SPECIES: Sisymbrium altissimum

Choose from the following categories of information.

INTRODUCTORY

SPECIES: Sisymbrium altissimum

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FEIS ABBREVIATION:
SISALT

SYNONYMS:
No entry

NRCS PLANT CODE [123]:
SIAL2

COMMON NAMES:

tumble mustard
tumblemustard
tumbling mustard
Jim Hill mustard
tall hedge-mustard

TAXONOMY:
The scientific name of tumble mustard is *Sisymbrium altissimum* L. (Brassicaceae) [32,51,56,66,68,75,83,99,119,126,130].

LIFE FORM:
Forb

FEDERAL LEGAL STATUS:
No special status

OTHER STATUS:
No entry

DISTRIBUTION AND OCCURRENCE

SPECIES: Sisymbrium altissimum

GENERAL DISTRIBUTION:
Tumble mustard is native to Eurasia. It is widely naturalized throughout most of the world [119] including most of Canada and the United States. Tumble mustard does not occur in eastern Nunavut, western Newfoundland, or Alabama [75], and is rare in Florida [140]. It is mostly absent from Mexico, occurring only in the northern tip of Baja California Norte [136]. Tumble mustard was probably introduced in North America as a contaminant in imported crop seed [78]. Plants database provides a map of tumble mustard's distribution in the Untied States.

The following biogeographic classification systems are presented as a guide to where tumble mustard may be found. Precise distribution information is limited. Because it is so widespread, it is difficult to exclude many ecosystems as potential hosts of tumble mustard plants or populations; therefore, these lists are speculative.

ECOSYSTEMS [49]:
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
FRES21 Ponderosa pine
FRES24 Hemlock-Sitka spruce
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

STATES/PROVINCES: (key to state/province abbreviations)

UNITED STATES

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

CANADA

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

MEXICO

B.C.N.

BLM PHYSIOGRAPHIC REGIONS [11]:
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 [80] PLANT ASSOCIATIONS:
K001 Spruce-cedar-hemlock forest
K009 Pine-cypress forest
K010 Ponderosa shrub forest
K011 Western ponderosa forest
K013 Cedar-hemlock-pine forest
K016 Eastern ponderosa forest
K017 Black Hills pine forest
K019 Arizona pine forest
K022 Great Basin pine forest
K023 Juniper-pinyon woodland
K024 Juniper steppe woodland
K025 Alder-ash forest
K026 Oregon oakwoods
K027 Mesquite bosques
K028 Mosaic of K002 and K026
K029 California mixed evergreen forest
K030 California oakwoods
K031 Oak-juniper woodland
K032 Transition between K031 and K037
K033 Chaparral
K034 Montane chaparral
K035 Coastal sagebrush
K036 Mosaic of K030 and K035
K037 Mountain-mahogany-oak scrub
K038 Great Basin sagebrush
K039 Blackbrush
K040 Saltbush-greasewood
K041 Creosote bush
K042 Creosote bush-bur sage
K043 Paloverde-cactus shrub
K044 Creosote bush-tarbush
K045 Ceniza shrub
K046 Desert: vegetation largely lacking
K047 Fescue-oatgrass
K048 California steppe
K049 Tule marshes
K050 Fescue-wheatgrass
K051 Wheatgrass-bluegrass
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
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
K091 Cypress savanna
K093 Great Lakes spruce-fir forest
K095 Great Lakes pine forest
K096 Northeastern spruce-fir forest
K097 Southeastern spruce-fir forest
K098 Northern floodplain forest
K099 Maple-basswood forest
K100 Oak-hickory forest
K101 Elm-ash forest
K102 Beech-maple forest
K103 Mixed mesophytic forest
K104 Appalachian oak forest
K106 Northern hardwoods
K107 Northern hardwoods-fir forest
K108 Northern hardwoods-spruce forest
K109 Transition between K104 and K106
K110 Northeastern oak-pine forest
K111 Oak-hickory-pine
K112 Southern mixed forest
K113 Southern floodplain forest
K114 Pocosin
K115 Sand pine scrub

SAF COVER TYPES [42]:
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
69 Sand pine
70 Longleaf pine

71 Longleaf pine-scrub oak
72 Southern scrub oak
73 Southern redcedar
74 Cabbage palmetto
75 Shortleaf pine
76 Shortleaf pine-oak
78 Virginia pine-oak
79 Virginia pine
80 Loblolly pine-shortleaf pine
81 Loblolly pine
82 Loblolly pine-hardwood
83 Longleaf pine-slash pine
84 Slash pine
85 Slash pine-hardwood
87 Sweetgum-yellow-poplar
88 Willow oak-water oak-diamondleaf (laurel) oak
89 Live oak
91 Swamp chestnut oak-cherrybark oak
92 Sweetgum-willow oak
93 Sugarberry-American elm-green ash
94 Sycamore-sweetgum-American elm
95 Black willow
96 Overcup oak-water hickory
97 Atlantic white-cedar
98 Pond pine
100 Pondcypress
101 Baldcypress
102 Baldcypress-tupelo
105 Tropical hardwoods
107 White spruce
108 Red maple
109 Hawthorn
110 Black oak
111 South Florida slash pine
201 White spruce
202 White spruce-paper birch
203 Balsam poplar
204 Black spruce
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
233 Oregon white oak
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
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

