Natural communities that are threatened by Canada thistle include nonforested plant communities such as prairies, barrens, savannas, glades, sand dunes, fields, and meadows, especially those that have

been impacted by disturbance as well as those undergoing manipulative restoration management [105,215]. In addition, Canada thistle can spread from adjacent disturbed sites into sedge meadows, wet prairies [105], and disturbed forests. Surveys in the Northwest indicate acreage infested by Canada thistle increasing at an annual rate of 10%, causing an average 42% reduction in range carrying capacity on infested lands [49].

Maintaining a healthy native community is the best defense against Canada thistle invasion, and can help to shade and weaken Canada thistle plants on sites already infested [56,105]. Canada thistle should be removed from lightly infested natural areas when first observed, since it is very tenacious and difficult to control once well established [162]. Priorities for controlling infestations must be developed when planning a Canada thistle management program, with actions ranging from prevention, to reduction and containment, to eradication. Control measures for Canada thistle have been developed primarily for agricultural systems, and may not be feasible in natural areas due to comparatively low forage values, rough topography, and/or large areas. Furthermore, some control measures can negatively impact wildlife and native plant populations [162,253]. Eradication of established Canada thistle in natural areas is, therefore, not often a practical goal. Reducing infestations to manageable levels is a more viable objective [162]. Some state noxious weed laws require the implementation of control measures [153]. Many native species of thistle occur in the U.S.; some of them are rare. Because of the possibility of confusion with native species, Canada thistle must be accurately identified before any control efforts are attempted [215].

Effective long-term control of Canada thistle includes killing the roots and root buds, and preventing seed production and reinfestation by seedlings [53,85]. Because Canada thistle has root nutrient stores, it recovers readily from most types of stress, including control attempts. Therefore, control is optimized by stressing the plant enough to force it to use all of its root-stored nutrients. New seedlings must be killed within 2.5 weeks of emergence so they will not become perennial [85]. A buffer zone between uninfested areas and external sources of thistle can help prevent vegetative invasion, and Canada thistle plants within wind-dispersal range must be controlled or kept from seeding. Treatment to control the perennial plants must be thought out in advance and followed until control is complete [53,85]. Control may take several years and the treatment area must be monitored annually for presence of Canada thistle [53,162]. It takes at least 2 growing seasons to determine whether a particular control method is effective. Degree of control is influenced by clonal structure, growth stage, season of treatment, weather conditions, ecotype, soil type, and control methods used [53,55,223]. Timing of control methods to coincide with the most susceptible phenological stage of the plant is critical in optimizing effects. A single control method is rarely effective, and it is often necessary to use 2 or more methods at any given site [55]. Treatments or combinations that are effective at one site may be ineffective at others [53]. Donald [53] provides a comprehensive review of cultural and chemical control practices for Canada thistle. Management of Canada thistle may be achieved through hand cutting, mowing, controlled burning, chemical poisoning, or some combination of these treatments, depending on the level of infestation and the type of area being managed.

Integrated weed management: Control programs with a series of well calculated and properly timed combinations of treatments are likely to be the most effective means of controlling Canada thistle, and may require 5 to 10 years of effort [53]. Haderlie and others [84] suggest optimizing control of Canada thistle by using late summer tillage to increase the number of foliar shoots and leaf area, thereby creating more surface area for subsequent herbicide application. In natural areas with limited infestations, Canada thistle can be pulled and/ or cut several times during the growing season to weaken roots, and carefully treated with spot application of herbicide in the fall. Combinations of mechanical (hand pulling and mowing) and chemical methods improved control of Canada thistle in non-crop situations in Colorado [198]. At another Colorado site, however, disking after herbicide application did not influence Canada thistle control for any of the herbicides tested, regardless of the timing of application (spring vs. fall) [255]. In native prairies, a spring burn followed by seeding of native species is a possible option [162]. Drought stress reduces the effectiveness of most herbicides against Canada thistle but increases the effectiveness of mechanical controls. Therefore, mowing and burning may be preferred strategies under drought conditions [162]. Tilling and planting competitive grasses was as effective as yearly applications of clopyralid for Canada thistle control in a Nebraska pasture [247]. The interaction of defoliation (by *Cassida rubiginosa*) and plant competition (by crownvetch (*Coronilla varia*)) and tall fescue (*Festuca arundinacea*)) can seriously reduce productivity of Canada thistle [5,6,7]. Similarly, the weevil *Ceutorhyncus litura*
alone will not effectively control Canada thistle, but may be more successful when combined with cultural techniques that allow for maximum desirable plant competition [182]. Canada thistle stands were treated with mechanical, chemical, and biological measures in Mesa Verde National Park, with some degree of success. Results are still forthcoming [64,65,66].

Prescribed fire: For information on prescribed fire as a management tool for Canada thistle control, please see the "Fire

Management Considerations" section of the "Fire Effects" frame in this report.

Competition: Canada thistle is susceptible to shading and grows best when no competing vegetation is present. In a study comparing possible control methods for perennial pepperweed, Canada thistle established, along with non-native cheatgrass (*Bromus tectorum*), after disking and herbicide treatments that reduced cover of native forbs and grasses [112]. Overgrazing is a major cause of perennial weed invasion, because grasses can compete effectively with and inhibit the establishment of non-natives if grass growth is favored by good management. Canada thistle growth may be discouraged in disturbed natural areas if suitable native species are seeded densely enough to provide sufficient competition [83]. To be effective against Canada thistle the seeded species must come up before Canada thistle, grow rapidly during the early summer in order to shade out the thistle, and retain vigor until frost [162]. In a riparian site in north-central Washington, areas seeded to grass kept noxious weeds out and areas which were missed during grass seeding operations were rapidly colonized by annual and perennial forbs including Canada thistle [34]. An attempt at controlling Canada thistle with competitive species in Minnesota failed because the grasses failed to establish [19]. On a reclaimed parking lot in Illinois that was planted by broadcast seeding and seedling transplanting, then burned 5 years later and on an annual basis thereafter, Canada thistle decreased over time and was virtually absent by year 8 [114].

Cultivation: Repeated tillage or mowing gives long-term Canada thistle control by depleting root carbohydrate reserves. A typical seedling, 14 days after emergence, does not yet have a perennial root, so it can be killed by cultivation. However, a 3-week-old seedling can regenerate after the top-growth is clipped. Tillage exposes roots to drying and freezing at the soil surface, and can be an effective method of control [85,153]. Because the roots of Canada thistle tend to be deeper than plow depth, cultivation may affect only a small part of the plant and must be started at flowerbud time, repeated every 10 to 14 days through the season, and repeated again the following year [85,158]. Tilling is generally limited to cropland [85], and is not recommended in natural areas since it is likely to severely damage natives and may make an infestation worse by spreading root pieces [162]. Tillage disturbance of soil may also provide ideal conditions for erosion, reinvasion, and introduction of other exotics.

