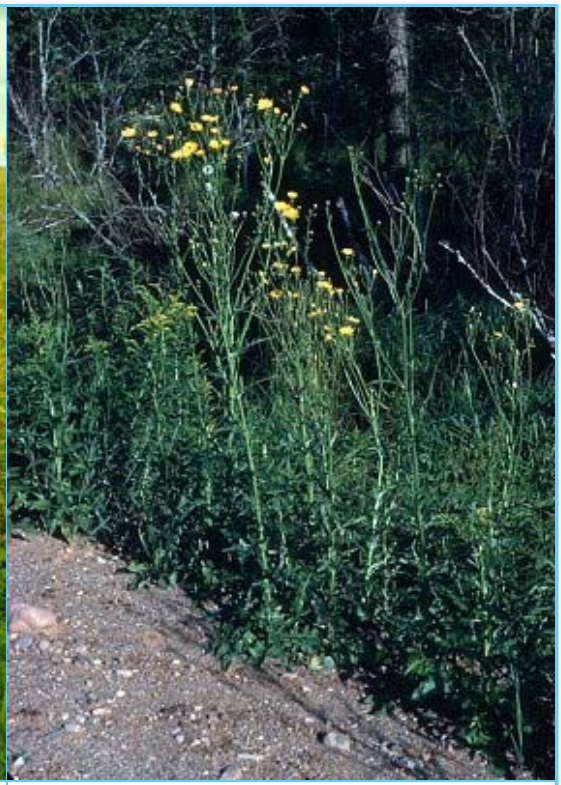
SPECIES: Sonchus arvensis

Choose from the following categories of information.

INTRODUCTORY

SPECIES: Sonchus arvensis

Photographer-John M. Randall/The Nature Conservancy



Photographer-Robert W. Freckman/Wisconsin State Herbarium,

AUTHORSHIP AND CITATION:
McWilliams, Jack 2004. Sonchus arvensis. 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, May 24].

FEIS ABBREVIATION:
SONARV:

SYNONYMS:
There are no recognized synonyms for *Sonchus arvensis*.

S. arvensis spp. *arvensis* is also known as *S. arvensis* var. *arvensis* [26,42,64,124].

S. arvensis spp. *uliginosus* is also known as *S. uliginosus* [34,58,71,126] and *S. arvensis* var. *glabrescens* [26,42,64,114,124].

NRCS PLANT CODE [121]:
SOAR2

COMMON NAMES:
perennial sowthistle
perennial sow thistle
field sowthistle

TAXONOMY:
The currently accepted scientific name for perennial sowthistle is *Sonchus arvensis* L. (Asteraceae) [26,34,42,45,57,58,62,64,71,72,81,114,124,126]. There are 2 recognized subspecies:

S. arvensis ssp. *arvensis*
S. arvensis ssp. *uliginosus* (Bieb.) Nyman [45,72]

In this summary, perennial sowthistle will be used when discussing *Sonchus arvensis*, and the subspecies will be referred to by their scientific names when information pertaining to them individually is available.

Naturally occurring hybrids produced by the 2 subspecies have been detected in areas where both subspecies occur [74].

LIFE FORM:
Forb

FEDERAL LEGAL STATUS:
No special status

OTHER STATUS:
Perennial sowthistle is listed as a noxious weed in 13 states as of this writing (2004). Plants database provides a state by state listing.

DISTRIBUTION AND OCCURRENCE

SPECIES: Sonchus arvensis

GENERAL DISTRIBUTION:

Perennial sowthistle is of European [53,108] and western Asian [108] origin and was probably introduced into North America as a seed contaminant [75]. *Sonchus arvensis* spp. *arvensis* was first reported in 1814 in Pennsylvania [108]. The earliest collection of ssp. *glabrescens* in North America was from Maine in 1894. Additional collections were reported from Massachusetts and Ohio as early as 1902 [37].

Perennial sowthistle is reported in all of the U.S. except Hawaii, Arizona, Oklahoma, Arkansas, Alabama, Georgia, South Carolina, and Florida. It occurs in all provinces of Canada. Subspecies *arvensis*, in addition to the states where perennial sowthistle is not described, is not known in California, Nebraska, Kansas, Virginia, North Carolina, and Alaska. Additionally, subspecies *uliginosus* is also not reported in a wide band of southern states from California and Nevada east to North Carolina on the Atlantic Coast or in Kentucky, Tennessse, and New Hampshire.

No specific mention of perennial sowthistle in Mexico occurs in the literature; consequently, no provinces of Mexico are listed as being occupied by perennial sowthistle. Since it occurs in Texas and New Mexico, it is reasonable to assume it may also occur in northern Mexico.

Plants database provides a state distribution map of perennial sowthistle and its infrataxa.

The following lists include North American ecosystems, habitat types, and forest and range cover types in which perennial sowthistle may occur. Perennial sowthistle grows well in wet and even saturated soils. Consequently, riparian areas or wetlands within these habitats could contain perennial sowthistle even if the habitat itself is not considered a wetland. Additionally, perennial sowthistle is often an invader of cultivated areas, especially of small grain and row crops. Areas within the habitat types, ecosystems, and cover types included that are under cultivation could be occupied by perennial sowthistle. For example, within Oregon, a state with both subspecies of perennial sowthistle, Kuchler [69] lists a total of 19 potential natural vegetation types from spruce-cedar-hemlock (*Picea sitchensis-Thuja plicata- Tsuga heterophylla*) forests along the coast to sagebrush-bluebunch wheatgrass (*Artemisia* spp.-*Pseudoroegneria spicata*) steppe in the interior. All of these vegetation types have the potential to support perennial sowthistle.

These lists are not necessarily inclusive or exhaustive. More information is needed to determine particular ecosystems and plant communities where perennial sowthistle is likely to occur.

ECOSYSTEMS [41]:
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
FRES31 Shinnery
FRES32 Texas savanna
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/PROVINCES: (key to state/province abbreviations)

UNITED STATES

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

CANADA

AB	BC	MB	NB	NF	NT	NS	NU	ON	PE
PQ	SK	YK							

BLM PHYSIOGRAPHIC REGIONS [14]:
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 [69] 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
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
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-bur sage
K043 Paloverde-cactus shrub
K044 Creosote bush-tarbush
K045 Ceniza shrub
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
K060 Mesquite savanna

K061 Mesquite-acacia savanna
K062 Mesquite-live oak 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
K071 Shinnery
K072 Sea oats prairie
K073 Northern cordgrass prairie
K074 Bluestem prairie
K075 Nebraska Sandhills prairie
K076 Blackland prairie
K077 Bluestem-sacahuista prairie
K078 Southern cordgrass prairie
K081 Oak savanna
K082 Mosaic of K074 and K100
K083 Cedar glades
K084 Cross Timbers
K085 Mesquite-buffalo grass
K086 Juniper-oak savanna
K087 Mesquite-oak savanna
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

SAF COVER TYPES [36]:
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
67 Mohrs (shin) oak
68 Mesquite
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
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
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 [107]:
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
719 Mesquite-liveoak-seacoast bluestem
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
726 Cordgrass
727 Mesquite-buffalo grass

728 Mesquite-granjeno-acacia
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
806 Gulf Coast salt marsh
807 Gulf Coast fresh marsh
ALASKAN RANGELANDS
901 Alder
902 Alpine herb
903 Beach wildrye-mixed forb
904 Black spruce-lichen
905 Bluejoint reedgrass
906 Broadleaf forest
907 Dryas
908 Fescue
909 Freshwater marsh
910 Hairgrass
911 Lichen tundra
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:
Perennial sowthistle is found in a wide range of habitats. It occurs in cultivated fields of both small grains and row crops, in disturbed areas, "waste grounds," meadows, sloughs, woods, and lawns, and along roadsides, streets, beaches, ditches, and river and lake shores [108,109]. Although perennial sowthistle is adapted to many habitats, it is mentioned most often in the literature in relation to saline habitat types.

Perennial sowthistle is found on disturbed sites in saline habitats in Saskatchewan, Manitoba, and Alberta in association with rayless alkali aster (*Symphyotrichum ciliatum*), spear saltbush (*Atriplex patula*), curlycup gumweed (*Grindelia squarrosa*), summer-cypress (*Kochia scoparia*), Nuttall's alkaligrass (*Puccinellia nuttalliana*), red swampfire (*Salicornia rubra*), and Pursh seepweed (*Suaeda calceoliformis*) [16].

Major species associated with ssp. *uliginosus*
in halophytic or semihalophytic communities in Saskatchewan near saline depressions include western yarrow (*Achillea millefolium*), rosy pussytoes (*Antennaria microphylla*), manyflowered aster (*Symphyotrichum ericoides* var. *pansum*), saltgrass (*Distichlis spicata*), wild licorice (*Glycyrrhiza lepidota*), foxtail barley (*Hordeum*

jubatum), mat muhly (*Muhlenbergia richardsonis*), and gray goldenrod (*Solidago nemoralis*) [33].

Redmann [97] described plant communities along a soil salinity-moisture gradient of an eastern North Dakota prairie. Perennial sowthistle was present in every plant community except the muhly *(Muhlenbergia* spp.) and bluestem (*Andropogon* spp.) types. In a prairie cordgrass (*Spartina pectinata*) community, perennial sowthistle commonly occurs with foxtail barley, slender wheatgrass (*Elymus trachycaulus*), scratchgrass (*M. asperifolia*), mat muhly, bluejoint reedgrass (*Calamagrostis canadensis*), northern bog aster (*Symphyotrichum boreale*), and marsh hedgenettle (*Stachys palustris*). In a bluegrass (*Poa* spp.) community type, perennial sowthistle occurs at lower elevations with foxtail barley, scratchgrass, wild licorice, and Maximilian sunflower (*Helianthus maximiliani*) [97].