SRM (RANGELAND) COVER TYPES [111]:
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
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
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
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
808 Sand pine scrub
809 Mixed hardwood and pine
810 Longleaf pine-turkey oak hills
812 North Florida flatwoods
813 Cutthroat seeps
814 Cabbage palm flatwoods
815 Upland hardwood hammocks

816 Cabbage palm hammocks
817 Oak hammocks
818 Florida salt marsh
819 Freshwater marsh and ponds
820 Everglades flatwoods
821 Pitcher plant bogs
822 Slough
ALASKA RANGELANDS
901 Alder
904 Black spruce-lichen
905 Bluejoint reedgrass
906 Broadleaf forest
907 Dryas
908 Fescue
915 Mixed herb-herbaceous
920 White spruce-paper birch
921 Willow

HABITAT TYPES AND PLANT COMMUNITIES:
Tumble mustard occurs in disturbed plant communities throughout most of the United States and Canada. It is most invasive in the West, where it is common below the ponderosa pine (*Pinus ponderosa*) belt [122]. It occurs in sagebrush (*Artemisia* spp.), salt-desert shrubland, and pinyon-juniper (*Pinus-Juniperus* spp.) communities in the Great Basin [76]. On sagebrush steppe it commonly associates with other annuals in early seres. Near an abandoned oil-drill site in Wyoming, for example, it occurred in a big sagebrush (*A. tridentata*) community type with exotic Russian-thistle (*Salsola kali*) and cheatgrass (*Bromus tectorum*) and native annuals including common pepperweed (*Lepidium densiflorum*), desert goosefoot (*Chenopodium pratericola*), and sixweeks fescue (*Vulpia octoflora*) [2]. Pinnate tansymustard (*Descurainia pinnata*), clasping pepperweed (*Lepidium perfoliatum*), red brome (*Bromus madritensis* ssp. *rubens)*, and medusahead (*Taeniatherum caput-medusae*) are other common annual associates [38]. In a big sagebrush-fourwing saltbush (*Atriplex canescens*) community in eastern Oregon, canopy cover of annuals exceeded 100%, with 42% cheatgrass, 10% cutleaf filaree (*Erodium cicutarium*), and 9% tumble mustard cover [50]. Associates of tumble mustard in Wyoming big sagebrush-broom snakeweed/Indian ricegrass (*Artemisia tridentata* ssp. *wyomingensis-Gutierrezia sarothrae/Achnatherum hymenoides*) of Utah included halogeton (*Halogeton glomeratus*), which was successionally replacing cheatgrass, and clasping pepperweed [84]. Blackburn and others [14] describe a tumble mustard-dominated disclimax community in west-central Nevada that occurs on highly disturbed rangelands.

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Sisymbrium altissimum

GENERAL BOTANICAL CHARACTERISTICS:
Tumble mustard is an exotic winter annual or biennial. It is the tallest species in the genus, reaching 4.9 feet (1.5 m) or more in height. Growth form is rounded and freely branching from a single basal stem. Leaves are

0.4 to 7.9 inches (1-20 cm) long, becoming smaller up the stem. The inflorescence is a raceme of perfect flowers. The fruit is a 2- to 3.9-inch-long (5-10 cm), narrow silique with 120 or more small (~1 mm in length), wingless seeds [56,62,88,99,122,126,129,130]. Tumble mustard has a thick taproot [122,141]. Maximum root depth of plants in Wyoming averaged 17 inches (43 cm) over 2 years, ranging from 9.1 to 23 inches (23-58 cm). Of 7 annuals species excavated, only Russian-thistle grew longer roots [2].

RAUNKIAER [100] LIFE FORM:
Therophyte

REGENERATION PROCESSES:
As an annual, tumble mustard reproduces solely from seed.

Breeding system: Mustards (Brassicaceae) are cross-pollinated. Selfing also occurs [61].

Pollination is by insects [61].

Seed production: Tumble mustard is a prolific seed producer. A single plant can produce up to 12,500 siliques and 1.5 million seeds [24,88].

Seed dispersal:
Seeds disperse when the dead, dried parent plant breaks at the stem base and tumbles or slides across the ground by wind or other movement [88,122,142]. The fruits are tough and shatter slowly, so only a few seeds at a time are released. Consequently, the dried plant may disperse seeds throughout fall and winter, across many miles [78,88,122,135]. Animals disperse seeds when the wet, mucilaginous seed coat sticks to feathers or fur [149]. Machinery can pick up branches and whole plants, transporting seeds hundreds to thousands of miles. Tumble mustard's initial expansion westward was probably facilitated by railroad cars. One of the species' common names, Jim Hill mustard, comes from the name of the early railroad magnate [88,129].

Seed banking: Tumble mustard builds up a long-term seed bank [50,52,63,146,152]. Seed stored over 40 years has germinated in the laboratory (review by [133]). It is unclear how long seed remains viable in natural seed banks. In a Virginia pasture experiment, tumble mustard seed buried 8 inches (20 cm) deep in pots showed 10% germination after 2 years' burial, 21.5% after 4 years, 79% after 7 years, and 0% germination after 17 and 22 years [52].