Mowing: Mowing or cutting Canada thistle plants temporarily reduces aboveground biomass and can prevent flowering and seed production, but does not kill plants unless repeated at 7- to 28-day intervals for up to 4 years [83,162]. Repeated and frequent pulling or hand cutting of individual plants will eventually starve underground stems. Cutting or pulling should be at least 3 times each season, in June, August, and September. This treatment is feasible for light and moderate infestations, but may be prohibitively time consuming in heavy infestations [105,153]. Stems with flowers that have been open for 8-10 days can develop viable seeds and must be removed from the site in order to prevent germination. The best time to cut is in the very early bud stage when food reserves are at their lowest point, and cutting must be repeated until the starch reserves in the roots are exhausted [215]. When the primary stem of Canada thistle is removed, rootbuds are stimulated to produce new shoots that might otherwise be suppressed. Therefore, plants must be cut high enough to leave more than 9 leaves/stem or more than 8 inches (20 cm) of bare stem tissue. In high humidity, root buds are stimulated to grow regardless of cutting method, and cut plants produce twice the length and weight of new shoots after 7 days under high humidity than they produce in low humidity [104]. After several years of mowing a hay meadow in Illinois and then stopping, native prairie species reemerged and dominated the site [190].

Biological control: Biological control may be a viable option for national parks and other natural areas that have restrictions on herbicide use [208]. Wilson and McAffrey [245] provide a discussion of considerations and safety issues in developing and implementing a biological control program.

There are more than 130 species, including pathogens, birds, and over 80 insects known to attack Canada thistle [137,162]. Some of the biocontrol agents that have been tested and references pertaining to them are listed below:

Biocontrol Agent	Location tested	References
Canada thistle rust (reduces flowering and vegetative reproduction; clones differ in susceptibility)	growth chamber research	[212]
Sclerotinia sclerotiorum (endemic white mold)	MT	[25,129,150]

Altica carduorum (flea beetle; failed to establish)	SD, Canada	[128,137,172,207]
Ceutorhynchus litura (stem boring weevil)	CA, CO, ID, MD, MT, NJ, OR, SD, WA	[111,137,150,181,182,207,244]
Larinus planus (seedhead weevil)	CO, MD, NY, OH, OR, PA, WA	[111,240,244]
Rhinocyllus conicus (flowerhead weevil)	ID, MD, MT, OR, UT, WA	[216,240,244,254]
Urophora cardui (gall fly; stresses plant, reducing flowering and seed set)	CO, ID, MT, OR, WA, Canada	[111,137,150,173,174,182,201,207
tortoise beetle (*Cassida rubiginosa*) (defoliator)	MD, VA, eastern and central U.S.	[5,6,7,182]
Orellia ruficauda (seed predator)	throughout North America	[69,125,208]
Baris sp. (root-boring weevil)	MT	[208]

To date, biological control of Canada thistle has not been successful, although some biological control agents (e.g., *Ceutorhynchus litura* and *Cassida rubiginosa*) suppress it to a limited extent and may be effective when combined with other control methods [5,6,7,53,69,85,181]. Even in its native range in Europe, Canada thistle is a serious weed in spite of the large number of insects that are found in and on the plant [83,162]. Most potential biocontrol organisms are not adequately synchronized with Canada thistle's life cycle in North America to induce high mortality. Management that delays Canada thistle maturation, such as mowing or burning, may help synchronize the susceptible thistle growth stage to the biocontrol agent life cycle [69]. Biological control measures may also be more effective when coupled with factors that favor the competitive ability of native forbs and grasses [111].

Grazing is not likely to be an effective control method for Canada thistle since cattle and horses avoid it and graze competing vegetation which results in gradual dominance by Canada thistle. Furthermore, heavy grazing breaks up sod and reduces cover of native vegetation, which encourages the spread of Canada thistle [162]. Some evidence suggests that domestic goats, sheep, and cattle may prevent Canada thistle from flowering by grazing it prior to the bud stage in early spring [129,153]. Domestic sheep have been reported to graze and trample plants that have been treated with salt [83], and intensive pasture grazing by sheep in Australia reduced the spread of Canada thistle compared to an ungrazed pasture [153].

Chemical: Most reports and studies of herbicide use for reduction of Canada thistle apply to agricultural areas and are not directly applicable for use in natural areas. Many herbicides cannot be used in natural areas because of their potential to harm non-target plant and animal species, including soil organisms, aquatic species, humans, and other vertebrates, and the potential to contaminate water resources and set back the succession of natural communities [105,111,162]. Dioxin toxicity is also a concern in herbicide use since these chemicals are often found as impurities in herbicides [227]. Herbicides usually require repeated applications to achieve moderate control, and their continual use may lead to herbicide resistance, soil sterilization, and erosion [111]. Herbicides seldom provide long-term control of weeds when used alone and outside the context of an integrated weed management plan. They may control existing weeds, but the lack of a healthy community of desirable plants usually allows that weed or another invasive species to become established after the residual effects of the herbicide have dissipated [31].

Donald [53] provides a comprehensive review of chemical control of Canada thistle. More information is available on

use of herbicides on rangelands [31], on national forests in the Pacific Northwest ([244] and USDA Forest Service-PNW), and in general (EXTOXNET or NPTN). See the Weed Control Methods Handbook for considerations on the use of herbicides in natural areas and detailed information on specific chemicals.

Results from herbicide treatment of Canada thistle can vary for several reasons including differential susceptibilities of different ecotypes, different growth stages [70], application method and rate, and the possibility of selecting a tolerant variety from the original gene pool [85,162]. If the physiological, morphological, and phenological stage of the plants and the environmental conditions under which the plants are growing are not optimal, herbicides will be ineffective and control will not be satisfactory [203]. Many herbicides recommended for control of Canada thistle are foliar applied, systemic toxins that must be translocated to the roots to be effective. These chemicals must be applied when moisture status of the plants is favorable (i.e. do not apply herbicides to old leaves or to drought stressed plants), plants are growing well, and, ideally, during the period when photosynthates are translocated to the roots [203,222]. For Canada thistle, this period is thought to correspond to the bud stage [203], but more recent evidence suggests that greater photoassimilate movement to the roots occurs during the rosette and bolt stages. Additionally, environmental conditions typical of fall, and possibly early spring, favored photoassimilate movements to the roots [223]. Spot treating Canada thistle with herbicides in the early spring or fall when native species are dormant may be less damaging to the ecosystem as well. Differences in foliar lipid extracts between Canada thistle ecotypes may have implications for chemical control, as those with greater amounts of lipids on the leaves are more resistant to foliarly applied herbicides [55,203].

Canada thistle was unaffected by AAl-toxin, a natural herbicide (a plant pathogen metabolite) [1], while wheat gluten meal was found to inhibit germination and root extension in Canada thistle [79]. Some persons have had success killing individual plants by cutting the top and putting table salt down the hollow stem [248].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Cirsium arvense

GENERAL BOTANICAL CHARACTERISTICS:
Canada thistle is a perennial introduced forb. It is distinguished from other thistles by creeping horizontal lateral roots, dense clonal growth, and dioecious habit [49,122,241]. Descriptions and terminology of Canada thistle biology can be confusing or contradictory. For example, descriptions of leaf morphology, stem height, and number of flowering heads may differ somewhat between floras. The following discussion provides ranges of what may be encountered for these characteristics, which will vary under different field conditions. Donald [55] and Moore [151] provide comprehensive reviews of the biology of Canada thistle.