Subspecies *uliginosus* is found in a "salt flat" area, or saltgrass community type, with saltgrass, serpentine aster (*Symphyotrichum ericoides*), curlycup gumweed, alkali cordgrass (*Spartina gracilis*), foxtail barley, slender wheatgrass, scratchgrass, and plains bluegrass (*Poa arida*). Subspecies *glabrescens* is also found in the foxtail barley community type where it occurs with plains bluegrass, scratchgrass, curlycup gumweed, serpentine aster, curly dock (*Rumex crispus*), prairie wedgescale (*Sphenopholis obtusata*), and Cuman ragweed (*Ambrosia psilostachya)* [97].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Sonchus arvensis

GENERAL BOTANICAL CHARACTERISTICS:
The following description of perennial sowthistle provides characteristics that may be relevant to fire ecology, and is not meant for identification. Keys for identification are available (e.g. [26,34,42,45]).

Perennial sowthistle is a perennial herb [53,74] that reproduces by seeds, by vertical, thickened roots, and by cylindrical, horizontal, spreading roots [109]. Vertical roots can penetrate 5 to10 feet (1.5-3 m) deep. Horizontal roots, frequently 2.5 to 5 mm in diameter (rarely exceeding 0.4 inches (1 cm)), are found 2 to 4 inches (5-10 cm) below the surface [10]. These horizontal roots can reach 3 to 6 feet (0.9-1.8 m) in length in a single growing season [109]. Fruits are achenes [15,89] with a pappus that generally stays attached to the achene [91].

Stems are erect, 12 to 71 inches (30-180 cm) , most commonly 24 to 59 inches (60-150 cm), high and 0.1 to 0.4 inches (3-10 mm) in diameter. Stems are hollow and branched, varying from 2 to many per plant. Leaves are crowded on the lower stems and sparse on the upper stems. The entire plant is filled with milky latex [74].

RAUNKIAER [96] LIFE FORM:
Hemicryptophyte

REGENERATION PROCESSES:
Perennial sowthistle can reproduce by seed and vegetatively [10,30,109].

Breeding system: Perennial sowthistle flowers are perfect [31] and generally self-incompatible [31,109].

Pollination:

Perennial sowthistle is pollinated by insects including honeybees and other bees, hover flies, and blister beetles [31,109].

Seed production: Perennial sowthistle is a prodigious seed producer. Harris [53] states perennial sowthistle produces "many" seeds, but seeds produced by self pollination are generally smaller and nonviable [31,109].

Heads contain many fertile flowers but the number of achenes produced varies widely among heads, plants, and locality. Variability likely results from several factors, including environmental conditions and availability of pollinators [109].

Perennial sowthistle can typically produce an average of 30 achenes per head and up to 50,000/yd^2 [109]. In North Dakota, 1 main stalk, with "relatively little" competition, produced 62 heads and 9,750 well-developed achenes. The author collected seeds from the plant for a 30-day period [111]. In South Dakota, artificially cross-pollinated heads from greenhouse- and field-grown plants produced about 50 achenes per head, but number of achenes per head in natural populations varied from about 20 to 40 or from 60 to 80 depending upon the year [31].

Seed dispersal: Seeds of perennial sowthistle are mostly wind dispersed [28,53,109], but other dispersal agents may play a minor role. The pappus, attached to the seed, aids in wind dispersal [91]. Hume and Archibold [63] placed seed traps at varying distances from a "weedy" field in Saskatchewan. Results show wind-blown seeds of perennial sowthistle can disperse at least 110 yards (100 m). They do not report wind speed.

Sheldon and Burrows [104] conducted experiments to determine maximum dispersal distance of perennial sowthistle seeds at differing wind speeds. They used perennial sowthistle plants with a mean height of 3 feet (90 cm). They observed a maximum dispersal distance of only 11 yards (10 m).

Wind speed (km/hour)	5.47	10.94	16.41
Dispersal distance (m)	3.34	6.67	10.00

In addition to wind dispersal, seeds of perennial sowthistle may also be dispersed by birds and other animals. Martin and others (as reported in [132], a literature review) state perennial sowthistle is a minor element in the diet of some North American birds, and some seeds may germinate after ingestion and excretion by birds and animals. Hooked cells at the tips of pappus hairs allow the pappus to cling to clothes and animal hairs and aid in seed dispersal [109,132].

Seed banking: Perennial sowthistle seeds can remain viable for at least 3 years in cultivated soil. Chepil [23] conducted seed dormancy tests for "weed" species in cultivated soil in Saskatchewan. Three separate experiments were conducted. In the 1st experiment an indefinite number of perennial sowthistle seeds was planted on 18 September, 1937, in 3 soil types and introduction of seeds from other sources was prevented. No seeds were planted greater than 3 inches (7.6 cm) deep. Values given are percentages of viable seeds germinated each year. Number of viable seeds remaining in the soil after 3 years was determined by repeated germination tests in the laboratory until no more germination occurred [23].

	1938	1939	1940	Viable seeds remaining
Clay	43.3	16.2	2.7	37.8
Loam	66.7	13.3	0	20.0
Sandy loam	86.7	0	3.3	10.0

In the 2nd experiment, 50 perennial sowthistle seeds were planted no deeper than 3 inches (7.6 cm) on 14 October, 1938, in 3 soil types. Again, number of viable seeds remaining in the soil after 6 years was determined

by repeated germination tests in the laboratory until no more germination occurred. Values given are number of viable seeds [23].

	1939	1940	1941	1942	1943	1944	Viable seeds remaining
Clay	33	0	4	0	0	0	0
Loam	1	0	0	0	0	0	0
Sandy loam	2	3	0	0	0	0	1

The 3rd experiment utilized 1,000 perennial sowthistle seeds planted no deeper than 3 inches (7.6 cm). Seeds were planted between 1 and 5 November, 1940, in 3 soil types and only seeds germinated in the field were counted. Numbers are actual seeds germinating, not percentages [23].

	1941	1942	1943	1944	1945
Clay	18	0	2	5	0
Loam	16	0	0	0	0
Sandy loam	12	0	0	1	0

From the above results, the author [23] concludes that although seeds of perennial sowthistle have low viability in cultivated fields, they can remain dormant but viable for more than 3 years in at least 3 different soil types. Clay appears to be most conducive to long-term viability of perennial sowthistle seeds (See Site Characteristics).

Perennial sowthistle seeds are also found in the seed bank of marshes and wetlands. In an experiment designed to test seedling emergence from boreal wetland soils under changing climatic conditions, perennial sowthistle seedlings emerged from the soil seed bank in the willow (*Salix* spp.) savanna and bluejoint reedgrass vegetation zones of a mid-boreal wetland in Alberta [60]. Pederson (1979) (as reported in [122]) studied seed banking in the Delta Marsh, Manitoba. He found perennial sowthistle seeds in 10 surface substrate samples from cattail (*Typha* spp.) and common reed (*Phragmites australis*) dominated habitats.

Germination:
Germination of perennial sowthistle seeds is increased by both increasing soil temperature and time since flowering. Perennial sowthistle seed in the field doesn't begin to germinate until the soil has warmed [74].

Seeds are capable of germination about 5 days after pollination [74], but germination rates increased from low to none 4 days after flowering to a maximum 7 to 9 days after flowering [31,66,109]. In field germination experiments in South Dakota, Derscheid and Schultz [31] noted that percentage of viable seeds produced by perennial sowthistle ranged from 10% 6 days after blooming to 89% 9 days after blooming. If perennial sowthistle plants are pulled or cut and placed in a pile it is possible for viable seeds to be produced if flowers are present when the plants are cut [109].

In laboratory germination tests viability is "relatively" high. Kinch and Termunde [66] achieved 95% germination in the laboratory using "well-matured" seed.

Orientation of perennial sowthistle seeds in the soil profile is important to germination, and light may stimulate germination. Bosy and Aarssen [15] conducted seed germination tests on perennial sowthistle using agar as a germinating medium. Agar was used to eliminate any environmental differences at a given depth and enabled the authors to maintain seed orientation. They found surface-lying seeds of perennial sowthistle displayed higher germination than buried seeds [15]. Germination was 50% for seeds germinated in soil and 80% for seeds germinated on moist filter paper, and germination was higher in diffuse laboratory light than in complete darkness [89]. When seeds were buried, seeds oriented with the radicle horizontal had significantly greater ($P<0.05$) germination than seeds with the radicle oriented either upward or downward.

Studies indicate temperatures from 77 to 86 ^{o}F (25-30 ^{o}C) are optimal for germination. Seeds germinate poorly (<5%) below 68 ^{o}F (20 ^{o}C) and above 95 ^{o}F (35 ^{o}C), but alternating temperatures were more favorable for germination than constant temperatures if temperatures above 77 ^{o}F (25 ^{o}C) are included in the cycle [52]. Stevens [109] reports seeds exposed to 90^{o} F (32^{o} C) for a "few hours daily" germinate "freely" in 4 to 7 days.

Perennial sowthistle seed germination in wetlands could be limited by saturated soils. For example, Hogenbirk and Wein [60] germinated seeds of perennial sowthistle from combined soil and litter samples from a mid-boreal wetland in Alberta. No perennial sowthistle seeds from a sedge (*Carex* spp.) marsh germinated. Perennial sowthistle seeds stored in fresh water were 100% decomposed after 3 months storage [18].

Seedling establishment/growth:
Perennial sowthistle seedlings survive best in areas with protective plant cover or litter and high moisture compared with open cultivated soil [109]. Accordingly, seedlings are often only found along pond, ditch, or field margins, or in lawns, meadows, or uncultivated fields [91]. In a series of field germination experiments with perennial sowthistle seeds, Stevens [109] had little success growing seedlings in cultivated field plots. Laboratory germination tests with the same lot of seeds showed 56% germination.

Most perennial sowthistle seedlings do not emerge until mid- to late May in Saskatchewan and the Great Plains of the United States [74]. Seedlings grow slowly for about the 1st 2 weeks until leaves are about 1.2 inches (3 cm) long [109]. They develop rapidly after that, and reproductive ability of spreading roots is established quickly [52,109]. Stevens [109] noted 10 seedlings on 17 May, 1923. The 10 seedlings grew slowly until 1 June when the largest leaves were 1.2 inches (3 cm) long. After that, they developed "rapidly" and on 5 July, a horizontal root 28 inches long (71 cm) was removed from the largest plant [109].

Most seedlings do not flower the 1st year, but flowering in late summer is possible from some first-year seedlings in favorable environments [52,109].