Tumble mustard's soil seed bank is dynamic, reaching greatest seasonal density in fall and greatest year-to-year fluctuation in wet years. In Yellowstone National Park, mean seed bank density of tumble mustard (based on number of emergents in soil samples) was 53 plants/m^2 [23]. A degraded big sagebrush-spiny hopsage/Thurber needlegrass (*Grayia spinosa/Achnatherum thurberianum*) community near Reno, Nevada, showed seasonal and spatial variation in density of tumble mustard seed as follows [146]:

Strata	Time of sampling (seeds/m^2)				
	Sept.	Nov.	Dec.	Feb.	May
between shrubs:					
litter	200	1,350	100	----	----
soil	100	25	----	25	
under shrubs:					
litter	750	750	550	100	540
soil	175	100	100	25	80

Germination:

Tumble mustard seeds become mucilaginous upon wetting, which helps them retain moisture. Seeds can germinate on the seedbed surface without litter or soil covering [78,146]. In the absence of cheatgrass, tumble mustard may show better germination and establishment with litter; however, when cheatgrass is present in the seed bank, cheatgrass tends to outcompete tumble mustard [146]. Tumble mustard seeds are immediately germinable at temperatures from 32 to 68 degrees Fahrenheit (0-20 ^{o}C), with no stratification requirement. Best germination occurs on fine-textured soils with temperatures around 50 degrees Fahrenheit (10 ^{o}C) [149]. Near Reno, seeds showed best germination in May [146]. Germination rates are generally good, but irregular. In southern Idaho, tumble mustard seed stored for a year in an unheated shed showed 93% germination [67]. Seed lots collected in northern Nevada and northeastern California showed irregular germination; they did not all germinate at 1 time under "ideal" laboratory temperature and moisture conditions. Seed lots were collected over 4 consecutive years. Germination continued for 12 weeks, with some seeds germinating in their 2nd year [149]. Frequency of tumble mustard in a black sagebrush (*Artemisia nova*) community of west-central Nevada was highest in a year of above-average annual precipitation. Mean frequency (% and 1 standard error (SE)) varied as follows [150]:

Average ppt (n=4 years, μ=175 mm annual ppt)	Dry year (1989, no April ppt; annual ppt not available)	Wet year (198
5 (0.9)	0	10 (0.8)

Tumble mustard seeds show some ability to withstand short-term high temperatures. Seeds collected from Yellowstone National Park showed equal emergence (53/m^2) from soil samples at room temperature and samples heated to 120 degrees Fahrenheit (50 ^{o}C). Emergence dropped to 13/m^2 at 210 degrees Fahrenheit (100 ^{o}C) and 0 at 300 degrees Fahrenheit (150 ^{o}C) [23].

Seedling establishment/growth:

Tumble mustard shows best establishment on mineral soil under an open canopy. In the Reno study discussed above, Young and Evans [146] found better tumble mustard establishment between shrubs compared to under shrubs. They attributed this to better litter and soil moisture conditions for cheatgrass under shrubs, where cheatgrass outcompeted tumble mustard.

Tumble mustard seedlings grow rapidly. In uncrowded stands, they form large rosettes before bolting [2]. Emergence and establishment are enhanced by uneven microtopography, with tumble mustard establishing best in pits and furrows [55,144,148].

As annuals, tumble mustard populations fluctuate in size depending upon climate and other factors [94,102]. In a big sagebrush/bluebunch wheatgrass (*Pseudoroegneria spicata*) community of eastern Washington, tumble mustard was absent from study plots in 1977, a drought year. Its mean biomass was 0.77 g/m^2 in 1978, when precipitation was average [35]. In years of above-average precipitation, tumble mustard and other annuals can produce considerable biomass. With disturbance, the annuals may invade areas where they were sparse or absent before the frequent rains [37].

SITE CHARACTERISTICS:

On native soils in the Middle East, tumble mustard grows on desert foothills. Tumble mustard is a common agricultural weed in its native Asia and throughout most of the rest of the world [78]. In North America it is a common weed of old fields, roadsides, and other disturbed places [56,66,68,83,91,126] such as alluvial fans [145] and disturbed rangelands [122].

Soils: Tumble mustard grows in soils of all textures, and is common on sand [91]. It readily establishes on loose, highly disturbed soils such as rodent mounds [106,115], but can also grow on compacted soils. On a

Mojave Desert restoration site in Antelope Valley, California, native seeded-in species did not establish on a highly disturbed site with compacted soil; however, tumble mustard colonized the site and established dense cover [55].

Elevation: Tumble mustard has been recorded at the following ranges:

State	Elevation
CA	< 8,200 ft (2,500 m) [62]
NM	5,000-7,000 ft (1,500-2,100 m) [83]
NV	1,400-6,500 ft (430-2,000 m) [76]
UT	2,660-7,190 ft (820-2,410 m) [130]

SUCCESSIONAL STATUS:
Tumble mustard requires an open to light canopy [69,124,146], and is most common in early stages of succession [2,22,25,31,96].