Canada thistle has a deep and wide-spreading root system with a slender taproot and far-creeping lateral roots. It often forms large patches, and individual clones may reach 115 feet (35 m) in diameter [55,75,127,187,249]. Most Canada thistle roots are in the top 0.7 to 2 feet (0.2-0.6 m) of soil, but roots can extend as deep as 6.5 to 22 feet (2-6.75 m) [113,153,158]. Carbohydrate reserves are stored in roots and can range from 3% of root fresh weight during spring to as high as 26% in late fall [138]. Roots are injured when directly exposed to freezing temperatures for 2 hours at -5 °C and killed after 2 hours at -7 °C [193]. Arbuscular mycorrhizal infection of Canada thistle roots has been observed in several studies [17,50,116]. Canada thistle does not form rhizomes, despite this assertion in some literature. Adventitious root buds that may form new adventitious shoots can develop along the root at any location, and at any time of the year with favorable growing conditions [55,85]. New plants can also form from root fragments as short as 0.2 inch (6 mm) [158]. Soil type, structure and horizonation may impact the anatomy, morphology and distribution of Canada thistle roots as well. This suggests that root morphology and distribution are site specific and greenhouse studies of root morphology may not apply [55].

Canada thistle has slender aerial shoots with leafy stems reaching 1 to 6.5 feet (0.3-2 m) tall [42,81,84,177,239]. Leaves are 1.2 to 7 inches (3-18 cm) long and 0.2 to 2.4 inches (0.5-6 cm) wide [81,135,239]. Canada thistle leaf morphology (texture, hairiness, lobing and spininess) can vary considerably, even within a geographical region [84,151]. Canada thistle has numerous aboveground branches that bear several, small flowerheads (0.4 to 0.75 inch (1-2 cm) in diameter) in clusters [49,81,122,127,177,241]. Seeds are 0.09 to 0.2 inch (2.4-5 mm) long, and 0.04 inch (1 mm) in diameter with a pappus of feathery bristles [42,75,177,239,241].

While allelopathy has not been conclusively demonstrated for Canada thistle, this species may produce phytotoxins that inhibit the growth of other plants [55,204]. Fructan metabolism in Canada thistle adds to its competitive advantages by allowing it to grow at relatively cool temperatures [37].

RAUNKIAER [179] LIFE FORM:
Geophyte

REGENERATION PROCESSES:
Canada thistle reproduces both sexually by seed and vegetatively by creeping roots. Generally, vegetative reproduction contributes to local spread and seeding to long distance dispersal. Introduction into new areas is mostly by wind- or water-borne seed, or by seed in contaminated crop seed, hay or machinery [55,105]. Canada thistle allocates most of its reproductive energy to vegetative propagation, and a patch can spread rapidly by vegetative means under favorable conditions. Total allocation of dry weight to sexual reproduction was only 7% for Canada thistle grown in pots [23]. However, the contribution of sexual reproduction to the survival and spread of Canada thistle may be underestimated and may be an important mechanism for initiating continued genetic diversity in a clonal population [89].

Sexual reproduction: Shoot elongation and flowering in Canada thistle are induced by 15-hour day length, therefore flowering and seed production will be limited or prevented in regions with shorter summer days [84]. A typical Canada thistle shoot may produce 32 to 69 flowerheads per shoot (1-5 per branch) on average, but can produce as many as 100 flowerheads in a season [151,153]. Canada thistle is "imperfectly dioecious" [55], with male and female flowers occurring on separate plants. Up to 26% of "male" plants are actually self-fertile hermaphrodites or subhermaphrodites that occasionally produce seed [108].

Seed production: Canada thistle is insect pollinated, primarily by honeybees [55,105,151]. Male and female plants must be located within a few hundred yards of each other for insect pollination and seed set to occur [84]. Seed set is highest when male and female plants are intermixed and decreases when female plants are more than 164 feet (50 m) from male plants [126]. Since Canada thistle can grow in large patches, it is not uncommon to find sterile heads of female flowers [126,153]. Canada thistle has a reputation for producing few viable seeds, but the literature gives a wide range of estimates for seed production with numbers ranging from 0 to 40,000 seeds per stem [38,89]. Reports of average seed-set per flowerhead range from 21-93 [89,153]. Kay [108] reports that females produce an average of 30 to 70 seeds/flowerhead and males average 2 to 10 seeds/head. The number of flowerheads per stem reported ranges from 0 to 100 [89]. In annual grasslands in northern California where biomass of Canada thistle was 13$\pm$ 8 g/m^2, seed production was 1300 seeds/m^2, seed rain was 80$\pm$ 50 seeds/m^2, and germinable seeds in the top 2 cm of soil were 280$\pm$110/m^2 [96]. Inefficient pollination and genetic variability may contribute to poor seed yields [89]. Seeds of Canada thistle are subject to predation by insects before dispersal, but information is more qualitative than quantitative [55,89]. Weather extremes (cool and moist or hot and dry) can interfere with pollination, so some years even female plants do not produce much seed [61].

Seed dispersal: Canada thistle seeds are released about 2-3 weeks after pollination [124]. They are equipped with a pappus, loosely attached to the seed tip, that enables wind dispersal, and have good aerodynamic efficiency [199]. Canada thistle seeds have been observed windborne on the prairie several hundred meters from the nearest source population [176]. Evidence from seed rain studies on Mount St. Helens, Washington suggests that Canada thistle seeds can travel several kilometers [250]. This dispersal mechanism accounts for the numerous examples of Canada thistle seedling establishment after disturbance in natural areas [45,106,109,217,221], especially after fire [139,164,189,194]. However, wind dispersal has not been considered a major factor in its spread, since the pappus readily breaks off, leaving the achenes within the seedheads [23]. In developed areas, seeds are more commonly spread by animals, in hay, contaminated crop seed, machinery, and irrigation water [162]. Observations in Rocky Mountain National Park indicate that trails, especially those used by horses, are major invasion pathways for Canada thistle [140]. Livestock consuming unprocessed hay before entering national forests will likely spread more Canada thistle seeds than those

consuming feed pellets, since pellet manufacturing destroys 99% of viable Canadian thistle seed when it includes grinding and screening [35].

