## SPECIES: Convolvulus arvensis

Choose from the following categories of information.



# INTRODUCTORY

SPECIES: Convolvulus arvensis



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AUTHORSHIP AND CITATION:
Zouhar, Kris. 2004. Convolvulus 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, September 24].

FEIS ABBREVIATION:
CONARV

SYNONYMS:
None

NRCS PLANT CODE [111]:
COAR4

COMMON NAMES:
field bindweed
field morning-glory
morning glory
small bindweed
devil's guts

TAXONOMY:
The currently accepted name for field bindweed is *Convolvulus arvensis* L. It is a member of the morning-glory family (Convolvulaceae) [30,37,50,54,60,64,70,71,81,88,96,110,145,146,149,153].

LIFE FORM:
Vine-forb

FEDERAL LEGAL STATUS:
No special status

OTHER STATUS:
As of this writing (2004), field bindweed is classified as a noxious or prohibited weed or weed seed in 35 states in the U.S. and 5 Canadian provinces [139]. See the Invaders, Plants, or APHIS databases for more information. The Eastern Region of the U.S. Forest Service ranks field bindweed as a Category 3 plant: often restricted to disturbed ground and not especially invasive in undisturbed natural habitats [136].

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# DISTRIBUTION AND OCCURRENCE

SPECIES: Convolvulus arvensis

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GENERAL DISTRIBUTION:
Field bindweed is native to Europe and Asia. Field bindweed is successful in many types of climates, including temperate, tropical, and mediterranean, but is most troublesome for agriculture throughout the temperate zone, from 60°N to 45°S latitude. Fifty-four countries report field bindweed as a weed in 32 different crops [66].

Field bindweed most likely arrived in the U.S. as contaminant in farm and garden seeds. Some plants were introduced intentionally and planted ornamentally as ground cover or in hanging baskets. It was first noted in Virginia in 1739 and was found all along the eastern seaboard, from Virginia to Maine, by the early 1800s. Western migration of field bindweed may have been hastened by the building of railroads; however, field bindweed seeds continued to arrive whenever immigrants settled new areas or whenever crop seed was imported. A "bindweed plague" in the Great Plains in 1877 was attributed to Ukrainian settlers who inadvertently brought the weed seed in wheat (*Triticum* spp.) seed during the early 1870s. Field bindweed reputedly established in the Pacific Northwest when an Oregon settler used it as a cover crop in his orchard. Field bindweed was evidently present in California as early as 1838. By the end of the 1st quarter of the 20th century, field bindweed was considered the "worst weed" in several states and a "serious pest" in several others, especially west of the Mississippi ([95] and references therein).

The current North American distribution of field bindweed extends from the agricultural regions of all provinces in Canada (except Newfoundland and Prince Edward Island) southward throughout the United States and into northern Mexico. It is common to abundant in the U.S., except in the extreme Southeast and parts of southern Texas, New Mexico, and Arizona ([144] and references therein). Field bindweed is adventitious in Hawaii [121]. Plants database provides a state distribution map of field bindweed. Field bindweed is especially common in cultivated fields and gardens [30,37,50,54,58,60,64,72,81,88,106,110,141,146,149], along roadsides [30,37,50,54,72,81,110,127,141,146,149], railroads [141,146], "disturbed sites" [37,96,151,153], and "waste places" [50,106,127,141,146]. It is reported from ballast heaps in Nova Scotia [110].

A survey of weed specialists and herbaria in the continental U.S., conducted in 1994 and 1995, found that field bindweed occurs at "serious" densities (> 1,000 acres/county) in 957 counties, "moderate" densities (250-1000 acres/county) in 845 counties; and "low" densities (< 250 acres/county) in 573 counties, in 47 of the 48 contiguous states. Only Florida and the southern parts of states from South Carolina to Texas did not report its presence. The authors also report that field bindweed infestations have increased in several western states since 1970, but have decreased in importance in most Great Plains states [18].