Tumble mustard occurrence in early **sagebrush steppe** succession is well documented. In big sagebrush of Wyoming, for example, tumble mustard occurred 2 and 3 years after disking near an abandoned oil drilling site [2]. A classic seral continuum is described by Piemeisel [96] and other authorities [40,113,121] where Russian-thistle pioneers on sagebrush steppe disturbed by fire or other means. Tumble mustard establishes next, followed by tansymustard (*Descurainia* spp.) and cheatgrass. Medusahead, Scotch thistle (*Onopordum acanthium*), and other species may extend or alter the classic continuum [40,41]. A 20-year study in southern Idaho showed old-field succession on former big sagebrush steppe was initially dominated by Russian-thistle, tumble mustard, and tansymustard. An increase in cheatgrass and bottlebrush squirreltail (*Elymus elymoides*) followed; after that, there was a temporary increase in mustards and a decrease in Russian-thistle. The community eventually stabilized as a cheatgrass-bottlebrush squirreltail cover type [64]. A similar pattern occurred in sagebrush steppe of Washington, where tumble mustard codominated recently disturbed sites along with Russian-thistle, prickly-lettuce (*Lactuca serriola*), and bur ragweed (*Ambrosia acanthicarpa*). Cheatgrass dominated slightly older seres such as old fields [15]. Some annual-dominated communities may be stable [64]. On the Atomic Energy Commission's Hanford Reservation, Washington, old fields have supported cheatgrass-tumble mustard-tansymustard communities for 30 or more years [27]. Tumble mustard is not highly invasive in undisturbed sagebrush communities. In lightly grazed and ungrazed sites in a big sagebrush/bluebunch wheatgrass community of eastern Washington, tumble mustard established in severely trampled areas where cattle congregated (watering troughs and fencelines), but did not invade other portions of the otherwise lightly grazed site or the ungrazed site [101].

Other communities:

Tumble mustard's successional role is less well documented in plant communities other than sagebrush. Similar to its pattern of occurrence in early seral sagebrush, a few studies show early tumble mustard invasion in disturbed communities followed by tumble mustard's successional replacement by perennials. In western wheatgrass-buffalo grass-blue grama (*Pascopyrum smithii-Buchloe dactyloides-Bouteloua gracilis*) communities of Nebraska, tumble mustard occurs in wetland succession at the edges of ponds. On upland sites it occurs on deep, poorly bound, wind-deposited soils along with common sunflower (*Helianthus annuus*), prairie sunflower (*H. petiolaris*), and lambsquarters (*Chenopodium album*) [74]. In a shadscale community of south-central Idaho, tumble mustard, halogeton, clasping pepperweed, and cheatgrass invaded after a combination of drought and root-mining mealybugs killed most of the overstory shadscale. Six years after the shadscale dieback, the site was dominated by halogeton and annual weeds. Grasshopper populations were high the 7th year following the dieback, so halogeton, tumble mustard, and other annuals maintained dominance with grasshopper grazing. Shadscale, gooseberryleaf globemallow (*Sphaeralcea grossulariifolia)*, and native perennial grasses gained dominance the next year, when the drought ended and the insect populations declined

[110].

Tumble mustard is nonmycorrhizal [12,46]; therefore, it can colonize sterile sites or sites undergoing primary succession.

SEASONAL DEVELOPMENT:
Tumble mustard germinates in winter or early spring, before most associated herbaceous species have started growth [2]. It develops a rosette after the cotyledon stage, then bolts [2,135]. The flowering period is lengthy. A single plant typically bears numerous racemes that flower sequentially up the pedicel. The flowers mature quickly, with relatively few in bloom at once. The lower leaves usually dry out around flowering time without affecting flower production [122]. Phenological events by region are as follows:

Region	Event	Time
Southwest and northern Mexico	flowers	March-April [76,83,136]
Great Plains	flowers	May-Aug. [56]
Pacific Northwest	flowers	May-Sept. [65]
Southeast	flowers	March-June [99,140]
Northeast	flowers	June-Aug.[51]
Great Lakes	flowers	mid-May–early September
	fruits	late June-late Sept. [91]

FIRE ECOLOGY

SPECIES: Sisymbrium altissimum

- FIRE ECOLOGY OR ADAPTATIONS
- POSTFIRE REGENERATION STRATEGY

FIRE ECOLOGY OR ADAPTATIONS:
Fire adaptations: Tumble mustard establishes from soil-stored seed after fire [41,45,108,137]. Wind, machinery, and animal transport from off-site may provide additional sources of seed [145] or introduce tumble mustard on burns where it was not already present in the soil seed bank. Fire creates conditions favorable for tumble mustard establishment (bare soil, open canopy, reduced growth interference) [97]. As a shade-intolerant, invasive species, tumble mustard can thrive in early postfire environments [26,71,72,139].