Viability and germination: Canada thistle seeds mature quickly and most are capable of germinating 8 to 11 days after the flowers open, even if the plants are cut when flowering. Moore [151] summarized research indicating that almost all Canada thistle seed can germinate upon dispersal, although germination is extremely variable (0-95%). Viability of seeds during the 1st season after dispersal may be as high as 90% [84]. Most seeds germinate in the spring after the year in which they are produced [97,189], with some seeds producing basal leaves before winter and emerging to flower the next spring [105]. However, Heimann and Cussans [89] indicate that seedlings are not always able to survive the winter. Germination may be affected by ecotype, temperature, day length, depth of seed burial, substrate stratification, and seed freshness [162]. Seeds from "male" plants are smaller and percent germination is lower [108]. Temperature requirements for germination were summarized by Moore [151]; the effects of light, pH, and salinity are summarized by Donald [55]. Canada thistle seeds germinate best in warm temperatures (68 to 104 degrees Fahrenheit (20-40 °C)), with alternating light and dark periods [22,189,246]. Germination in Canada thistle was best after 0.5 to 16 days at 88 to 108 degrees Fahrenheit (31-42 °C) [213]. At lower temperatures germination is aided by high light intensity [89,97]. Germination at higher temperatures can help ensure that maximum germination takes place during warmer periods of the year [89]. Canada thistle seeds are somewhat tolerant of heat, and some were still viable after 10 minutes at 216 degrees Fahrenheit (102 °C) and 2 minutes at 504 degrees Fahrenheit (262 °C), although viability was decreased at these temperatures compared to unheated controls [213]. Canada thistle seeds germinate over a wide range of soil moisture [246]. Heimann and Cussans [89] provide a summary indicating that Canada thistle seed can germinate on the soil surface, but that germination is best when seeds are buried 0.2 to 0.6 inch (0.5-1.5 cm) deep. Emergence as deep as 6 cm in some soil types has been reported [246]. Most germination studies have been done under artificial conditions, and factors influencing germination in the field are far more complex [89].

Seed banking: The soil seed bank does not usually contain large numbers of Canada thistle seeds [36,185], although there is evidence of seed banking in a coastal British Columbia coniferous forest soil [110], in mature forest sites in central Idaho [117], and in the Delta Marsh in Manitoba [230]. Length of survival is related to depth of burial, with seeds surviving up to 22 years when they are buried more than 8 inches (20 cm) deep [78]. Under more natural conditions of shallower burial and periodic soil disturbance, Canada thistle seeds are more short lived (<5 years), with most seed being lost from the soil seed bank by germination during the 1st year [55]. Seeds that have been in water for several months can still be viable [84]. Donald [55] summarizes the research on seed banking in Canada thistle and the effects of seed immersion in water.

Seedling establishment: Canada thistle seedlings usually start growing slowly and are sensitive to competition and shading [55,89,129]. Seedlings grow poorly in very moist, poorly aerated soils and do not tolerate drought stress [246]. Before seedlings become perennial, they are also highly susceptible to tillage [153].

Asexual reproduction: Vegetative spread of Canada thistle can occur from horizontal extension of the root system, from root fragments, or from subterranean stem tissue [132]. Spread can be rapid when there is little competition, with 13 to 20 feet (4-6 m) of horizontal root growth possible in one season [97,186]. Canada thistle can develop new aerial shoots at any location along the root length, from the original vertical root, or from buds on lateral roots. Within a few weeks of germination, a Canada thistle seedling with at least 4 true leaves can begin producing root buds that can eventually produce new shoots [84]. Buds on lateral roots may form new adventitious shoots as frequently as 0.3 to 1-inch (0.8 to 2.4 cm) intervals [103], although the number of root buds is likely to vary from place to place and year to year [158]. A single Canada thistle plant can potentially produce 26 adventitious shoots, 154 adventitious root buds, and 364 feet (111 m) of roots after 18 weeks of growth [153,158]. It is possible that a colony of male plants would maintain itself regardless of whether it produced fruits [241].

Root buds are inhibited by the presence of the main shoot, primarily due to a competition for water [104], and new root bud growth is highest during late fall and winter months following death of aerial shoots [138]. When the main shoot is removed (e.g. as by mowing) the root buds are released, and new shoots emerge rapidly, especially when humidity is high [104,158]. Wilson [246] found that some 19-day old plants were capable of regenerating top-growth after clipping, and that 40-day old plants could produce 2 or 3 shoots after clipping. Root fragments as short as 0.2 inch (6 mm) and more than 6 weeks but less than 2 years old can regenerate entire plants, regardless of whether they have identifiable root buds at the time [158]. Nadeau and Vanden Born [158] observed that an 18-week-old plant had the potential of producing 930 shoots if its root system was cut into 10-cm-long pieces.

Vegetative spread of Canada thistle may also occur from subterranean stem tissue that can produce shoot buds and adventitious roots at each node. Partially buried stem sections from the postbloom stage survived and produced adventitious roots that over wintered and produced new infestations the following spring [132]. Similarly, Canada thistle can survive disturbance to be part of the early successional community in natural areas by resprouting from buried root and stem fragments [2,45,189,217].

SITE CHARACTERISTICS:
Temperature: Canada thistle grows best between 32 and 90 degrees Fahrenheit (0-32 °C) [151,153]. Extended periods with temperatures over 90 degrees Fahrenheit (32 °C) reduce plant vigor and generally limit growth. High temperatures and shorter days keep Canada thistle from thriving in the southern U.S. Optimum day/night temperatures for growth are 77 and 59 degrees Fahrenheit (25 and 15 °C), respectively [85]. The northern limit of Canada thistle's growth corresponds to the 0 degrees Fahrenheit (-18 °C) mean January isotherm; flowering is also limited in the northern latitudes [151]. Canada thistle invasion of native rangelands appears to be a problem especially of highly productive, mesic habitats [180,204,253]. However, Canada thistle was able to infest subalpine fir/twinflower habitats in western Montana [68]. The temperature exposure of overwintering buds required to reduce survival of Canada thistle was 2 hours at 19 degrees Fahrenheit (-7 °C) and to reduce total dry weight was 2 hours at 23 degrees Fahrenheit (-5 °C) [193]. The ability of adventitious root buds to withstand freezing depends on their location in the soil profile [55,193]. In soil samples from a mid-boreal wetland subjected to increased temperatures, Canada thistle seedling emergence increased significantly ($p<0.05$) at higher temperatures [99,100].

Moisture: Canada thistle tolerates annual precipitation ranging from 12 to 40 inches (305-1015 mm) per year, and grows best with 16 to 30 inches (400-750 mm) of precipitation per year [83,151,153]. In range and pastureland, Canada thistle is often restricted to swales or other areas of deep, moist soils [129]. Canada thistle is concentrated in disturbed areas and along streams, rivers and other moist areas in Rocky Mountain National Park, although individual plants have been found on relatively dry, sagebrush-dominated sites [140]. A high water table limits root growth [186], but Canada thistle often occurs in wetlands where water levels fluctuate, and in degraded sedge meadows it may be found growing on tussocks elevated above the normal high water line. In a mid-boreal wetland subjected to drought, Canada thistle increased 5- to 13-fold over predrought levels [98,100]. Canada thistle survives well in dry places [186] and under extended periods of drought, but biomass and number of root buds decrease after several years [195]. Growth was increased by high relative humidity (90-100%) over low relative humidity (30-50%) [104].