The following lists suggest ecosystems and vegetation types in which field bindweed may be invasive, especially following disturbance. It is unclear from the literature which vegetation types may be susceptible to invasion by field bindweed in the absence of disturbance. These lists were derived from known or perceived ecological tolerances of field bindweed, are largely speculative, and may not be exhaustive.

ECOSYSTEMS [48]:
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
FRES25 Larch
FRES26 Lodgepole pine
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**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| AL | 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 |

**CANADA**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AB | BC | MB | NB | NS | ON | PE | PQ | SK |

**MEXICO**

| |
|---|
| B.C.N. |

BLM PHYSIOGRAPHIC REGIONS [15]:
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:
K015 Western spruce-fir forest
K016 Eastern ponderosa forest
K017 Black Hills pine forest
K018 Pine-Douglas-fir forest
K019 Arizona pine forest
K022 Great Basin pine forest

K023 Juniper-pinyon woodland
K024 Juniper steppe woodland
K026 Oregon oakwoods
K027 Mesquite bosques
K028 Mosaic of K002 and K026
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
K045 Ceniza shrub
K047 Fescue-oatgrass
K048 California steppe
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
K060 Mesquite 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
K074 Bluestem prairie
K075 Nebraska Sandhills 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
K098 Northern floodplain forest

SAF COVER TYPES [43]:
16 Aspen
19 Gray birch-red maple
40 Post oak-blackjack oak
42 Bur oak
50 Black locust
68 Mesquite

109 Hawthorn
110 Black oak
209 Bristlecone pine
216 Blue spruce
217 Aspen
218 Lodgepole pine
219 Limber pine
220 Rocky Mountain juniper
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
246 California black oak
247 Jeffrey pine
249 Canyon live oak
250 Blue oak-foothills pine
255 California coast live oak

SRM (RANGELAND) COVER TYPES [118]:
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
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
214 Coastal prairie
215 Valley grassland
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

309 Idaho fescue-western wheatgrass
310 Needle-and-thread-blue grama
311 Rough fescue-bluebunch wheatgrass
312 Rough fescue-Idaho fescue
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
411 Aspen woodland
412 Juniper-pinyon woodland
413 Gambel oak
415 Curlleaf mountain-mahogany
416 True mountain-mahogany
417 Littleleaf mountain-mahogany
418 Bigtooth maple
419 Bittercherry
420 Snowbrush
421 Chokecherry-serviceberry-rose
422 Riparian
502 Grama-galleta
503 Arizona chaparral
504 Juniper-pinyon pine woodland
509 Transition between oak-juniper woodland and mahogany-oak association
601 Bluestem prairie
602 Bluestem-prairie sandreed
603 Prairie sandreed-needlegrass
604 Bluestem-grama prairie
605 Sandsage prairie
606 Wheatgrass-bluestem-needlegrass
607 Wheatgrass-needlegrass
608 Wheatgrass-grama-needlegrass
609 Wheatgrass-grama
610 Wheatgrass
611 Blue grama-buffalo grass
612 Sagebrush-grass
613 Fescue grassland

614 Crested wheatgrass
615 Wheatgrass-saltgrass-grama
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
712 Galleta-alkali sacaton
713 Grama-muhly-threeawn
714 Grama-bluestem
715 Grama-buffalo grass
716 Grama-feathergrass
717 Little bluestem-Indiangrass-Texas wintergrass
718 Mesquite-grama
720 Sand bluestem-little bluestem (dunes)
721 Sand bluestem-little bluestem (plains)
722 Sand sagebrush-mixed prairie
724 Sideoats grama-New Mexico feathergrass-winterfat
725 Vine mesquite-alkali sacaton
727 Mesquite-buffalo grass
729 Mesquite
730 Sand shinnery oak
731 Cross timbers-Oklahoma
732 Cross timbers-Texas (little bluestem-post oak)
733 Juniper-oak
735 Sideoats grama-sumac-juniper
801 Savanna
802 Missouri prairie
803 Missouri glades
804 Tall fescue
805 Riparian

HABITAT TYPES AND PLANT COMMUNITIES:
Field bindweed is invasive primarily in agricultural areas, although some authors indicate that it is also invasive in natural areas (e.g. [28,86,109]). Natural area managers are most likely to find it in moist locations (e.g. riparian corridors and irrigated areas) on tracts once used for agriculture [86]. Field bindweed is normally found in open communities in association with annual, biennial, and short-lived perennial weeds [144]. Habitats that are most like agricultural lands (little competition, repeated disturbance, and high light intensity) are ideal for growth of field bindweed (Cox (1915) as cited by [86]).