Fire regimes: Introduced species can alter the probability of occurrence of fire, the rate of fire spread, and the intensity of fire in an ecosystem [30]. The degree of change and impacts on native ecosystems vary with differences in species composition and structure of invaded plant communities [17,111]. Historic fire regimes in big sagebrush/bunchgrass ecosystems, where tumble mustard is common, are variable. Fire return intervals range between 10 and 70 years [7,18,87,92,125,148]. The introduction and increasing dominance of cheatgrass has changed the seasonal occurrence, frequency, and size of wildfires in these ecosystems, thus altering successional patterns [13,95,131,134,143]. Tumble mustard invaded the western Unites States shortly before cheatgrass [78,88]. There is no evidence suggesting that tumble mustard alone has altered historic fire patterns in sagebrush steppe, but interactive effects of tumble mustard and cheatgrass are largely unstudied. Further research is needed on the impacts of tumble mustard invasion in sagebrush steppe and other ecosystems where weeds have drastically altered fire regimes.

Because tumble mustard is widespread, it is difficult to exclude many ecosystems as potential hosts of tumble mustard plants or populations. The following table provides some fire regime intervals for plant communities

where tumble mustard may be important. For further information, see the FEIS summary on the dominant species listed below. If you are interested in the fire regime of a plant community that is not listed here, please consult the complete FEIS fire regime table.

Community or Ecosystem	Dominant Species	Fire Return Interval Range (years)
maple-beech-birch	*Acer-Fagus-Betula*	> 1,000
silver maple-American elm	*Acer saccharinum-Ulmus americana*	< 35 to 200
sugar maple	*A. saccharum*	> 1,000
sugar maple-basswood	*A. saccharum-Tilia americana*	> 1,000 [127]
California chaparral	*Adenostoma* and/or *Arctostaphylos* spp.	< 35 to < 100 [92]
bluestem prairie	*Andropogon gerardii* var. *gerardii-Schizachyrium scoparium*	< 10 [79,92]
Nebraska sandhills prairie	*A. gerardii* var. *paucipilus-S. scoparium*	< 10
bluestem-Sacahuista prairie	*A. littoralis-Spartina spartinae*	< 10 [92]
silver sagebrush steppe	*Artemisia cana*	5-45 [60,98,138]
sagebrush steppe	*A. tridentata/Pseudoroegneria spicata*	20-70 [92]
basin big sagebrush	*A. tridentata* var. *tridentata*	12-43 [105]
mountain big sagebrush	*A. tridentata* var. *vaseyana*	15-40 [7,18,87]
Wyoming big sagebrush	*A. tridentata* var. *wyomingensis*	10-70 (40**) [125,148]
coastal sagebrush	*A. californica*	< 35 to < 100
saltbush-greasewood	*Atriplex confertifolia-Sarcobatus vermiculatus*	< 35 to < 100
desert grasslands	*Bouteloua eriopoda* and/or *Pleuraphis mutica*	5-100 [92]
plains grasslands	*Bouteloua* spp.	< 35 [92,138]
blue grama-needle-and-thread grass-western wheatgrass	*B. gracilis-Hesperostipa comata-Pascopyrum smithii*	< 35 [92,104,138]
blue grama-buffalo grass	*B. gracilis-Buchloe dactyloides*	< 35 [92,138]
grama-galleta steppe	*Bouteloua gracilis-Pleuraphis jamesii*	< 35 to < 100
blue grama-tobosa prairie	*B. gracilis-P. mutica*	< 35 to < 100 [92]
cheatgrass	*Bromus tectorum*	< 10 [95,134]
California montane chaparral	*Ceanothus* and/or *Arctostaphylos* spp.	50-100 [92]
sugarberry-America elm-green ash	*Celtis laevigata-Ulmus americana-Fraxinus pennsylvanica*	< 35 to 200 [127]
paloverde-cactus shrub	*Cercidium microphyllum/Opuntia* spp.	< 35 to < 100 [92]
curlleaf mountain-mahogany*	*Cercocarpus ledifolius*	13-1,000 [8,107]
mountain-mahogany-Gambel oak scrub	*C. ledifolius-Quercus gambelii*	< 35 to < 100 [92]
Atlantic white-cedar	*Chamaecyparis thyoides*	35 to > 200 [127]
blackbrush	*Coleogyne ramosissima*	< 35 to < 100