Elevation and slope: Canada thistle occurs over a wide range of elevations from sea level [58] to elevations in excess of 8,000 feet (2,500 m) [49]. In the northern Rocky Mountains, it is found mainly by roadsides and other disturbed sites in the lower elevations and warmer, drier habitats, and escapes to undisturbed sites at upper elevations [141,236]. In Yellowstone National Park, Wyoming, Canada thistle occurs at elevations ranging from 5,970 to over 7,875 feet (1,820-2,400 m) [4]. In Rocky Mountain National Park, Colorado, Canada thistle coverage is greater at elevations around 8,375 feet (2,550 m) and decreases at elevations around 9,095 feet (2,770 m), but occurs up to at least 9,185 feet (2,800 m) [140]. Canada thistle grows best on shallow (9-30%) slopes [4,141].

Soils: The wide distribution of Canada thistle suggests that it is adaptable to many soil types [55,186]. It grows on all but waterlogged, poorly aerated, and peat soils, including clay, clay loam, silt loam, sandy loam, sandy clay, sand dunes, gravel, limestone, and chalk [162]. Rogers [186] suggests that Canada thistle grows best on limestone soils with abundant moisture. Some authors suggest that it is best adapted to clay soils [153]; others suggest that it prefers well-aerated soils [151]. Preliminary results in Rocky Mountain National Park indicate that soils supporting Canada thistle tended to have a surface (0-10 cm) texture higher in clay and silt than in sand [140]. Canada thistle was found growing on heavily saline soils in central Alberta, though it was absent from saline areas of Saskatchewan and Manitoba [24]. Hardpans, gravel, sand, or very alkaline soil horizons can limit root development of Canada thistle [186].

Competition and light: Canada thistle grows best in open sunny sites [151]. Canada thistle seedlings are much less competitive than established plants, and will survive only if competition is limited and the daytime light intensity remains above 20% of full sunlight [153]. In Rocky Mountain National Park, total canopy cover of vegetation within Canada thistle patches is less than outside the patches [140]. At Yellowstone National Park, Canada thistle was found in 6 out of 10 campgrounds, with occurrences most frequent under a canopy cover of less than 20%, although it was occasionally present under more closed canopy covers (up to 95%) suggesting that it is somewhat tolerant of shade. Twenty percent of the quadrats in which Canada thistle was present had no evidence of disturbance [4]. Because Canada thistle is relatively shade intolerant, it may be found growing along the edges of woods (both deciduous and

coniferous), but is rarely found under forest canopy, in undisturbed prairies, good to excellent pastures, or woodland or sites that are shaded most of the day [83,105,162]. In the Delta Marsh in Manitoba, Canada thistle is present in communities dominated by common reed. It is capable of persisting on undisturbed plots, growing with stunted spindly stems and no flowers, but growth improves after disturbance [214].

Generally, Canada thistle establishes and develops best on open, moist, disturbed areas, including ditch banks, overgrazed pastures, meadows, tilled fields or open waste places, fence rows, roadsides, and campgrounds; and after logging, road building, fire and landslides in natural areas [4,45,106,115,123,139,159,164,189,194,217,221]. Roads, streams and ditches provide areas of disturbance and corridors for invasion. At Yellowstone National Park, Canada thistle was found in all levels of disturbance (along horse and foot trails, roadways, and campgrounds) and its abundance increased as disturbance cover increased [4,220]. Physically disturbed habitat in fragmented old growth in Indiana facilitated invasion by exotics including Canada thistle [26]. Canada thistle invasion was also enhanced by heavy grazing by bison [238], areas left barren during planting operations, and on earth mounds made by pocket gophers and badgers in North and South Dakota [93].

SUCCESSIONAL STATUS:
Canada thistle is an early successional species that emerges from seed or root fragments shortly after disturbance. It grows best in open sunny sites, though may be somewhat tolerant of shade (see "Site Characteristics"). Canada thistle may establish in natural areas as part of the initial plant community after logging [106,109,161,251], fire [16,80,139,164,189,194,243], volcanic eruption (debris deposit, landslide) [2,45,217,218], grazing [144], and road building [141]. Canada thistle and other introduced species are taking over large tracts of logged, burned, or otherwise disturbed land in British Columbia [221]. In northern Idaho, Canada thistle establishes following clearcutting with soil displacement. With low soil displacement, the plant community follows a successional sequence that favors the eventual establishment of tree and shrub species, but with heavy soil displacement, a persistent forb-rich community, including Canada thistle, develops with few tree species present, and very little species replacement over time [106]. Canada thistle may not establish immediately after logging and fire disturbances, but may be delayed for 2 or more seasons [3,56,165,243]. Canada thistle was among the 3 most common species to survive a debris deposit created by the 1980 eruption of Mount St. Helens, where it sprouted from transported root fragments, and from seed [2,45,217]. Canada thistle is also found among the emergent vegetation after drawdown in the Delta Marsh, Manitoba [143,230]. In a study comparing possible control methods for perennial pepperweed, Canada thistle established, along with cheatgrass, after disking and herbicide treatments that reduced cover of native forbs and grasses [112].

SEASONAL DEVELOPMENT:
Most Canada thistle seed is sufficiently mature to germinate 8 to 11 days after flowering begins, depending on specific growing conditions [89]. Seedlings begin to develop lateral roots and adventitious root buds when they are about 3 to 5 weeks old, thereby becoming perennial [85,153]. Canada thistle seedlings can flower in the same growing season that they emerge, but they require a juvenile vegetative period before established plants can flower in response to light [14,55]. It has not been established whether shoots arising from adventitious root buds on established root systems have a similar juvenile period before flowering [55].

Canada thistle phenology varies with ecotype, but follows a general pattern. Plants develop new roots and underground shoots in January and begin to elongate in February [162]. New shoots from established Canada thistle plants begin to emerge when average weekly temperature reaches 41 degrees Fahrenheit (5 °C), with optimum emergence after temperatures are at least 46 degrees Fahrenheit (8 °C) [97,153,162]. Plants remain short until long days trigger flowering and stem elongation, normally in May and June, or about 3 weeks after emergence [84,97]. When soil is warm and temperatures are moderate (as in fall) Canada thistle grows vigorously [84,162].

The growth response of Canada thistle shoots and roots to temperature and photoperiod has been reviewed [151]. In general, flowering occurs in response to 15-hour photoperiods, and low temperature and short photoperiods (fall) favor root growth more than shoot growth [55]. The flowering period varies from place to place and year to year, but occurs sometime between May and October in North America. The blooming period is longer in northern locales than in the south [162]. The flowering periods for some locations are presented below:

Location	Flowering period	Reference
Canada	mid-June to September	[83,205]

Idaho and Montana	late May to August	[55]
Colorado and Nebraska	early to mid-June to August	[55,97]
Intermountain region	July and August	[42]
Northeast	July and August	[75]
seaside habitats from northern New Jersey to Greenland	June to October	[58]
New Mexico	June to September	[135]
Great Plains	June to August	[81,127]
Tennessee	July to October	[249]
West Virginia	June to September	[209]
Carolinas	July until frost	[178]

Root carbohydrate reserves follow an annual cycle, though it is unclear whether root reserve depletion and replenishment are controlled by environment or plant growth stage. Root carbohydrate reserves decline at several growth stages in the spring and early summer, and replenishment occurs only in late summer and fall [223]. The period of rapid shoot elongation may correspond to the period when root reserves are lowest [97]. Root growth continues in the fall as long as leaves are present [84]. Canada thistle emerging in fall tends to form rosettes with stems that do not elongate to produce flowers prior to killing frosts, whereas shoots that emerge in spring tend to elongate without forming extensive rosettes [55]. Seasonal dormancy in Canada thistle is induced by limiting growth temperatures [85].