Asexual regeneration:
Perennial sowthistle reproduces vegetatively from buds that develop on horizontal and vertical roots and on underground portions of aerial stems. Thickened roots develop as a result of secondary growth of original fibrous roots [51] and begin to show reproductive capacity when thickened to 1 to 1.5 mm [50]. This occurs on vertical primary roots when seedlings reach the 4-leaf stage and on horizontal roots when seedlings have 6 to 7 photosynthetic leaves. One-month-old seedlings can have 7 to 8 leaves with horizontal roots from 4 to 6 inches (10-15 cm) long and 1.5 mm thick. Horizontal roots from 24 to 39 inches (60-100 cm) and vertical roots penetrating 20 inches (50 cm) can develop from seedlings within 4 months after emergence. Vertical roots can produce vegetative buds as deep as 20 inches (50 cm) below the soil surface [109]. New shoots develop from buds that overwinter on both vertical or horizontal "spreading" roots or on basal portions of aerial stems [51,88]. In North Dakota, the rate of vegetative spread of perennial sowthistle clones varied from 1.6 to 9 feet (0.5-2.8 m) per year, depending on the clone (personal observation in [74]).

Harris [53] describes horizontal roots as "easily broken," and new plants can be produced from root sections less than 1 inch (2.5 cm) long if well-developed buds are present. Root sections less than 0.4 inches (1 cm) long can produce plants that flower within 1 year [52,109].

SITE CHARACTERISTICS:
Perennial sowthistle is adapted to moist, sunny locations in temperate regions but is absent from tropical areas [74]. Within temperate regions, perennial sowthistle has a broad tolerance to variable environments and adapts well to wet sites, even with little soil disturbance. In Canada, perennial sowthistle occurs in areas that receive average annual precipitation of 12 to 120 inches (300-3,000 mm) [132]. In a greenhouse study, growth of perennial sowthistle plants was positively correlated with increasing soil water, with greatest growth occurring at complete saturation [131]. However, perennial sowthistle also establishes on dry sites [97]. Neither the climatic conditions required for successful establishment nor conditions, if any, favoring ssp. *arvensis* over ssp. *uliginosus*

have been established [74].

Perennial sowthistle is adapted to many soil types but appears to prefer fine-textured soils and does not thrive on dry, coarse-textured sand. Perennial sowthistle seems to prefer slightly alkaline or neutral soils and does not thrive in acid soils, salt marshes, or highly alkaline areas [109]. However, Zollinger and Kells [131] determined soil pH had little effect on leaf production, plant height, or number of capitula produced.

Perennial sowthistle is present in a variety of community types from those occurring on wet, very strongly saline surface soil and strongly saline subsoil to nonsaline and dry soils [97]. Dodd and Coupland [33] describe perennial sowthistle as occurring in halophytic or semihalophytic communities in Saskatchewan.

SUCCESSIONAL STATUS:
Perennial sowthistle is an early-successional plant. Komarova [67] and Zollinger and Parker [132] describe perennial sowthistle as a pioneer species. In a study of succession after fire in "highland hardwoods" in Wisconsin, it appeared in 6 out of 10 plots in the herbaceous stage of succession [44]. Although infrequent, perennial sowthistle is part of the early successional community on wetlands in the blast zone after the Mount St. Helen's eruption [120].

Perennial sowthistle is most competitive under abundant precipitation and moderate climates [132].

SEASONAL DEVELOPMENT:
Shoots and new roots in established stands begin to develop when the soil starts to warm [51,109]. Small leaves begin to appear from shallow roots about 1 week from initial growth [109], and adventitious root development begins 3 to 4 weeks later. Initial thickening of new roots begins when plants have 5 to 7 leaves [50,52]. Secondary thickening proceeds quickly, and spreading roots 4 mm thick and over 79 inches (200 cm) long can be detected by 3 months after initial growth [109]. Thickening of new roots ceases by mid-summer. New shoots develop from roots 2-3 mm in diameter until late summer [74].

Flowering stems begin to develop when plants have 12 to 15 leaves [50,109]. Flowering begins about 1 July in the northern United States and continues until plants are frosted, although most flowering is complete by late summer [109]. Time required from flowering to fruit maturation is about 10 days [74].

FIRE ECOLOGY

SPECIES: Sonchus arvensis

FIRE ECOLOGY OR ADAPTATIONS:

Fire adaptations:

Wind-disseminated seeds of perennial sowthistle may colonize burned areas. No field research of perennial sowthistle's ability to colonize burned areas has been reported as of this writing (2004), but Ahlgren [3] tested germination in soil removed from burned and unburned areas of an old-growth red pine (*Pinus resinosa*) forest in Minnesota. He found no perennial sowthistle germinants from the soil from unburned areas but extrapolated 3,485,000 seedlings per hectare in soil of burned areas. The author concluded perennial sowthistle seedlings probably developed from seeds blown into the burned areas after the fire.

Fire regimes:

There are no descriptions of fire regimes for perennial sowthistle in the literature. It occurs in a wide range of habitat types, community types, and forest and range ecosystems. The following table provides fire return

intervals for important plant communities and ecosystems where perennial sowthistle may occur. Perennial sowthistle may also occur within riparian or wetland areas included in these ecosystems. For further information, see the FEIS summary on the dominant species listed below

Community or Ecosystem	Dominant Species	Fire Return Interval Range (years)
silver fir-Douglas-fir	*Abies amabilis-Pseudotsuga menziesii* var. *menziesii*	> 200
grand fir	*Abies grandis*	35-200 [6]
maple-beech-birch	*Acer-Fagus-Betula*	> 1,000
silver maple-American elm	*Acer saccharinum-Ulmus americana*	< 35 to 200
sugar maple	*Acer saccharum*	> 1,000
sugar maple-basswood	*Acer saccharum-Tilia americana*	> 1,000 [125]
California chaparral	*Adenostoma* and/or *Arctostaphylos* spp.	< 35 to < 100 [87]
bluestem prairie	*Andropogon gerardii* var. *gerardii-Schizachyrium scoparium*	< 10 [68,87]
Nebraska sandhills prairie	*Andropogon gerardii* var. *paucipilus-Schizachyrium scoparium*	< 10
bluestem-Sacahuista prairie	*Andropogon littoralis-Spartina spartinae*	< 10 [87]
silver sagebrush steppe	*Artemisia cana*	5-45 [56,95,129]
sagebrush steppe	*Artemisia tridentata/Pseudoroegneria spicata*	20-70 [87]
basin big sagebrush	*Artemisia tridentata* var. *tridentata*	12-43 [100]
mountain big sagebrush	*Artemisia tridentata* var. *vaseyana*	15-40 [8,22,80]
Wyoming big sagebrush	*Artemisia tridentata* var. *wyomingensis*	10-70 (40**) [123,130]
coastal sagebrush	*Artemisia californica*	
saltbush-greasewood	*Atriplex confertifolia-Sarcobatus vermiculatus*	
desert grasslands	*Bouteloua eriopoda* and/or *Pleuraphis mutica*	5-100 [87]
plains grasslands	*Bouteloua* spp.	< 35 [87,129]
blue grama-needle-and-thread grass-western wheatgrass	*Bouteloua gracilis-Hesperostipa comata-Pascopyrum smithii*	< 35 [87,99,129]
blue grama-buffalo grass	*Bouteloua gracilis-Buchloe dactyloides*	< 35 [87,129]
grama-galleta steppe	*Bouteloua gracilis-Pleuraphis jamesii*	< 35 to < 100
blue grama-tobosa prairie	*Bouteloua gracilis-Pleuraphis mutica*	< 35 to < 100 [87]
cheatgrass	*Bromus tectorum*	< 10 [94,127]
California montane chaparral	*Ceanothus* and/or *Arctostaphylos* spp.	50-100 [87]
sugarberry-America elm-green ash	*Celtis laevigata-Ulmus americana-Fraxinus pennsylvanica*	< 35 to 200 [125]
paloverde-cactus shrub	*Cercidium microphyllum/Opuntia* spp.	< 35 to < 100 [87]
curlleaf mountain-mahogany*	*Cercocarpus ledifolius*	13-1,000 [9,102]

mountain-mahogany-Gambel oak scrub	*Cercocarpus ledifolius-Quercus gambelii*	< 35 to < 100 [87]
Atlantic white-cedar	*Chamaecyparis thyoides*	35 to > 200 [125]
blackbrush	*Coleogyne ramosissima*	< 35 to < 100
Arizona cypress	*Cupressus arizonica*	< 35 to 200
northern cordgrass prairie	*Distichlis spicata-Spartina* spp.	1-3 [87]
beech-sugar maple	*Fagus* spp.-*Acer saccharum*	> 1,000 [125]
California steppe	*Festuca-Danthonia* spp.	< 35 [87,113]
black ash	*Fraxinus nigra*	< 35 to 200
juniper-oak savanna	*Juniperus ashei-Quercus virginiana*	< 35
Ashe juniper	*Juniperus ashei*	< 35
western juniper	*Juniperus occidentalis*	20-70
Rocky Mountain juniper	*Juniperus scopulorum*	< 35 [87]
cedar glades	*Juniperus virginiana*	3-22 [49,87]
tamarack	*Larix laricina*	35-200 [87]
western larch	*Larix occidentalis*	25-350 [,13,29]
creosotebush	*Larrea tridentata*	< 35 to < 100
Ceniza shrub	*Larrea tridentata-Leucophyllum frutescens-Prosopis glandulosa*	< 35 [87]
yellow-poplar	*Liriodendron tulipifera*	< 35 [125]
wheatgrass plains grasslands	*Pascopyrum smithii*	< 5-47+ [87,95,129]
Great Lakes spruce-fir	*Picea-Abies* spp.	35 to > 200
northeastern spruce-fir	*Picea-Abies* spp.	35-200 [35]
southeastern spruce-fir	*Picea-Abies* spp.	35 to > 200 [125]
Engelmann spruce-subalpine fir	*Picea engelmannii-Abies lasiocarpa*	35 to > 200 [6]
black spruce	*Picea mariana*	35-200
conifer bog*	*Picea mariana-Larix laricina*	35-200 [35]
blue spruce*	*Picea pungens*	35-200 [6]
red spruce*	*Picea rubens*	35-200 [35]
pine-cypress forest	*Pinus-Cupressus* spp.	< 35 to 200 [6]
pinyon-juniper	*Pinus-Juniperus* spp.	< 35 [87]
whitebark pine*	*Pinus albicaulis*	50-200 [2,4]
jack pine	*Pinus banksiana*	<35 to 200 [35]
Mexican pinyon	*Pinus cembroides*	20-70 [82,116]
Rocky Mountain lodgepole pine*	*Pinus contorta* var. *latifolia*	25-340 [12,13,118]
Sierra lodgepole pine*	*Pinus contorta* var. *murrayana*	35-200 [6]
shortleaf pine	*Pinus echinata*	2-15
shortleaf pine-oak	*Pinus echinata-Quercus* spp.	< 10 [125]