Arizona cypress	*Cupressus arizonica*	< 35 to 200 [92]
beech-sugar maple	*Fagus* spp.-*Acer saccharum*	> 1,000 [127]
California steppe	*Festuca-Danthonia* spp.	< 35 [92,116]
black ash	*Fraxinus nigra*	< 35 to 200 [127]
juniper-oak savanna	*Juniperus ashei-Quercus virginiana*	< 35
Ashe juniper	*J. ashei*	< 35
western juniper	*J. occidentalis*	20-70
Rocky Mountain juniper	*J. scopulorum*	< 35
cedar glades	*J. virginiana*	3-7
tamarack	*Larix laricina*	35-200
creosotebush	*Larrea tridentata*	< 35 to < 100
Ceniza shrub	*L. tridentata-Leucophyllum frutescens-Prosopis glandulosa*	< 35 [92]
yellow-poplar	*Liriodendron tulipifera*	< 35 [127]
wheatgrass plains grasslands	*Pascopyrum smithii*	< 5-47+ [92,98,138]
Great Lakes spruce-fir	*Picea-Abies* spp.	35 to > 200
northeastern spruce-fir	*Picea-Abies* spp.	35-200 [34]
southeastern spruce-fir	*Picea-Abies* spp.	35 to > 200 [127]
black spruce	*P. mariana*	35-200 [34]
pine-cypress forest	*Pinus-Cupressus* spp.	< 35 to 200 [Arno 00]
pinyon-juniper	*Pinus-Juniperus* spp.	< 35 [92]
jack pine	*P. banksiana*	<35 to 200 [34]
Mexican pinyon	*P. cembroides*	20-70 [89,118]
shortleaf pine	*P. echinata*	2-15
shortleaf pine-oak	*P. echinata-Quercus* spp.	< 10 [127]
Colorado pinyon	*P. edulis*	10-400+ [44,53,92]
slash pine	*P. elliottii*	3-8
slash pine-hardwood	*P. elliottii*-variable	< 35
sand pine	*P. elliottii* var. *elliottii*	25-45 [127]
longleaf-slash pine	*P. palustris-P. elliottii*	1-4 [90,127]
longleaf pine-scrub oak	*P. palustris-Quercus* spp.	6-10 [127]
Pacific ponderosa pine*	*P. ponderosa* var. *ponderosa*	1-47 [6]
interior ponderosa pine*	*P. ponderosa* var. *scopulorum*	2-30 [6,9,82]
Arizona pine	*P. ponderosa* var. *arizonica*	2-15 [9,29,109]
Table Mountain pine	*P. pungens*	< 35 to 200 [127]
red pine (Great Lakes region)	*P. resinosa*	10-200 (10**) [34,48]
red-white-jack pine*	*P. resinosa-P. strobus-P. banksiana*	10-300 [34,58]
pitch pine	*P. rigida*	6-25 [16,59]

pocosin	*P. serotina*	3-8
pond pine	*P. serotina*	3-8
eastern white pine	*P. strobus*	35-200
eastern white pine-eastern hemlock	*P. strobus-Tsuga canadensis*	35-200
eastern white pine-northern red oak-red maple	*P. strobus-Quercus rubra-Acer rubrum*	35-200
loblolly pine	*P. taeda*	3-8
loblolly-shortleaf pine	*P. taeda-P. echinata*	10 to < 35
Virginia pine	*P. virginiana*	10 to < 35
Virginia pine-oak	*P. virginiana-Quercus* spp.	10 to < 35
sycamore-sweetgum-American elm	*Platanus occidentalis-Liquidambar styraciflua-Ulmus americana*	< 35 to 200 [127]
galleta-threeawn shrubsteppe	*Pleuraphis jamesii-Aristida purpurea*	< 35 to < 100
eastern cottonwood	*Populus deltoides*	< 35 to 200 [92]
aspen-birch	*P. tremuloides-Betula papyrifera*	35-200 [34,127]
mesquite	*Prosopis glandulosa*	< 35 to < 100 [86,92]
mesquite-buffalo grass	*P. glandulosa-Buchloe dactyloides*	< 35
Texas savanna	*P. glandulosa* var. *glandulosa*	< 10 [92]
black cherry-sugar maple	*Prunus serotina-Acer saccharum*	> 1,000 [127]
mountain grasslands	*Pseudoroegneria spicata*	3-40 (10**) [5,6]
California mixed evergreen	*Pseudotsuga menziesii* var. *m.-Lithocarpus densiflorus-Arbutus menziesii*	< 35
California oakwoods	*Quercus* spp.	< 35 [6]
oak-hickory	*Quercus-Carya* spp.	< 35 [127]
oak-juniper woodland (Southwest)	*Quercus-Juniperus* spp.	< 35 to < 200 [92]
northeastern oak-pine	*Quercus-Pinus* spp.	10 to < 35 [127]
oak-gum-cypress	*Quercus-Nyssa*-spp.-*Taxodium distichum*	35 to > 200 [90]
southeastern oak-pine	*Quercus-Pinus* spp.	< 10 [127]
coast live oak	*Q. agrifolia*	2-75 [57]
white oak-black oak-northern red oak	*Q. alba-Q. velutina-Q. rubra*	< 35 [127]
canyon live oak	*Q. chrysolepis*	<35 to 200
blue oak-foothills pine	*Q. douglasii-P. sabiniana*	<35 [6]
northern pin oak	*Q. ellipsoidalis*	< 35 [127]
Oregon white oak	*Q. garryana*	< 35 [6]
bear oak	*Q. ilicifolia*	< 35 >[127]
California black oak	*Q. kelloggii*	5-30 [92]
bur oak	*Q. macrocarpa*	< 10 [127]

oak savanna	*Q. macrocarpa/Andropogon gerardii-Schizachyrium scoparium*	2-14 [92,127]
shinnery	*Q. mohriana*	< 35 [92]
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 [127]
interior live oak	*Q. wislizenii*	< 35 [6]
cabbage palmetto-slash pine	*Sabal palmetto-Pinus elliottii*	< 10 [90,127]
blackland prairie	*Schizachyrium scoparium-Nassella leucotricha*	< 10
Fayette prairie	*Schizachyrium scoparium-Buchloe dactyloides*	< 10
little bluestem-grama prairie	*S. scoparium-Bouteloua* spp.	< 35 [92]
baldcypress	*Taxodium distichum* var. *distichum*	100 to > 300
pondcypress	*T. distichum* var. *nutans*	< 35 [90]
western redcedar-western hemlock	*Thuja plicata-Tsuga heterophylla*	> 200 [6]
eastern hemlock-yellow birch	*Tsuga canadensis-Betula alleghaniensis*	> 200 [127]
western hemlock-Sitka spruce	*T. heterophylla-Picea sitchensis*	> 200 [6]
elm-ash-cottonwood	*Ulmus-Fraxinus-Populus* spp.	< 35 to 200 [34,127]