FIRE ECOLOGY

SPECIES: Cirsium arvense

FIRE ECOLOGY OR ADAPTATIONS:
Canada thistle is adapted to both survive fire on site, and to colonize recently burned sites with exposed bare soil. The extensive root system gives it the ability to survive major disturbances as observed, for example, at Mt. St. Helens, where Canada thistle was part of the initial community after the 1980 eruption. It survived landslide and resprouted from root and stem fragments after the blast [2,45,217]. Similarly, the roots can survive fires of varying severity and produce new shoots [189]. Additionally, there are numerous examples from the literature where Canada thistle seedlings established from wind-deposited seed, anywhere from 2 to 9 years after fire [3,56,123,139,159,191,220,243].

Canada thistle may change the fire ecology of the site in which it occurs by its abundant, flammable aboveground biomass. For example, in boreal wet-meadows, Canada thistle has the potential to increase fire frequency and perhaps severity as a result of its abundant and readily ignited litter [100].

The following table provides some historic fire regime intervals for habitats in which Canada thistle may occur:

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 [9]
maple-beech-birch	*Acer-Fagus-Betula*	> 1000
silver maple-American elm	*A. saccharinum-Ulmus americana*	< 35 to 200
sugar maple	*A. s.*	> 1000

sugar maple-basswood	*A. s.-Tilia americana*	> 1000 [234]
bluestem prairie	*Andropogon gerardii* var. *gerardii-Schizachyrium scoparium*	< 10 [118,169]
Nebraska sandhills prairie	*A. g.* var. *paucipilus-S. s.*	< 10
bluestem-Sacahuista prairie	*A. littoralis-Spartina spartinae*	< 10
sagebrush steppe	*Artemisia tridentata/Pseudoroegneria spicata*	20-70 [169]
basin big sagebrush	*A. t.* var. *tridentata*	12-43 [192]
mountain big sagebrush	*A. t.* var. *vaseyana*	20-60 [10,30]
Wyoming big sagebrush	*A. t.* var. *wyomingensis*	10-70 (40**) [232,252]
coastal sagebrush	*A. californica*	< 35 to < 100
plains grasslands	*Bouteloua* spp.	< 35
blue grama-needle-and-thread grass-western wheatgrass	*B. gracilis-Hesperostipa comata-Pascopyrum smithii*	< 35
blue grama-buffalo grass	*B. g.-Buchloe dactyloides*	< 35
cheatgrass	*Bromus tectorum*	< 10
California montane chaparral	*Ceanothus* and/or *Arctostaphylos* spp.	50-100 [169]
sugarberry-America elm-green ash	*Celtis laevigata-Ulmus americana-Fraxinus pennsylvanica*	< 35 to 200 [234]
curlleaf mountain-mahogany*	*Cercocarpus ledifolius*	13-1000 [11,196]
mountain-mahogany-Gambel oak scrub	*C. l.-Quercus gambelii*	< 35 to < 100
northern cordgrass prairie	*Distichlis spicata-Spartina* spp.	1-3 [169]
beech-sugar maple	*Fagus* spp.*-Acer saccharum*	> 1000 [234]
California steppe	*Festuca-Danthonia* spp.	< 35 [169]
black ash	*Fraxinus nigra*	< 35 to 200 [234]
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
tamarack	*Larix laricina*	35-200 [169]
western larch	*L. occidentalis*	25-100 [9]
yellow-poplar	*Liriodendron tulipifera*	< 35 [234]
wheatgrass plains grasslands	*Pascopyrum smithii*	< 35 [169]
Great Lakes spruce-fir	*Picea-Abies* spp.	35 to > 200
northeastern spruce-fir	*P.-A.* spp.	35-200 [57]
Engelmann spruce-subalpine fir	*P. engelmannii-A. lasiocarpa*	35 to > 200 [9]
black spruce	*P. mariana*	35-200
conifer bog*	*P. m.-Larix laricina*	35-200 [57]
blue spruce*	*P. pungens*	35-200 [9]
red spruce*	*P. rubens*	35-200 [57]
pine-cypress forest	*Pinus-Cupressus* spp.	< 35 to 200 [9]
pinyon-juniper	*P.-Juniperus* spp.	< 35 [169]

whitebark pine*	*P. albicaulis*	50-200 [9]
jack pine	*P. banksiana*	<35 to 200 [57]
Rocky Mountain lodgepole pine*	*P. contorta* var. *latifolia*	25-300+ [8,9,188]
Sierra lodgepole pine*	*P. c.* var. *murrayana*	35-200 [9]
shortleaf pine	*P. echinata*	2-15
shortleaf pine-oak	*P. e.-Quercus* spp.	< 10 [234]
Colorado pinyon	*P. edulis*	10-49 [169]
South Florida slash pine	*P. elliottii* var. *densa*	1-5 [157,234]
Jeffrey pine	*P. jeffreyi*	5-30
western white pine*	*P. monticola*	50-200
Pacific ponderosa pine*	*P. ponderosa* var. *ponderosa*	1-47
interior ponderosa pine*	*P. p.* var. *scopulorum*	2-10
Arizona pine	*P. p.* var. *arizonica*	2-10 [9]
Table Mountain pine	*P. pungens*	< 35 to 200 [234]
red pine (Great Lakes region)	*P. resinosa*	10-200 (10**) [57,72]
red-white-jack pine*	*P. r.-P. strobus-P. banksiana*	10-300 [57,90]
pitch pine	*P. rigida*	6-25 [29,91]
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 [234]
eastern cottonwood	*Populus deltoides*	< 35 to 200 [169]
aspen-birch	*P. tremuloides-Betula papyrifera*	35-200 [57,234]
quaking aspen (west of the Great Plains)	*P. t.*	7-120 [9,82,142]
black cherry-sugar maple	*Prunus serotina-Acer saccharum*	> 1000 [234]
mountain grasslands	*Pseudoroegneria spicata*	3-40 (10**) [8,9]
Rocky Mountain Douglas-fir*	*Pseudotsuga menziesii* var. *glauca*	25-100 [9]
coastal Douglas-fir*	*P. m.* var. *menziesii*	40-240 [9,154,184]
California mixed evergreen	*P. m.* var. *m.-Lithocarpus densiflorus-Arbutus m.*	< 35
California oakwoods	*Quercus* spp.	< 35 [9]
oak-hickory	*Q.-Carya* spp.	< 35[234]
oak-juniper woodland (Southwest)	*Q.-Juniperus* spp.	< 35 to < 200 [169]
northeastern oak-pine	*Q.-Pinus* spp.	10 to < 35 [234]
coast live oak	*Q. agrifolia*	<35 to 200 [9]
white oak-black oak-northern red oak	*Q. alba-Q. velutina-Q. rubra*	< 35 [234]
canyon live oak	*Q. chrysolepis*	<35 to 200