Colorado pinyon	*Pinus edulis*	10-400+ [39,43,87]
slash pine	*Pinus elliottii*	3-8
slash pine-hardwood	*Pinus elliottii*-variable	< 35 [125]
Jeffrey pine	*Pinus jeffreyi*	5-30
western white pine*	*Pinus monticola*	50-200 [6]
longleaf-slash pine	*Pinus palustris-P. elliottii*	1-4 [85,125]
longleaf pine-scrub oak	*Pinus palustris-Quercus* spp.	6-10 [125]
Pacific ponderosa pine*	*Pinus ponderosa* var. *ponderosa*	1-47 [6]
interior ponderosa pine*	*Pinus ponderosa* var. *scopulorum*	2-30 [6,11,73]
Arizona pine	*Pinus ponderosa* var. *arizonica*	2-15 [11,25,103]
Table Mountain pine	*Pinus pungens*	< 35 to 200 [125]
red pine (Great Lakes region)	*Pinus resinosa*	10-200 (10**) [35,40]
red-white-jack pine*	*Pinus resinosa-P. strobus-P. banksiana*	10-300 [35,54]
pitch pine	*Pinus rigida*	6-25 [21,55]
pocosin	*Pinus serotina*	3-8
pond pine	*Pinus serotina*	3-8
eastern white pine	*Pinus strobus*	35-200
eastern white pine-eastern hemlock	*Pinus strobus-Tsuga canadensis*	35-200
eastern white pine-northern red oak-red maple	*Pinus strobus-Quercus rubra-Acer rubrum*	35-200
loblolly pine	*Pinus taeda*	3-8
loblolly-shortleaf pine	*Pinus taeda-P. echinata*	10 to < 35
Virginia pine	*Pinus virginiana*	10 to < 35
Virginia pine-oak	*Pinus virginiana-Quercus* spp.	10 to < 35
sycamore-sweetgum-American elm	*Platanus occidentalis-Liquidambar styraciflua-Ulmus americana*	< 35 to 200 [125]
galleta-threeawn shrubsteppe	*Pleuraphis jamesii-Aristida purpurea*	< 35 to < 100
eastern cottonwood	*Populus deltoides*	< 35 to 200 [87]
aspen-birch	*Populus tremuloides-Betula papyrifera*	35-200 [35,125]
quaking aspen (west of the Great Plains)	*Populus tremuloides*	7-120 [6,47,79]
mesquite	*Prosopis glandulosa*	< 35 to < 100 [78,87]
mesquite-buffalo grass	*Prosopis glandulosa-Buchloe dactyloides*	< 35
Texas savanna	*Prosopis glandulosa* var. *glandulosa*	< 10
black cherry-sugar maple	*Prunus serotina-Acer saccharum*	> 1,000 [125]
mountain grasslands	*Pseudoroegneria spicata*	3-40 (10**) [5,6]
Rocky Mountain Douglas-fir*	*Pseudotsuga menziesii* var. *glauca*	25-100 [6,7,8]

coastal Douglas-fir*	*Pseudotsuga menziesii* var. *menziesii*	40-240 [6,83,98]
California mixed evergreen	*Pseudotsuga menziesii* var. *menziesii-Lithocarpus densiflorus-Arbutus menziesii*	< 35
California oakwoods	*Quercus* spp.	< 35 Arno00 [6]
oak-hickory	*Quercus-Carya* spp.	< 35 [125]
oak-juniper woodland (Southwest)	*Quercus-Juniperus* spp.	< 35 to < 200 [87]
northeastern oak-pine	*Quercus-Pinus* spp.	10 to < 35 [125]
oak-gum-cypress	*Quercus-Nyssa*-spp.-*Taxodium distichum*	35 to > 200 [85]
southeastern oak-pine	*Quercus-Pinus* spp.	< 10 [125]
coast live oak	*Quercus agrifolia*	2-75 [46]
white oak-black oak-northern red oak	*Quercus alba-Q. velutina-Q. rubra*	< 35 [125]
canyon live oak	*Quercus chrysolepis*	<35 to 200
blue oak-foothills pine	*Quercus douglasii-P. sabiniana*	<35 [6]
northern pin oak	*Quercus ellipsoidalis*	< 35 [125]
Oregon white oak	*Quercus garryana*	< 35 [6]
bear oak	*Quercus ilicifolia*	< 35 [125]
California black oak	*Quercus kelloggii*	5-30 [87]
bur oak	*Quercus macrocarpa*	< 10 [125]
oak savanna	*Quercus macrocarpa/Andropogon gerardii-Schizachyrium scoparium*	2-14 [87,125]
shinnery	*Quercus mohriana*	< 35 [87]
chestnut oak	*Quercus prinus*	3-8
northern red oak	*Quercus rubra*	10 to < 35
post oak-blackjack oak	*Quercus stellata-Q. marilandica*	< 10
black oak	*Quercus velutina*	< 35
live oak	*Quercus virginiana*	10 to< 100 [125]
interior live oak	*Quercus wislizenii*	< 35 [6]
cabbage palmetto-slash pine	*Sabal palmetto-Pinus elliottii*	< 10 [85,125]
blackland prairie	*Schizachyrium scoparium-Nassella leucotricha*	< 10
Fayette prairie	*Schizachyrium scoparium-Buchloe dactyloides*	< 10 [125]
little bluestem-grama prairie	*Schizachyrium scoparium-Bouteloua* spp.	< 35
tule marshes	*Scirpus* and/or *Typha* spp.	< 35 [87]
redwood	*Sequoia sempervirens*	5-200 [6,38,115]
southern cordgrass prairie	*Spartina alterniflora*	1-3 [87]
baldcypress	*Taxodium distichum* var. *distichum*	100 to > 300
pondcypress	*Taxodium distichum* var. *nutans*	< 35 [85]

western redcedar-western hemlock	*Thuja plicata-Tsuga heterophylla*	> 200 [6]
eastern hemlock-yellow birch	*Tsuga canadensis-Betula alleghaniensis*	> 200 [125]
western hemlock-Sitka spruce	*Tsuga heterophylla-Picea sitchensis*	> 200
mountain hemlock*	*Tsuga mertensiana*	35 to > 200 [6]
elm-ash-cottonwood	*Ulmus-Fraxinus-Populus* spp.	< 35 to 200 [35,125]

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

POSTFIRE REGENERATION STRATEGY [Stickney citation # from your reference section goes here]:
Rhizomatous herb, rhizome in soil
Geophyte, growing points deep in soil
Ground residual colonizer (on-site, initial community)
Initial off-site colonizer (off-site, initial community)

FIRE EFFECTS

SPECIES: Sonchus arvensis

IMMEDIATE FIRE EFFECT ON PLANT:
There are no specific references in the literature discussing or describing immediate effects of fire on perennial sowthistle. Research is needed on the fire ecology of perennial sowthistle. It is reasonable to assume it is top-killed by fire.

DISCUSSION AND QUALIFICATION OF FIRE EFFECT:
Horizontal roots of perennial sowthistle, which sprout after mechanical disturbance, are found 2 to 4 inches (5-10 cm) below the surface [10] and would probably be protected from all but the most severe fires. Vertical roots of perennial sowthistle can be 5 to 10 feet (1.5-3 m) deep [10] and would survive fire. These roots could sprout after fire, but no mention of postfire response is made in the available literature.

PLANT RESPONSE TO FIRE:
Information in the literature concerning perennial sowthistle's response to fire is both sparse and conflicting. Hogenbirk and Wein [59] simulated "light" and "severe" burns in both a bluejoint reedgrass and willow savannah habitat and concluded there was no increase in cover of perennial sowthistle for either treatment. In a literature review, D'Antonio [27] interpreted Hogenbirk and Wein's [59] results as indicating "no change in perennial sowthistle abundance with any fire intensity." Olson [86] conducted prescribed burns on grassland within the Tewaukon National Wildlife Refuge in southeastern North Dakota as part of a wildlife habitat study. In his study there appears to be no clear trend for the percent canopy coverage of perennial sowthistle after prescribed burning in May or June.

In northwestern Minnesota, flowering of perennial sowthistle showed a positive response on both a disturbed prairie site and an undisturbed prairie site after prescribed fire was used as part of a prairie restoration project [90]. Finally, Thompson and Shay [119] found density and biomass of perennial sowthistle increased "greatly"

after summer burns, less after fall burns, and increased only slightly or were unchanged after spring burns at Delta Marsh in Manitoba. None of the studies described reported statistically significant trends. As of this writing (2004), more research is needed into perennial sowthistle's response to fire.

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE:
Hogenbirk and Wein [59] used a propane torch to simulate "light" and "severe" burns in 2 different mid-boreal wetland habitats and documented results of these simulations on perennial sowthistle in a growth chamber. They concluded there was no increase in cover of perennial sowthistle for either treatment and hypothesize this lack of increase was likely due to temporal and spatial limitations of the study. The experiment was conducted in a bluejoint reedgrass meadow and willow savannah habitat type. Their results, presented as mean percent cover (± SEM), are presented below. There was an *n*
of 15 for all treatments in the willow savannah and for the severe burned treatment in the bluejoint reed grass meadow. In the bluejoint reedgrass meadow, *n* was 25 for unburned and lightly burned treatments.