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

POSTFIRE REGENERATION STRATEGY [114]:
Ground residual colonizer (on-site, initial community)
Initial off-site colonizer (off-site, initial community)
Secondary colonizer (on-site or off-site seed sources)

FIRE EFFECTS

SPECIES: Sisymbrium altissimum

IMMEDIATE FIRE EFFECT ON PLANT:
While in the rosette stage, tumble mustard may be top-killed by fire. If the root crown is not damaged, tumble mustard rosettes can sprout new basal leaves from the root crown. As an annual with a single stem, tumble mustard lacks adaptations for regrowth once it has bolted, and plants burned after the rosette stage are killed [51]. Research on fire's impact to the seed bank is lacking as of this writing (2003), but fire probably has little

effect on tumble mustard seed populations. Tumble mustard has tiny seeds [56,62,88,99,122,126,129,130] that easily fall into fire-safe microsites such as soil crevices [55,144,148]. While fire is likely to kill some seed, its overall effect to the tumble mustard seed bank is probably negligible.

DISCUSSION AND QUALIFICATION OF FIRE EFFECT:
No entry

PLANT RESPONSE TO FIRE:
Tumble mustard establishes from soil-stored seed and seed blown or transported in after fire [41,45,108,137]. It is most frequent on early seral burns [26,72]. For example, in a Idaho fescue-prairie Junegrass (*Festuca idahoensis-Koeleria macrantha)*
community of northeastern Oregon, tumble mustard and mountain tansymustard (*Descurainia richardsonii*) pioneered on severely burned sites, but were absent by the 5th postfire year [72]. In Colorado pinyon-Utah juniper (*Juniperus osteosperma*) stands of west-central Utah, tumble mustard occurred on 6- and 11-year-old burns, but not older burns [10].

Tumble mustard cover (%) on burned and unburned plots after a June 1977 fire on Mt. Sentinel in Missoula, Montana, is shown below. The cover type is rough fescue (*Festuca altaica*)-Idaho fescue-bluebunch wheatgrass mountain grassland [4].

Autumn 1977		Spring 1978		Summer 1979	
unburned	burned	unburned	burned	unburned	burned
<0.05%	0.6	0.3	2.6**	0.4	3.0*

*=differences between burned and unburned significant (p<0.05) at 2 of 4 sites
**=differences between burned and unburned significant (p<0.05) at 3 of 4 sites

Another study of plant cover the after same fire showed similar effects. Although tumble mustard cover (%) was low on burned and unburned plots, tumble mustard increased with fire. Measurements were taken in November 1977, 5 months after the Mt. Sentinel Fire [85]:

unburned	burned
0.05	0.58*

*=differences between burned and unburned significant (p<0.01)

One year after a July wildfire in a ponderosa pine/bluebunch wheatgrass community of British Columbia, tumble mustard established as follows [71]:

Frequency (%)		Basal cover (%)		Aerial cover (%)	
unburned	burned	unburned	burned	unburned	burned
0.0	20.0	0.0	trace	0.0	0.2±4.80

Although fire creates the open canopy and bare mineral soil that favors tumble mustard establishment, tumble mustard is not an obligate "fire follower." Any area with bare ground, open sunlight, and a seed source is vulnerable to tumble mustard invasion [70].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE:
Burning does not always increase tumble mustard cover [112,132,147]. In his classic study of postfire succession of tumble mustard and other exotics in big sagebrush, Piemeisel [96] wrote "the mere statement that a field has been burned is not sufficient information to foretell what the effect will be on the succeeding plant

cover."

Frequency of tumble mustard on 50 ×
50-cm plots burned under prescription on 15 September 1983 on the Shoshone District, Idaho BLM, was 8.8% in autumn 1982 (prefire), 1.3% in 1983 (postfire), 23.8% in 1984, and 86.3% in 1986. Burning was conducted in threetip sagebrush (*Artemisia tripartita*) and successfully reduced persistent litter. Macrobiotic soil crusts began recovery in postfire year 3. Burning conditions were [19]:

temperature	70^{o} F
relative humidity	14%
windspeed	5-8 mph
live sagebrush moisture	92%
soil moisture	4%

The Research Project Summary Nonnative annual grass fuels and fire in California's Mojave Desert provides information on prescribed fire and postfire response of plant community species including tumble mustard.

FIRE MANAGEMENT CONSIDERATIONS:
Fire as a control agent:
There are no published studies on using fire to control tumble mustard, but given tumble mustard's positive response to increased light and nutrients and open ground, fire alone is unlikely to provide control of tumble mustard. If tumble tansymustard is already onsite in the seed bank, or as a few plants, fire is likely to increase the species' importance in the early postfire community.