blue oak-foothills pine	*Q. douglasii-P. sabiana*	<35 [9]
northern pin oak	*Q. ellipsoidalis*	< 35 [234]
Oregon white oak	*Q. garryana*	< 35 [9]
bear oak	*Q. ilicifolia*	< 35 >[234]
California black oak	*Q. kelloggii*	5-30 [169]
bur oak	*Q. macrocarpa*	< 10
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 [234]
interior live oak	*Q. wislizenii*	< 35 [9]
blackland prairie	*Schizachyrium scoparium-Nassella leucotricha*	< 10
Fayette prairie	*S. s.-Buchloe dactyloides*	< 10
little bluestem-grama prairie	*S. s.-Bouteloua* spp.	< 35
tule marshes	*Scirpus* and/or *Typha* spp.	< 35 [169]
redwood	*Sequoia sempervirens*	5-200 [9,62,210]
western redcedar-western hemlock	*Thuja plicata-Tsuga heterophylla*	> 200 [9]
eastern hemlock-yellow birch	*T. canadensis-Betula alleghaniensis*	> 200 [234]
western hemlock-Sitka spruce	*T. h.-Picea sitchensis*	> 200
mountain hemlock*	*T. mertensiana*	35 to > 200 [9]
elm-ash-cottonwood	*Ulmus-Fraxinus-Populus* spp.	< 35 to 200 [57,234]

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

POSTFIRE REGENERATION STRATEGY [206]:
Geophyte, growing points deep in soil
Ground residual colonizer (on-site, initial community)
Initial off-site colonizer (off-site, initial community)

FIRE EFFECTS

SPECIES: Cirsium arvense

IMMEDIATE FIRE EFFECT ON PLANT:
Fire kills the aboveground portion of Canada thistle plants, while the roots can survive severe fires [253].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT:
No entry

PLANT RESPONSE TO FIRE:
Canada thistle is slightly damaged to enhanced by fire [253]. It can survive fire and sprout vegetatively from its extensive perennial root system [189], or colonize bare ground via seedling establishment after fire [3,56,191]. For example, in Yellowstone National Park, Canada thistle is rare in unburned forests but locally abundant in burned areas [48]. When sites supporting Canada thistle are burned, its response is variable, and may be affected by season of burn, burn severity, site conditions, and plant community composition and phenology before and after the fire. Existing research provides no clear correlations with these variables.

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE:
Several studies have indicated the presence of Canada thistle in burned areas where it was absent from the prefire community and/or adjacent unburned areas [123,139,159,164,194]. In Grand Teton National Park, Wyoming, Canada thistle did not occur in unburned forest and was not part of the initial postfire vegetation after a mixed-severity wildfire. It established 2 years after fire on a moderate-severity site, and 9 years after fire on a severe site. On both sites, it decreased to $\leq$1% cover by postfire year 17 as cover of tree saplings increased [56]. Seedlings were found in a red pine forest in Minnesota, 3 years after fire, but not on adjacent unburned forest [3]. Canada thistle established 3 years after mixed-severity fires in sedge meadows in Glacier National Park [243]. In Yellowstone National Park, Canada thistle established after 1988 fires and increased in density over time, 2 to 5 years after fire, in all burn severities. Density was lowest in the low-severity burns and highest in the stand-replacing burns [220]. Canada thistle established on both bulldozer lines and burned areas after a 1988 wildfire in Glacier National Park, but was not present in comparable undisturbed sites [16].

Response of established Canada thistle plants to fire is unclear, as there are mixed reports in the literature. A Canada thistle clone in a mid-boreal wetland site was not noticeably changed when burned in the spring with a propane torch to simulate both light and deep burns [98]. The authors concluded that there is a moderate to high probability that Canada thistle and other Eurasian xerophytic species will dominate these wet-meadows in the short term after fire, and that they will continue to dominate small areas for longer periods [100]. There were no significant differences ($p<0.05$) in Canada thistle cover after spring burning in the prairie pothole region of Iowa [146]. In Mesa Verde National Park, Colorado, populations of Canada thistle that were well established before an August wildfire resprouted immediately after the burn, and spread downstream in the canyons. Canada thistle and other non-native species (e.g., cheatgrass (*Bromus tectorum*) and musk thistle (*Carduus nutans*)) continued to dominate the severely burned areas and expanded their area by 260% 6 years after the wildfire [64,67]. In a native mixed-grass prairie in North Dakota, late-spring and late-summer burning increased seed production and seedling numbers in Canada thistle, but fewer thistles were observed during the years following the burn than before or during the year of the burn [202]. Dormant season (winter and early spring) burning in eastern Oregon resulted in fewer total and fewer functional flowerheads on reproductive shoots of Canada thistle when compared to unburned control. Also, Canada thistle plants on burned sites grew more slowly and associated vegetation was more productive than on control sites. It was concluded that burning reduced the relative abundance of Canada thistle and may be useful as a means of halting its invasion or spread by maintaining a productive stand of native vegetation [253]. The discrepancy in these reports is probably due to the large number of variables that can affect the response of Canada thistle to fire, including fire severity, for which we lack a standard nomenclature in the literature. Other important variables include vegetation and site characteristics, frequency, and season of burning.

Site differences such as soil moisture content, plant community, and slope aspect can influence fire severity and may influence the response of Canada thistle to fire. In a northwestern Minnesota prairie site, prescribed burning on a nearly level mesic site in badly disturbed prairie had no effect on Canada thistle flowering while flowering was inhibited on a level, wet-mesic site in badly disturbed prairie after burning [171]. On a forested site in western Montana that was harvested and burned, Canada thistle seems to have increased with both light and severe burning in the fall, with larger increases on south aspects compared with others [123]. Olson [163] provided evidence that prescribed burning in the spring either reduced or did not change canopy cover of Canada thistle in Minnesota. Results differed between sites, which differed primarily in plant community type and in time and frequency of burning.

Frequency, severity and season of burning may have a considerable effect on Canada thistle response. In a study conducted on a mesic tallgrass prairie site in Colorado, plots that were burned frequently (5 times over 7 years) had lower density of Canada thistle than did and area that was burned only twice during the same period. Results were inconclusive, however, since the final season of the study saw increased spread of Canada thistle from the surrounding

area, probably due to clonal growth from existing plants [152]. In a prairie site at Pipestone National Monument, Minnesota, 5 years of annual spring burning in mid- to late April, with fires of low to moderate severity, reduced the frequency of Canada thistle over time until it was absent after the 5th year [15]. Similarly, observations in tallgrass prairie sites in South Dakota indicate that late spring prescribed burning (when native species are still dormant) on a 4 to 5 year rotation (as per the historic fire regime) encourages the growth of native plants and discourages the growth of Canada, bull and musk thistles. Livestock use must be carefully timed following burning, since grazing early in the growing season can potentially negate beneficial effects of prescribed fire [44]. On a common reed marsh in Manitoba, Canada thistle response to burning varied with season of burn. Aboveground biomass, stem density, and seedling density were unchanged on spring burns, but increased on both summer and fall burns [214]. Results are presented below:

	Biomass (g/m^2)	density (stems of nonseedling shoots/m^2)	density of seedlings (stems/m^2)
Control	5.0±7.0	0.9+0.9	0.2±0.4
Spring	5.3±4.8	4.9+3.1	0.4±0.2
Summer	63.3±39.4	20+3.9	1.5+3.3
Fall	27.6±48.6	9.5+12.5	1.4+2.6

For further information on Canada thistle response to fire, see Fire Case Studies. 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 Canada thistle.