	Burn treatment		
	None	Light	"Heavy"
Bluejoint reedgrass meadow	1 ± 1	2 ± 1	4 ± 2
Willow savannah	10 ± 3	15 ± 5	15 ± 4

Prescribed fire was used as part of a prairie restoration project in northwestern Minnesota [90]. Burns were conducted in spring 1973, and data on flowering response were collected that growing season. Perennial sowthistle was present on 2 site types contained within the burn. Flowering of perennial sowthistle showed a positive response on both site types, but was much stronger on a disturbed prairie site than an undisturbed prairie site. Results were based on comparison of 25 burned and unburned transects.

Thompson and Shay [119] conducted a series of prescribed burns at Delta Marsh in Manitoba. The summer burn was conducted in August 1979, during peak growth, the fall burn after winter dormancy had started in October 1979, and the spring burn in May 1980, before growth began. Perennial sowthistle was absent on both unburned control and treated plots before they were burned. Density and aboveground biomass of perennial sowthistle increased "greatly" the fall after summer burns, less 1 year after fall burns, and increased only slightly or were unchanged the fall after spring burns. Perennial sowthistle seedlings were "abundant" within 1 year after summer and fall burns but not after spring burns or on unburned controls [119]. Summer burning was the only treatment followed for more than 1 year. The 2nd fall after treatment, no seedlings were observed, despite the fact that perennial sowthistle can apparently seedbank (see Seed banking).

The authors [119] conclude that perennial sowthistle's ability to overwinter as rosettes accounts for the presence of nonseedling shoots in 1980 on sites burned in summer of 1979. Perennial sowthistle seedlings emerged mainly in the fall so the abundance of suitable sites for germination after summer fires was especially conducive to its establishment.

Olson [86] conducted prescribed burns on grassland within the Tewaukon National Wildlife Refuge in southeastern North Dakota as part of a wildlife habitat study. He provides postburn and control data for perennial sowthistle from 5 plots. Perennial sowthistle was not a plant the author was studying and he provides no discussion. His data show both great variation in percent canopy cover and no clear trend of increase or decrease due to fire.

FIRE MANAGEMENT CONSIDERATIONS:
More information is needed to provide any firm suggestions for fire management of perennial sowthistle. However, trends from results observed after spring burning in North Dakota [86] and from 3 season prescribed burns in Manitoba [119] suggest spring burning to control perennial sowthistle may be effective. Summer is probably the worst season to control perennial sowthistle through prescribed burning. Fall burning may be effective at controlling perennial sowthistle.

Flowering of perennial sowthistle may be stimulated by prescribed burning [90], but there is generally a low germination rate of perennial sowthistle seeds in the field (See Germination).

If perennial sowthistle plants are pulled or cut and placed in a pile so the lower plants remain fresh for "some days," it is possible for viable seeds to be produced if flowers are present when the plants are cut. These plants should be burned or otherwise treated or removed if there is any possibility of viable seeds being produced [109].

MANAGEMENT CONSIDERATIONS

SPECIES: Sonchus arvensis

IMPORTANCE TO LIVESTOCK AND WILDLIFE:
Perennial sowthistle is "good" as a livestock feed [110,128]. Sheep and cattle will eat new growth and sometimes roots [132], and pronghorns were observed utilizing perennial sowthistle in central Montana during the fall [24].

Perennial sowthistle is considered "excellent" forage for rabbits [117] and Martin and others (as reported in [132], a literature review) state perennial sowthistle is a minor element in the diet of some North American birds.

Perennial sowthistle is listed as a nonnative plant occurring in critical habitat of the threatened desert tortoise in the Mojave and Colorado deserts. It is of concern because it competes with native plants vital to the tortoises' survival [17].

Palatability/nutritional value: Although perennial sowthistle compares favorably with alfalfa (*Medicago sativa*) for nutritional value, it is not especially palatable to grazing animals. Dry perennial sowthistle is about 10% protein by weight [19,20]. Palatability of perennial sowthistle to lambs was lower compared to grasses and alfalfa, and infestations of perennial sowthistle in pastures and hayfields may decrease overall forage feeding value [76].

Perennial sowthistle has equal or higher in vitro digestible dry matter, micro- and macromineral content and crude protein and lower neutral detergent fiber compared to alfalfa. The following table provides nutritional values (in g kg^{-1}) for perennial sowthistle [76]:

	1981		1982
	15 June	29 June	1 June
In vitro digestible dry matter concentration	818	660	792
Neutral detergent fiber concentration	312	447	267
Crude protein concentration	164	132	214

Herbage macromineral and micromineral concentrations for perennial sowthistle are given in the following tables [76]:

Herbage macromineral concentrations in g kg^{-1}				
	Ca	P	K	Mg
1981 (mean of 2 sample dates)	16.8	3.0	26.6	6.8

1982 (single sample date)	17.3	4.8	47.9	3.6

Herbage micromineral concentrations in µg g^{-1}						
	Zn	Cu	B	Mn	Al	Fe
1981 (mean of 2 sample dates)	22	10	26	63	393	334
1982 (single sample date)	40	10	26	53	83	108

Cover value:

Cover value of perennial sowthistle for wildlife for 2 western states is provided by Dittberner and Olson [32] in the following table:

	Elk	Mule deer	White-tailed deer	Pronghorn	Upland game bird	Waterfowl	Small nongame bird	Small mammal
Utah	poor	poor		poor	fair	poor	poor	fair
North Dakota		good	good	fair		fair		

OTHER USES:

Roasted roots of perennial sowthistle have been used like chicory (*Cichorium intybus*) root as an additive or a replacement for coffee. The young, tender leaves can be eaten raw in salads or cooked [117].

Most of the latex of perennial sowthistle is oil and may be a potential crop for oil or hydrocarbon production [19,20]. Perennial sowthistle is a good source of pentacyclic triterpenes, which may become important in the pharmaceutical industry [61].

IMPACTS AND CONTROL:

Impacts:

Information concerning the impacts of perennial sowthistle on natural communities is absent from the literature. Research is needed to determine and document what effects perennial sowthistle may have on wildlands.

Control:

Perennial sowthistle is relatively resistant to many common broadleaf herbicides compared to most annual broadleaf weeds. Consequently, the best systems for control often include a combination of cultural and chemical treatments designed to reduce competition from perennial sowthistle, prevent seed production, and reduce the reproductive capacity of its roots (Fryer and Makepeace, 1982, as reported in a literature review [74]).

As of this writing (2004) there is no information available on control of perennial sowthistle in natural areas.

Prevention:

The most efficient and effective method of managing invasive species is to prevent their invasion and spread [106]. Since perennial sowthistle seed is so easily disseminated by wind, scouting and detection are keys to preventing plant establishment [132]. It is easier to prevent initial colonization by perennial sowthistle than to eliminate established populations. Seedlings are easily controlled through mechanical and chemical methods. Planting weed-free crop seed and controlling perennial sowthistle on field borders can prevent initial infestations in wildlands adjacent to agricultural settings [132] (See Seedling establishment/growth).

Integrated management:

Components of any integrated weed management program are sustained effort, constant evaluation, and the adoption of improved strategies [105]. Factors to be addressed before a management decision is made include inventory and assessment to identify the target weed(s) and determine the size of the infestation(s); assessment of nontarget vegetation, soil types, climatic conditions, and important water resources. An evaluation of the benefits

and limitations of each control method also needs to be accomplished [84].

Combinations of tillage plus cultural practices or herbicides applied regularly have controlled perennial sowthistle in agricultural settings [30]. No information is available on integrated control measures for perennial sowthistle in wildlands.

Timing of control measures may increase the effectiveness of integrated management techniques. Schimming and Messersmith [101] conducted artificial freezing experiments with perennial sowthistle. They determined a temperature of 1 ^{o}F (-17 ^{o}C) reduced survival of perennial sowthistle roots by 50% and a temperature of 4 ^{o}F (-15 ^{o}C) reduced total dry weight of emerging perennial sowthistle shoots by 50%. The authors speculate conditions that tend to minimize hardening, such as lack of photosynthetic material in fall after tillage or chemical treatment, stimulation of fall growth after tillage, or high nitrogen levels may increase injury caused by freezing temperatures in the field.

Physical/mechanical:

Tillage generally reduces perennial sowthistle, but its effectiveness depends on plant growth characteristics at time of tillage [10,50,52], type of tillage being utilized [30,51], and frequency of tillage [91]. Intensive tillage is usually not appropriate in wildland settings, so it is not discussed further here.

Studies of mowing as a control method for perennial sowthistle show mixed results. Defoliation was less effective than burial for reducing infestations of perennial sowthistle in a study done in Sweden in 1967 [52], suggesting mowing is not as effective as tillage for control of perennial sowthistle [74]. However, Stevens [109] found defoliation an efficient method to control perennial sowthistle. Plants grown from root cuttings planted 3 May, had their leaves removed by hoe on 23 May when the largest leaves were about 6 inches (15 cm) long. The plants had the leaves removed again on 1 June, when leaves had again grown to about 6 inches (15 cm). After the 1 June defoliation, leaf growth was less vigorous. There was "very little" regrowth of leaves after a 1 July defoliation and none after a 19 July defoliation although weather conditions were favorable for growth. No plants appeared the next spring.

Fire: See the Fire Management Considerations section of this summary.

Biological:

There appears to be limited biological agents available to help control perennial sowthistle. A tephritid fly from Europe that transforms the seedhead of perennial sowthistle into a gall has been released into Canada but has not become established [53]. *Cystiphora sonchi*, another fly native to Europe, was released into Canada and has become established in Alberta, Saskatchewan, Manitoba, and Nova Scotia [92]. Zollinger and Parker [132] report as many as 721 galls were formed on one plant of perennial sowthistle, but Lemna and Messersmith [74] state no reduction in perennial sowthistle because of *Cystiphora sonchi* has been observed. A third fly, *Liriomyza sonchi*, has been authorized for release into Canada (Peschken and Derby 1988, reported in [74]).

Zollinger and Parker [132] provide a literature review of biological control efforts as of 1998.