MANAGEMENT CONSIDERATIONS

SPECIES: Sisymbrium altissimum

IMPORTANCE TO LIVESTOCK AND WILDLIFE:
All classes of livestock consume minor to moderate amounts of tumble mustard, depending upon availability of other, more palatable forage [69]. For example, Rocky Mountain mule deer consume minor amounts of tumble mustard throughout the growing season [81]. Black-tailed jackrabbit in southern Idaho ate minor amounts of tumble mustard in summer [43]. Tumble mustard was a minor item in the spring diet of Townsend's ground squirrels on the Arid Land Ecology Reserve of Washington [72,73].

Palatability/nutritional value:

Tumble mustard is palatable to livestock when young. Palatability of mature plants is low. The seeds are unpalatable to livestock [122]. Palatability of tumble mustard for livestock and wildlife has been rated as follows [33]:

	MT	ND	UT	WY
cattle	poor	poor	poor	fair
domestic sheep	fair	fair	fair	fair

horses	poor	poor	fair	----
pronghorn	----	----	fair	----
elk	poor	----	fair	----
mule deer	poor	----	fair	----
small mammals	----	----	fair	----
small nongame birds	----	----	fair	----
upland game birds	----	----	fair	----
waterfowl	----	----	poor	----

Cover value of tumble mustard for Utah wildlife has been rated as follows [33]:

pronghorn	poor
elk	poor
mule deer	poor
small mammals	fair
small game birds	fair
upland game birds	fair
waterfowl	poor

OTHER USES:
Tumble mustard is a honeybee and butterfly plant [75]. It helps bind fine-textured soils [88].

Native Americans made meal from ground tumble mustard seeds. The greens can be used in salads [88].

IMPACTS AND CONTROL:
Impacts: Next to cheatgrass, tumble mustard is the 2nd most invasive alien plant species in the Great Basin [144,149]. Allen and Knight [2] suggest tumble mustard's success as an invasive weed is due to more effective seed dispersal compared to native herbaceous perennials, morphological plasticity in response to density stress (tumble mustard plants are short with shallow roots when crowded, but still produce numerous seeds), and earlier germination and more rapid seedling growth compared to native herbs.

Range:
Tumble mustard is uncommon on good- to excellent-condition rangeland, and is an indicator of deteriorating rangeland quality [69]. Rangelands dominated by tumble mustard and other annuals show poor productivity compared to ranges dominated by perennial grasses [94]. Tumble mustard increases in response to grazing [93]. In mountain grasslands of central Utah, it was among the most important invaders on overgrazed plots in bluebunch wheatgrass-Sandberg bluegrass (*Poa secunda)* along with cheatgrass, Russian-thistle, cutleaf filaree, and yellow salsify (*Tragopogon dubius*) [22]. Daubemire [31] described tumble mustard as a seral species that benefits from grazing by release from the competition of more palatable species, but declines in frequency when successionally replaced.

Cropland: Tumble mustard is a serious crop weed [122,153]. Hay or grain infested with tumble mustard seeds is unpalatable to cattle and horses [122]. Tumble mustard is an alternate host for several crop diseases including potato leafroll virus [47,120].

Tumble mustard absorbs soil contaminants such as heavy metals and radioactive waste. Due to its tumbling

habit, it may spread the contaminants to other sites [128].

Control:

Tumble mustard does not usually persist in late-seral communities and may not require special control measures. Canopy closure, litter accumulation and/or growth interference from later-successional species tend to exclude tumble mustard over time.

Prevention:

Since tumble mustard is an early seral species, minimizing soil disturbance and seed dispersal and maintaining a healthy plant community is the best way to prevent establishment of tumble mustard [28]. Anderson and Inouye [3] found sagebrush steppe ecosystems of southeastern Idaho were statistically more resistant to invasion by tumble mustard and other exotic annuals when cover of native species was high (R^2=0.16, P=0.008).

Integrated management:

Land management practices that promote later-successional species can exclude tumble mustard from most plant communities [28]. Managers are encouraged to use combinations of control techniques that are appropriate to the site objectives, desired plant community, available resources, and timing of application. For information on integrated weed management without herbicides, see the Bio-Integral Resource Center (BIRC) website.

Physical/mechanical:

Small infestations of tumble mustard can be controlled by hand pulling rosettes in the fall or early spring [28].

Fire: See Fire Management Considerations.

Biological:

In free-choice trials, tumble mustard was the most palatable of 18 early successional annuals and biennials to native and introduced slug species [21].

Chemical:

Herbicides are effective in gaining initial control of a new invasion or a severe infestation, but are rarely a complete or long-term solution to weed management [20]. Herbicides are more effective on large infestations when incorporated into long-term management plans that include replacement of weeds with desirable species, careful land use management, and prevention of new infestations. Control with herbicides is temporary, as it does not change those conditions that allow infestations to occur [151]. See the Weed Control Methods Handbook
for considerations on the use of herbicides in natural areas and detailed information on specific chemicals.

Tumble mustard is susceptible to broadleaf herbicides including 2,4-D, MCPA, bromoxynil, atrazine, and chlorsulfon [1,36,77,117]. Phenoxy herbicides such as 2,4-D and MCPA provide best control (90-99%) [1,77,117].

Cultural: No information

Sisymbrium altissimum: References

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