FIRE MANAGEMENT CONSIDERATIONS:
Abundant evidence of postfire establishment of Canada thistle [16,139,164,194] suggests that managers need to be aware of this possibility, especially if a known seed source is in the area, and take measures to prevent the establishment of Canada thistle after prescribed burning and wildfires. Seeding with aggressive, introduced grasses such as crested wheatgrass, intermediate wheatgrass, orchardgrass, and smooth brome following a prescribed burn in Utah pinyon-juniper communities prevented establishment of Canada thistle, whereas unseeded areas supported Canada thistle seedlings [77]. Similarly, in disturbed forest sites where Canada thistle becomes established, it may be shaded out over time as trees reestablish [56].

Research in this report suggests that response of Canada thistle to fire is variable and it depends on vegetation and site characteristics, as well as frequency, severity and season of burning. Prescribed burns may be effective at stimulating growth of native species and thereby discouraging the growth of invasives such as Canada thistle [183], and may be best if timed to emulate the natural fire regime of a site [44]. Hutchison [105] states that prescribed burning is a "preferred treatment" for the control of Canada thistle, and that late spring burns effectively discourage this species, whereas early spring burns can increase sprouting and reproduction. During the first 3 years of control efforts, he recommends that burns be conducted annually [105]. Season of burn is an important consideration for prescribed burning, as the timing of the burn will determine species composition and cover in the post-fire community [101,102]. Dormant season burning may be a preferred treatment method in some areas, because in many habitats it stimulates growth of native vegetation that subsequently competes with Canada thistle [162,253]. However, dormant season burning may not be as effective as late spring burning [105]. Controlled studies comparing the effects of these variables in different natural areas are currently lacking in the literature.

Equations for estimating fuel loading of forb communities including Canada thistle are available [27].

The USDA Forest Service's "Guide to Noxious Weed Prevention Practices" [225] provides several fire management considerations for weed prevention in general that apply to Canada thistle. To prevent invasion after wildfires and prescribed burns, re-establish vegetation on bare ground as soon as possible using either natural recovery or artificial techniques as appropriate to site objectives. When reseeding burn areas, use only certified weed-free seed. Monitor burn sites and associated disturbed areas after the fire and the following spring for emergence of Canada thistle, and treat to eradicate any emergent Canada 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.

When planning a prescribed burn, preinventory the project area and evaluate cover and phenology of any Canada thistle present on or adjacent to the site, and avoid ignition and burning in areas at high risk for Canada thistle establishment or

spread due to fire effects. Avoid creating soil conditions that promote weed germination and establishment. Discuss weed status and risks in burn rehabilitation plans. Wildfire managers might consider including weed prevention education and providing weed identification aids during fire training; avoiding known weed infestations when locating fire lines, monitoring camps, staging areas, helibases, etc., to be sure they are kept weed free; taking care that equipment is weed free; incorporating weed prevention into fire rehabilitation plans; and acquiring restoration funding. Additional guidelines and specific recommendations and requirements are available [225].

FIRE CASE STUDIES:

SPECIES: Cirsium arvense

CASE NAME:
Malheur National Wildlife Refuge prescribed burns

REFERENCES:
Young, R. P. 1986 [253]

FIRE CASE STUDY AUTHORSHIP:
Zouhar, Kris. 2001.

SEASON/SEVERITY CLASSIFICATION:
winter and early-spring/low to moderate

STUDY LOCATION:
The study was conducted at the Malheur National Wildlife Refuge in southeast Oregon.

PREFIRE VEGETATIVE COMMUNITY:
The study area is a mesic herbaceous community dominated by creeping wildrye (*Elymus triticoides*). Associated vegetation includes Douglas sedge (*Carex douglasii*), Baltic rush (*Juncus balticus* var. *montanus*), Sandberg bluegrass (*Poa secunda*), and a diverse mixture of other graminoids and forbs. Populations of Canada thistle (*Cirsium arvense*), ranging from scattered shoots to dense patches, occur throughout the study area. Canada thistle was the dominant or codominant species on each of the study sites.

TARGET SPECIES PHENOLOGICAL STATE:
Prescribed burns were conducted in winter and early spring while vegetation was dormant.

SITE DESCRIPTION:
Elevation ranges from 4,100 to 4,200 feet (1,250-1,280 m) and annual precipitation averages 10 to 12 inches (250-300 mm) at the refuge. Soils are derived from lake sediments and alluvium. The landscape consists of extensive wet meadows and mesic herbaceous uplands that have been managed for native hay production and/or grazing since before the turn of the century.

FIRE DESCRIPTION:
Both the winter (10 December) and spring (7 April) burns were conducted when weather was cool (36 to 43 degrees Fahrenheit (2-6 °C)) with moderate to high relative humidity (38-53%) and steady, light winds (2.4 to 7.2 mi/hr (4-12 km/h)). Fuels were abundant (averaging 473-644g/m^2) and continuous and produced uniform, steadily advancing fires. Fire intensities of the winter and spring burns were 1,004 kW/m and 4,465 kW/m, respectively. Both burns consumed virtually all aboveground plant residues, leaving only white ash.

FIRE EFFECTS ON TARGET SPECIES:
Newly emerged rosettes of Canada thistle were noted on 5 April after the 10 December burn. Height and development over the remainder of the season was not discernibly different between winter and spring burns. Growth on burned plots was not different from controls until 21 June, when control plants were significantly taller ($p<0.05$). Bud formation in burn treatments was delayed by 1-2 weeks, and most flowerheads were aborted, resulting in the production of few functional flowers (>10%) on the burns, compared with >45% functional flowers on control. Shoots on control sites were still significantly taller than those on burn sites on 8 August. Total shoot density was more than 2 times greater on burn plots compared with control. Number of reproductive shoots was similar between burned and control plots, therefore the difference was attributed to the greater number of vegetative shoots on the burn plots. Total aboveground herbage production was greater on burned plots and was attributed to increased production by the associated vegetation in the burned areas. Burning altered the population structure of Canada thistle to a higher density of smaller shoots.

FIRE MANAGEMENT IMPLICATIONS:
Prescribed burning during the dormant season did not decrease biomass of Canada thistle and, therefore, may not be effective in eliminating it where it has become established in these plant communities. Fire did, however, reduce the relative abundance of Canada thistle within these communities, as well as the potential for spreading by seed. Canada thistle may be slowed or contained by prescribed burning under these conditions. The treatment warrants further study as a potential control measure.

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