**California**: Field bindweed establishes locally in vernal pools in Sacramento County, and in large pools in Tehama County. These habitats support populations of endangered hairy Orcutt grass (*Orcuttia pilosa*) and Hoover's spurge (*Chamaesyce hooveri*), and also support thriving field bindweed and cocklebur (*Xanthium strumarium* var. *canadense*) populations. Field bindweed occurs in open annual grassland and oak savannah sites. Dominant natives include blue oak (*Quercus douglasii*) and chamise (*Adenostoma fasciculatum*). Grassland natives include purple needlegrass (*Nassella pulchra*), Sandberg bluegrass (*Poa secunda*), California melic grass (*Melica californica*), small fescue (*Vulpia microstachys*), and many native forbs [68]. At

Sugarloaf Ridge State Park, field bindweed is occasional in disturbed places such as campgrounds and horse corrals [19].

In **Nevada**, field bindweed occurs on disturbed, moist soil of cultivated fields, near springs, roadsides, and homesteads with pinyon (*Pinus* spp.), juniper (*Juniperus* spp.), and saltbush (*Atriplex* spp.) [71].

At the Thousand Springs Preserve, **Idaho**, field bindweed thrives under cultivated and irrigated conditions, and managers there suggest that field bindweed outcompetes native grasses [86,109]. At Garden Creek Preserve in northern Idaho, managers report that field bindweed threatens bunchgrass and forb-dominated habitats [86].

**Wyoming**: Olson and Gerhart [100] describe a field bindweed vegetation type in a Wyoming riparian area with an overstory dominated by quaking aspen (*Populus tremuloides*), and blue spruce (*Picea pungens*), and shrub layer dominated by russet buffaloberry (*Shepherdia canadensis*) and willow (*Salix* spp.), with rose (*Rosa* spp.), shrubby cinquefoil (*Dasiphora floribunda*), and bog birch (*Betula glandulosa*) also present. They describe 2 other habitat types with herbaceous plant communities dominated by field bindweed, bluegrass (*Poa* spp.), western wheatgrass (*Pascopyrum smithii*), and an unknown annual forb, with coniferous overstories dominated by blue spruce, lodgepole pine (*Pinus contorta*), and white fir (*Abies concolor*).

In **Colorado**, field bindweed has been identified in "seemingly remote, undisturbed aspen stands" in Rocky Mountain National Park [28]. At the Phantom Canyon Preserve, field bindweed is most problematic in riparian corridors and mountain-mahogany (*Cercocarpus* spp.) shrubland/grassland [86].

**Midwest**: Field bindweed occurs with purple loosestrife (*Lythrum salicaria*) in wetland sites in the Midwest [132]. It occurs in Theodore Roosevelt National Park in North Dakota [26], and occurs in the understory in eastern cottonwood (*Populus deltoides*) stands along the Missouri River in southeastern South Dakota [150]. Field bindweed had relatively high (compared with other regulated noxious weeds) frequency and canopy cover on study areas in the glaciated prairie pothole region of the Northern Great Plains [61].

**Canada**: Field bindweed is a dominant species in some disturbed riverbank areas in the Montréal area of Québec. Codominant species include common wormwood (*Artemisia vulgaris*), common dandelion (*Taraxacum officinale*), and bird vetch (*Vicia cracca*) [97].

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# BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Convolvulus arvensis

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GENERAL BOTANICAL CHARACTERISTICS:
The following description of field bindweed is based on descriptions found in several florae [30,64,65,71,81,88,127]. It provides characteristics that may be relevant to fire ecology, and is not meant for identification. Keys for identification are available (e.g. [60,64,65,88,146,149]). Proper identification is important if control strategies are planned, as field bindweed may closely resemble some native morning-glories.