Chemical:

Auxin-type herbicides are the primary chemicals used to control perennial sowthistle. Perennial sowthistle is "moderately susceptible" to auxins such as 2,4-D, 2,4-DB, and MCPA in the seedling stage, and established stands are "moderately resistant" (Fryer and Makepeace, 1982, as reported in a literature review [74]). Growth of aerial portions can be retarded by auxin-type herbicides, and flowering can be completely suppressed if the plant is treated when growth is vigorous (Fryer and Makepeace 1982 as reported in a literature review [74]), and [77]. A more detailed discussion of chemical control of perennial sowthistle is provided by Lemna and Messersmith [74] and by Zollinger and Parker [132].

Cultural: Patches of perennial sowthistle were cut for hay or were pastured as an early control measure [110,128]. An alfalfa or alfalfa-grass mixture, regularly cut for hay, can eliminate 90% of perennial sowthistle in

3 years (Martin and others 1961 in [74]).

"Intensive" grazing by domestic sheep or cattle weakens perennial sowthistle when the animals eat new growth and sometimes roots [132]. Grazing also enhances other control practices. However, perennial sowthistle is classified as an "increaser" under heavy grazing because it increases as more palatable plants are preferentially grazed [70].

Sonchus arvensis: References

1.
Abbas, Hamed K.; Tanaka, T.; Duke, S. O.; Boyette, C. D. 1995. Susceptibility of various crop and weed species to AAL-toxin, a natural herbicide. Weed Technology. 9(1): 125-130. [37302]

2.
Agee, James K. 1994. Fire and weather disturbances in terrestrial ecosystems of the eastern Cascades. Gen. Tech. Rep. PNW-GTR-320. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 52 p. (Everett, Richard L., assessment team leader; Eastside forest ecosystem health assessment; Hessburg, Paul F., science team leader and tech. ed., Volume III: assessment). [22991]

3.
Ahlgren, Clifford E. 1979. Emergent seedlings on soil from burned and unburned red pine forest. Minnesota Forestry Research Notes No. 273. St. Paul, MN: University of Minnesota, College of Forestry. 4 p. [16910]

4.
Arno, Stephen F. 1976. The historical role of fire on the Bitterroot National Forest. Res. Pap. INT-187. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 29 p. [15225]

5.
Arno, Stephen F. 1980. Forest fire history in the Northern Rockies. Journal of Forestry. 78(8): 460-465. [11990]

6.
Arno, Stephen F. 2000. Fire in western forest ecosystems. In: Brown, James K.; Smith, Jane Kapler, eds. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 97-120. [36984]

7.
Arno, Stephen F.; Fischer, William C. 1995. Larix occidentalis--fire ecology and fire management. In: Schmidt, Wyman C.; McDonald, Kathy J., compilers. Ecology and management of Larix forests: a look ahead: Proceedings of an international symposium; 1992 October 5-9; Whitefish, MT. Gen. Tech. Rep. GTR-INT-319. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 130-135. [25293]

8.
Arno, Stephen F.; Gruell, George E. 1983. Fire history at the forest-grassland ecotone in southwestern Montana. Journal of Range Management. 36(3): 332-336. [342]

9.
Arno, Stephen F.; Wilson, Andrew E. 1986. Dating past fires in curlleaf mountain-mahogany communities. Journal of Range Management. 39(3): 241-243. [350]

10.
Arny, A. C. 1932. Variations in the organic reserves in underground parts of five perennial weeds from late April to November. Technical Bulletin 84. St. Paul, MN: University of Minnesota, Agricultural Experiment Station. 28 p. [48290]

11.
Baisan, Christopher H.; Swetnam, Thomas W. 1990. Fire history on a desert mountain range: Rincon Mountain Wilderness, Arizona, U.S.A. Canadian Journal of Forest Research. 20: 1559-1569. [14986]

12.
Barrett, Stephen W. 1993. Fire regimes on the Clearwater and Nez Perce National Forests north-central Idaho. Final Report: Order No. 43-0276-3-0112. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Fire Sciences Laboratory. 21 p. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT. [41883]

13.
Barrett, Stephen W.; Arno, Stephen F.; Key, Carl H. 1991. Fire regimes of western larch - lodgepole pine forests in Glacier National Park, Montana. Canadian Journal of Forest Research. 21: 1711-1720. [17290]

14.
Bernard, Stephen R.; Brown, Kenneth F. 1977. Distribution of mammals, reptiles, and amphibians by BLM physiographic regions and A.W. Kuchler's associations for the eleven western states. Tech. Note 301. Denver, CO: U.S. Department of the Interior, Bureau of Land Management. 169 p. [434]

15.
Bosy, J.; Aarssen, L. W. 1995. The effect of seed orientation on germination in a uniform environment: differential success without genetic or environmental variation. Journal of Ecology. 83(5): 769-773. [44984]

16.
Braidek, J. T.; Fedec, P.; Jones, D. 1984. Field survey of halophytic plants of disturbed sites on the Canadian prairies. Canadian Journal of Plant Science. 64: 745-751. [24018]

17.
Brooks, Matthew L.; Esque, Todd C. 2002. Alien plants and fire in desert tortoise (Gopherus agassizii) habitat of the Mojave and Colorado deserts. Chelonian Conservation Biology. 4(2): 330-340. [44468]

18.
Bruns, V. F. 1965. The effects of fresh water storage on the germination of certain weed seeds. Weeds. 13: 38-39. [48293]

19.
Buchanan, R. A.; Cull, I. M.; Otey, F. H.; Russell, C. R. 1978. Hydrocarbon- and rubber-producing crops. Economic Botany. 32: 131-145. [47819]

20.
Buchanan, R. A.; Otey, F. H.; Russell, C. R.; Cull, I. M. 1978. Whole-plant oils, potential new industrial raw materials. Journal of the American Oil Chemists' Society. 55: 657-662. [47815]

21.
Buchholz, Kenneth; Good, Ralph E. 1982. Density, age structure, biomass and net annual aboveground productivity of dwarfed Pinus rigida Moll. from the New Jersey Pine Barren Plains. Bulletin of the Torrey Botanical Club. 109(1): 24-34. [8639]

22.
Burkhardt, Wayne J.; Tisdale, E. W. 1976. Causes of juniper invasion in southwestern Idaho. Ecology. 57: 472-484. [565]

23.
Chepil, W. S. 1946. Germination of seeds. I. Longevity, periodicity of germination, and vitality of

seeds in cultivated soil. Scientific Agriculture. 26: 307-346. [48281]

24.
Cole, G. F. 1956. The pronghorn antelope--its range use and food habits in central Montana with special reference to alfalfa. Technical Bulletin 516. Bozeman, MT: Montana State College, Agricultural Experiment Station. 63 p. [43976]

25. Cooper, Charles F. 1961. Pattern in ponderosa pine forests. Ecology. 42(3): 493-499. [5780]

26.
Cronquist, Arthur; Holmgren, Arthur H.; Holmgren, Noel H.; [and others]. 1994. Intermountain flora: Vascular plants of the Intermountain West, U.S.A. Vol. 5. Asterales. New York: The New York Botanical Garden. 496 p. [28653]

27.
D'Antonio, Carla M. 2000. Fire, plant invasions, and global changes. In: Mooney, Harold A.; Hobbs, Richard J., eds. Invasive species in a changing world. Washington, DC: Island Press: 65-93. [37679]

28.
Dale, Virginia H. 1989. Wind dispersed seeds and plant recovery on the Mount St. Helens debris avalanche. Canadian Journal of Botany. 67: 1434-1441. [12670]

29.
Davis, Kathleen M. 1980. Fire history of a western larch/Douglas-fir forest type in northwestern Montana. In: Stokes, Marvin A.; Dieterich, John H., technical coordinators. Proceedings of the fire history workshop; 1980 October 20-24; Tucson, AZ. Gen. Tech. Rep. RM-81. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 69-74. [12813]

30.
Derscheid, Lyle A.; Nash, Russell L.; Wicks, Gail A. 1961. Thistle control with cultivation, cropping and chemicals. Weeds. 9: 90-102. [48292]

31.
Derscheid, Lyle A.; Schultz, Robert E. 1960. Achene development of Canada thistle and perennial sowthistle. Weeds. 8: 55-62. [48291]

32.
Dittberner, Phillip L.; Olson, Michael R. 1983. The plant information network (PIN) data base: Colorado, Montana, North Dakota, Utah, and Wyoming. FWS/OBS-83/86. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 786 p. [806]

33.
Dodd, J, D.; Coupland, R. T. 1966. Vegetation of saline areas in Saskatchewan. Ecology. 47(6): 958-968. [11209]

34.
Dorn, Robert D. 1988. Vascular plants of Wyoming. Cheyenne, WY: Mountain West Publishing. 340 p. [6129]

35.
Duchesne, Luc C.; Hawkes, Brad C. 2000. Fire in northern ecosystems. In: Brown, James K.; Smith, Jane Kapler, eds. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 35-51. [36982]

36.
Eyre, F. H., ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p. [905]

37.
Fernald, M. L.; Wiegand, K. M. 1910. A summer's botanizing in eastern Maine and western New Brunswick. Rhodora. 12(138): 101-121, 133-146. [48297]

38.
Finney, Mark A.; Martin, Robert E. 1989. Fire history in a Sequoia sempervirens forest at Salt Point State Park, California. Canadian Journal of Forest Research. 19: 1451-1457. [9845]

39.
Floyd, M. Lisa; Romme, William H.; Hanna, David D. 2000. Fire history and vegetation pattern in Mesa Verde National Park, Colorado, USA. Ecological Applications. 10(6): 1666-1680. [37590]

40.
Frissell, Sidney S., Jr. 1968. A fire chronology for Itasca State Park, Minnesota. Minnesota Forestry Research Notes No. 196. St. Paul, MN: University of Minnesota. 2 p. [34527]

41.
Garrison, George A.; Bjugstad, Ardell J.; Duncan, Don A.; Lewis, Mont E.; Smith, Dixie R. 1977. Vegetation and environmental features of forest and range ecosystems. Agric. Handb. 475. Washington, DC: U.S. Department of Agriculture, Forest Service. 68 p. [998]

42.
Gleason, Henry A.; Cronquist, Arthur. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. 2nd ed. New York: New York Botanical Garden. 910 p. [20329]

43.
Gottfried, Gerald J.; Swetnam, Thomas W.; Allen, Craig D.; [and others]. 1995. Pinyon-juniper woodlands. In: Finch, Deborah M.; Tainter, Joseph A., eds. Ecology, diversity, and sustainability of the Middle Rio Grande Basin. Gen. Tech. Rep. RM-GTR-268. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 95-132. [26188]

44.
Grant, Martin L. 1929. The burn succession in Itasca County, Minnesota. Minneapolis, MN: University of Minnesota. 63 p. Thesis. [36527]

45.
Great Plains Flora Association. 1986. Flora of the Great Plains. Lawrence, KS: University Press of Kansas. 1392 p. [1603]

46.
Greenlee, Jason M.; Langenheim, Jean H. 1990. Historic fire regimes and their relation to vegetation patterns in the Monterey Bay area of California. The American Midland Naturalist. 124(2): 239-253. [15144]

47.
Gruell, G. E.; Loope, L. L. 1974. Relationships among aspen, fire, and ungulate browsing in Jackson Hole, Wyoming. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 33 p. In cooperation with: U.S. Department of the Interior, National Park Service, Rocky Mountain Region. [3862]

48.
Guy, Robert D.; Reid, David M.; Krouse, H. Roy. 1986. Factors affecting 13C/12C ratios of inland halophytes. II. Ecophysiological interpretations of patterns in the field. Canadian Journal of Botany. 642: 2700-2707. [48276]

49.
Guyette, Richard; McGinnes, E. A., Jr. 1982. Fire history of an Ozark glade in Missouri. Transactions, Missouri Academy of Science. 16: 85-93. [5170]

50.
Hakansson, Sigurd. 1969. Experiments with Sonchus arvensis L. I. Development and growth, and the response to burial and defoliation in different developmental stages. Lantbrukshogskolans Annaler. 35: 989-1030. [48284]

51.
Hakansson, Sigurd. 1982. Multiplication, growth and persistence of perennial weeds. In: Holzner, W.; Numata, M., eds. Biology and ecology of weeds. The Hague: Dr. W. Junk: 123-135. [47816]

52.
Hakansson, Sigurd; Wallgren, Bengt. 1972. Experiments with Sonchus arvensis L. II. Reproduction, plant development and response to mechanical disturbance. Swedish Journal of Agricultural Research. 2: 3-14. [48381]

53.
Harris, P.; Shorthouse, J. D. 1996. Effectiveness of gall inducers in weed biological control. The Canadian Entomologist. 128(6): 1021-1055. [37288]

54.
Heinselman, Miron L. 1970. The natural role of fire in northern conifer forest. In: The role of fire in the Intermountain West: Combined business meeting, Intermountain Research Council and symposium; 1970 October 27-29; Missoula, MT. Missoula, MT: Intermountain Fire Research Council: 30-41. In cooperation with: University of Montana, School of Forestry. [15735]

55.
Hendrickson, William H. 1972. Perspective on fire and ecosystems in the United States. In: Fire in the environment: Symposium proceedings; 1972 May 1-5; Denver, CO. FS-276. [Washington, DC]: U.S. Department of Agriculture, Forest Service: 29-33. In cooperation with: Fire Services of Canada, Mexico, and the United States; Members of the Fire Management Study Group; North American Forestry Commission; FAO. [17276]

56.
Heyerdahl, Emily K.; Berry, Dawn; Agee, James K. 1994. Fire history database of the western United States. Final report. Interagency agreement: U.S. Environmental Protection Agency DW12934530; U.S. Department of Agriculture, Forest Service PNW-93-0300; University of

Washington 61-2239. Seattle, WA: U.S. Department of Agriculture, Pacific Northwest Research Station; University of Washington, College of Forest Resources. 28 p. [+ Appendices]. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT. [27979]

57.
Hickman, James C., ed. 1993. The Jepson manual: Higher plants of California. Berkeley, CA: University of California Press. 1400 p. [21992]

58.
Hitchcock, C. Leo; Cronquist, Arthur. 1973. Flora of the Pacific Northwest. Seattle, WA: University of Washington Press. 730 p. [1168]

59.
Hogenbirk, John C.; Wein, Ross W. 1991. Fire and drought experiments in northern wetlands: a climate change analogue. Canadian Journal of Botany. 69: 1991-1997. [17127]

60.
Hogenbirk, John C.; Wein, Ross W. 1992. Temperature effects on seedling emergence from boreal wetland soils: implications for climate change. Aquatic Botany. 42(4): 361-373. [19959]

61.
Hooper, Shirley N.; Chandler, R. Frank. 1984. Herbal remedies of the maritime Indians: phytosterols and triterpenes of 67 plants. Journal of Ethnopharmacology. 10: 181-194. [48295]

62.
Hulten, Eric. 1968. Flora of Alaska and neighboring territories. Stanford, CA: Stanford University Press. 1008 p. [13403]

63.
Hume, L.; Archibold, O. W. 1986. The influence of a weedy habitat on the seed bank of an adjacent cultivated field. Canadian Journal of Botany. 64: 1879-1883. [27685]

64.
Jones, Stanley D.; Wipff, Joseph K.; Montgomery, Paul M. 1997. Vascular plants of Texas. Austin, TX: University of Texas Press. 404 p. [28762]

65.
Kartesz, John T.; Meacham, Christopher A. 1999. Synthesis of the North American flora (Windows Version 1.0), [CD-ROM]. Available: North Carolina Botanical Garden. In cooperation with the Nature Conservancy, Natural Resources Conservation Service, and U.S. Fish and Wildlife Service [2001, January 16]. [36715]

66.
Kinch, R. C.; Termunde, Darrold. 1957. Germination of perennial sow thistle and Canada thistle at various stages of maturity. Proceedings, Association of Official Seed Analysts. 47: 165-166. [48278]

67.
Komarova, T. A. 1986. Role of forest fires in germination of seed dormant in the soil. Soviet Journal of Ecology. 16(6): 311-315. [20252]

68.
Kucera, Clair L. 1981. Grasslands and fire. In: Mooney, H. A.; Bonnicksen, T. M.; Christensen, N. L.; [and others], technical coordinators. Fire regimes and ecosystem properties: Proceedings of the conference; 1978 December 11-15; Honolulu, HI. Gen. Tech. Rep. WO-26. Washington, DC: U.S. Department of Agriculture, Forest Service: 90-111. [4389]

69.
Kuchler, A. W. 1964. United States [Potential natural vegetation of the conterminous United States]. Special Publication No. 36. New York: American Geographical Society. 1:3,168,000; colored. [3455]

70.
Lacey, John; Mosley, John. 2002. 250 plants for range contests in Montana. MONTGUIDE MT198402 AG 6/2002. Range E-2 (Misc.). Bozeman, MT: Montana State University, Extension Service. 4 p. [43671]

71.
Lackschewitz, Klaus. 1991. Vascular plants of west-central Montana--identification guidebook. Gen. Tech. Rep. INT-227. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 648 p. [13798]

72.
Larson, Gary E. 1993. Aquatic and wetland vascular plants of the Northern Great Plains. Gen. Tech. Rep. RM-238. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 681 p. [22534]

73.
Laven, R. D.; Omi, P. N.; Wyant, J. G.; Pinkerton, A. S. 1980. Interpretation of fire scar data from a ponderosa pine ecosystem in the central Rocky Mountains, Colorado. In: Stokes, Marvin A.; Dieterich, John H., technical coordinators. Proceedings of the fire history workshop; 1980 October 20-24; Tucson, AZ. Gen. Tech. Rep. RM-81. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 46-49. [7183]

74.
Lemna, Wanda K.; Messersmith, Calvin G. 1990. The biology of Canadian weeds. 94. Sonchus arvensis L. Canadian Journal of Plant Science. 70: 509-532. [24019]

75.
Long, Bayard. 1922. Sonchus uliginosus occurring in the Philadelphia area. Torreya. 22(6): 91-98. [48282]

76.
Marten, G. C.; Sheaffer, C. C.; Wyse, D. L. 1987. Forage nutritive value and palatability of perennial weeds. Agronomy Journal. 79: 980-986. [3449]

77.
May, M. J. 1977. Perennial weeds and their control on organic soils. ADAS Quarterly Review. 27: 146-154. [47820]

78.
McPherson, Guy R. 1995. The role of fire in the desert grasslands. In: McClaran, Mitchel P.; Van Devender, Thomas R., eds. The desert grassland. Tucson, AZ: The University of Arizona Press: 130-151. [26576]

79.
Meinecke, E. P. 1929. Quaking aspen: A study in applied forest pathology. Tech. Bull. No. 155. Washington, DC: U.S. Department of Agriculture. 34 p. [26669]

80.
Miller, Richard F.; Rose, Jeffery A. 1995. Historic expansion of Juniperus occidentalis (western juniper) in southeastern Oregon. The Great Basin Naturalist. 55(1): 37-45. [26637]

81.
Mohlenbrock, Robert H. 1986. [Revised edition]. Guide to the vascular flora of Illinois. Carbondale, IL: Southern Illinois University Press. 507 p. [17383]

82.
Moir, William H. 1982. A fire history of the High Chisos, Big Bend National Park, Texas. The Southwestern Naturalist. 27(1): 87-98. [5916]

83.
Morrison, Peter H.; Swanson, Frederick J. 1990. Fire history and pattern in a Cascade Range landscape. Gen. Tech. Rep. PNW-GTR-254. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 77 p. [13074]

84.
Mullin, Barbara. 1992. Meeting the invasion: integrated weed management. Western Wildlands. 18(2): 33-38. [19462]

85.
Myers, Ronald L. 2000. Fire in tropical and subtropical ecosystems. In: Brown, James K.; Smith, Jane Kapler, eds. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 161-173. [36985]

86.
Olson, Wendell W. 1975. Effects of controlled burning on grassland within the Tewaukon National Wildlife Refuge. Fargo, ND: North Dakota University of Agriculture and Applied Science. 137 p. Thesis. [15252]

87.
Paysen, Timothy E.; Ansley, R. James; Brown, James K.; [and others]. 2000. Fire in western shrubland, woodland, and grassland ecosystems. In: Brown, James K.; Smith, Jane Kapler, eds. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-volume 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 121-159. [36978]

88.
Pegtel, D. M. 1973. Aspects of ecotypic differentiation in the perennial sowthistle. Acta Horticulturae. 32: 55-71. [48287]

89.
Pemadasa, M. A.; Kangatharalingam, N. 1977. Factors affecting germination of some composites. Ceylon Journal of Science (Biological Science). 12: 157-168. [48274]

90.
Pemble, R. H.; Van Amburg, G. L.; Mattson, Lyle. 1981. Intraspecific variation in flowering activity following a spring burn on a northwestern Minnesota prairie. In: Stuckey, Ronald L.; Reese, Karen J., eds. The prairie peninsula--in the "shadow" of Transeau: Proceedings, 6th North American prairie conference; 1978 August 12-17; Columbus, OH. Ohio Biological Survey: Biological Notes No. 15. Columbus, OH: Ohio State University, College of Biological Sciences: 235-240. [3435]

91.
Peschken, D. P. 1984. Sonchus arvensis L., perennial sow-thistle, S. oleraceus L., annual sow-thistle, and S. asper (L.) Hill, spiny annual sow-thistle (Compositae). In: Kelleher, J. S.; Hulme, M. A., eds. Biological control programmes against insects and weeds in Canada 1969-1980. Slough, UK: Commonwealth Agriculture Bureax: 205-209. [24021]

92.
Peschken, D. P.; McClay, A. S.; Derby, J. L.; DeClerck, R. 1989. Cystiphora sonchi (Bremi) (Diptera: Cedidomyiidae), a new biological control agent established on the weed perennial sow-thistle (Sonchus arvensis L.) (Compositae) in Canada. The Canadian Entomologist. 121: 781-791. [24020]

93.
Peschken, Diether P.; Thomas, A. Gordon; Wise, Robin F. 1983. Loss in yield of rapeseed (Brassica napus, B. campestris) caused by perennial sowthistle (Sonchus arvensis) in Saskatchewan and Manitoba. Weed Science. 31: 740-744. [48294]

94.
Peters, Erin F.; Bunting, Stephen C. 1994. Fire conditions pre- and postoccurrence of annual grasses on the Snake River Plain. In: Monsen, Stephen B.; Kitchen, Stanley G., compilers. Proceedings--ecology and management of annual rangelands; 1992 May 18-22; Boise, ID. Gen. Tech. Rep. INT-GTR-313. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 31-36. [24249]

95.
Quinnild, Clayton L.; Cosby, Hugh E. 1958. Relicts of climax vegetation on two mesas in western North Dakota. Ecology. 39(1): 29-32. [1925]

96.
Raunkiaer, C. 1934. The life forms of plants and statistical plant geography. Oxford: Clarendon Press. 632 p. [2843]

97.
Redmann, R. E. 1972. Plant communities and soils of an eastern North Dakota prairie. Bulletin of the Torrey Botanical Club. 99(2): 65-76. [3639]

98.
Ripple, William J. 1994. Historic spatial patterns of old forests in western Oregon. Journal of Forestry. 92(11): 45-49. [33881]

99.
Rowe, J. S. 1969. Lightning fires in Saskatchewan grassland. Canadian Field-Naturalist. 83: 317-324. [6266]

100.
Sapsis, David B. 1990. Ecological effects of spring and fall prescribed burning on basin big sagebrush/Idaho fescue--bluebunch wheatgrass communities. Corvallis, OR: Oregon State University. 105 p. Thesis. [16579]

101.
Schimming, Wanda K.; Messersmith, Calvin G. 1988. Freezing resistance of overwintering buds of four perennial weeds. Weed Science. 36: 568-573. [24022]

102.
Schultz, Brad W. 1987. Ecology of curlleaf mountain mahogany (Cercocarpus ledifolius) in western and central Nevada: population structure and dynamics. Reno, NV: University of Nevada. 111 p. Thesis. [7064]

103.
Seklecki, Mariette T.; Grissino-Mayer, Henri D.; Swetnam, Thomas W. 1996. Fire history and the possible role of Apache-set fires in the Chiricahua Mountains of southeastern Arizona. In: Ffolliott, Peter F.; DeBano, Leonard F.; Baker, Malchus, B., Jr.; [and others], tech. coords. Effects of fire on Madrean Province ecosystems: a symposium proceedings; 1996 March 11-15; Tucson, AZ. Gen. Tech. Rep. RM-GTR-289. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 238-246. [28082]

104.
Sheldon, J. C.; Burrows, F. M. 1973. The dispersal effectiveness of the achene-pappus units of selected Compositae in steady winds with convection. New Phytologist. 72: 665-675. [24023]

105.

Sheley, Roger L.; Jacobs, James S.; Carpinelli, Michael F. 1998. Distribution, biology, and management of diffuse knapweed (Centaurea diffusa) and spotted knapweed (Centaurea maculosa). Weed Technology. 12(2): 353-362. [37449]

106.
Sheley, Roger; Manoukian, Mark; Marks, Gerald. 1999. Preventing noxious weed invasion. In: Sheley, Roger L.; Petroff, Janet K., eds. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press: 69-72. [35711]

107.
Shiflet, Thomas N., ed. 1994. Rangeland cover types of the United States. Denver, CO: Society for Range Management. 152 p. [23362]

108.
Shumovich, W.; Montgomery, F. H. 1955. The perennial sowthistles in northeastern North America. Canadian Journal of Agricultural Science. 35: 601-605. [48280]

109.
Stevens, O. A. 1924. Perennial sow thistle: Growth and reproduction. Bulletin 181. Fargo, ND: North Dakota Agricultural College, Agricultural Experiment Station. 42 p. [48289]

110.
Stevens, O. A. 1926. The sow thistle. Circular 32. Fargo, ND: North Dakota Agricultural College, Agricultural Experiment Station. 16 p. [48288]

111.
Stevens, O. A. 1932. The number and weight of seeds produced by weeds. American Journal of Botany. 19: 784-794. [47817]

112.
Stickney, Peter F. 1989. Seral origin of species originating in northern Rocky Mountain forests. Unpublished draft on file at: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Fire Sciences Laboratory, Missoula, MT. 10 p. [20090]

113.
Stomberg, Mark R.; Kephart, Paul; Yadon, Vern. 2001. Composition, invasibility, and diversity in coastal California grasslands. Madrono. 48(4): 236-252. [41371]

114.
Strausbaugh, P. D.; Core, Earl L. 1977. Flora of West Virginia. 2nd ed. Morgantown, WV: Seneca Books, Inc. 1079 p. [23213]

115.
Stuart, John D. 1987. Fire history of an old-growth forest of Sequoia sempervirens (Taxodiaceae) forest in Humboldt Redwoods State Park, California. Madrono. 34(2): 128-141. [7277]

116.
Swetnam, Thomas W.; Baisan, Christopher H.; Caprio, Anthony C.; Brown, Peter M. 1992. Fire history in a Mexican oak-pine woodland and adjacent montane conifer gallery forest in southeastern Arizona. In: Ffolliott, Peter F.; Gottfried, Gerald J.; Bennett, Duane A.; [and others], technical coordinators. Ecology and management of oak and associated woodlands: perspectives in the southwestern United States and northern Mexico: Proceedings; 1992 April 27-30; Sierra Vista, AZ. Gen. Tech. Rep. RM-218. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 165-173. [19759]

117.
Szczawenski, A. F.; Turner, N. J. 1978. Edible garden weeds of Canada. Ottawa, ON: National Museum of Natural Science. 184 p. [48296]

118.
Tande, Gerald F. 1979. Fire history and vegetation pattern of coniferous forests in Jasper National Park, Alberta. Canadian Journal of Botany. 57: 1912-1931. [18676]

119.
Thompson, D. J.; Shay, Jennifer M. 1989. First-year response of a Phragmites marsh community to seasonal burning. Canadian Journal of Botany. 67: 1448-1455. [7312]

120.
Titus, Jonathan H.; Moore, Scott; Arnot, Mildred; Titus, Priscilla J. 1998. Inventory of the vascular flora of the blast zone, Mount St. Helens, Washington. Madrono. 45(2): 146-161. [30322]

121.
U.S. Department of Agriculture, National Resource Conservation Service. 2004. PLANTS database (2004), [Online]. Available: http://plants.usda.gov/. [34262]

122.
van der Valk, A. G. 1981. Succession in wetlands: A Gleasonian approach. Ecology. 62(3): 688-696.

[15751]

123.
Vincent, Dwain W. 1992. The sagebrush/grasslands of the upper Rio Puerco area, New Mexico. Rangelands. 14(5): 268-271. [19698]

124.
Voss, Edward G. 1996. Michigan flora. Part III: Dicots (Pyrolaceae--Compositae). Cranbrook Institute of Science Bulletin 61/University of Michigan Herbarium. Ann Arbor, MI: The Regents of the University of Michigan. 622 p. [30401]

125.
Wade, Dale D.; Brock, Brent L.; Brose, Patrick H.; [and others]. 2000. Fire in eastern ecosystems. In: Brown, James K.; Smith, Jane Kapler, eds. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 53-96. [36983]

126.
Weber, William A.; Wittmann, Ronald C. 1996. Colorado flora: eastern slope. 2nd ed. Niwot, CO: University Press of Colorado. 524 p. [27572]

127.
Whisenant, Steven G. 1990. Postfire population dynamics of Bromus japonicus. The American Midland Naturalist. 123: 301-308. [11150]

128.
Whiteman, R. 1936. Sow thistle control. Circular No. 115. Winnipeg, MB: Manitoba Department of Agriculture and Immigration. 7 p. [48275]

129.
Wright, Henry A.; Bailey, Arthur W. 1982. Fire ecology: United States and southern Canada. New York: John Wiley & Sons. 501 p. [2620]

130.
Young, James A.; Evans, Raymond A. 1981. Demography and fire history of a western juniper stand. Journal of Range Management. 34(6): 501-505. [2659]

131.
Zollinger, Richard K.; Kells, James J. 1991. Effect of soil pH, soil water, light intensity, and temperature on perennial sowthistle (Sonchus arvensis L.). Weed Science. 39: 376-384. [24015]

132.
Zollinger, Richard K.; Parker, Robert. 1999. Sowthistles. In: Sheley, Roger L.; Petroff, Janet K., eds. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press: 336-349. [35742]

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