Field bindweed is a perennial vine arising from deep, persistent, spreading roots. It has slender, trailing to somewhat twining, branched stems, 8 to 79 inches (20-200 cm) long, sometimes forming tangled mats. Herbage is glabrous to pubescent and leaves are variable, 0.4 to 4 inches (1-10 cm) long and 0.1 to 2.4 inches (0.3-6 cm) wide, with petioles 5-40 mm long. Peduncles arise from leaf axils, range from 0.2 to 2.4 inches (0.5-6 cm) long, and bear 1 to several flowers. Corollas are broadly funnelform, 0.6 to 1.2 inches (1.5-3 cm) long and 0.9 to 1.4 inches (2.2-3.5 cm) broad. Fruit is a capsule, 5-10 mm long, bearing 1 to 4 seeds, each about 3-4 mm long. Kennedy and Crafts [74] provide a detailed description of the anatomy of field bindweed.

Several authors describe variations in botanical characteristics of field bindweed. A review by Weaver and Riley [144] indicates the leaves of field bindweed vary greatly in size and shape with environmental factors such as light intensity, soil moisture, and damage due to frequent cultivation or defoliation. Degennaro and Weller [35] identified and characterized 5 biotypes among field bindweed clones collected from a field in Indiana. Consistent variations in leaf morphology, floral characteristics, flowering capacity, phenology, vegetative reproduction potential, and accumulation of shoot and root biomass were found between biotypes when grown in a controlled environment. Pollination studies showed that presumed biotypes were self-incompatible. The variability in growth and reproduction observed in field bindweed biotypes may explain the survival and adaptability of a field bindweed population as environmental conditions and control practices change.

Several researchers have described the anatomy and development of field bindweed roots (e.g. [34,47,74,75]). The root system is characterized by a taproot with large numbers of annual lateral roots that develop adventitiously throughout its length, and penetrate the soil in all directions (see Seedling establishment/growth for more detail). Some laterals are ephemeral and some are persistent. It is by these lateral roots that plants spread horizontally. Shoot buds arise on these horizontal laterals and develop into rhizomes which, reaching the surface, establish new crowns [47,74]. The ability to produce buds, together with the root food reserves, favors vegetative reproduction and makes field bindweed plants persistent [74] (see Asexual regeneration for more detail).

Field bindweed taproots may be 2 to 10 feet (0.5-3 m) or more long. Other vertical roots may penetrate to depths of 17 to 30 feet (5-9 m) [10,66,75], depending on climate and soil type. Lateral roots are found primarily in the top 12 inches (30 cm) of soil, and most commonly in the upper 4 to 6 inches [47,75,128]. In field bindweed plants grown from root cuttings in a sandy loam soil in Oxford, England 70% of lateral root spread was in the top 3 to 6 inches (7.5-15 cm) of soil, and none was below 12 inches (30 cm) [34]. Similarly, Swan [128] notes that the lateral roots are generally found within the top 12 inches (30 cm) of soil, but approximately 1 third of the total root system is in the vertical roots below the 24 inch (60 cm) zone. Estimates of the amount of root by weight in the upper 24 inches (60 cm) of soil range from 50% to 70% [133,144]. The concentration of food reserves increases with root depth, and maximum percentages of reserves were found in roots 6 to 8 feet (2-2.4 m) deep [10].

Field bindweed from an old-field site in Ontario was among the few plant species observed in the laboratory that were not infected with native arbuscular mycorrhizal fungi [76]. Field bindweed plants growing on disturbed sites in Utah were infected with vesicular-arbuscular mycorrhizae [102].

Root exudations may decrease the germination of some crop seed (Grummer 1957, as cited by [128]).

RAUNKIAER [107] LIFE FORM:
Hemicryptophyte
Geophyte

REGENERATION PROCESSES:
Field bindweed reproduces both sexually and vegetatively.

**Breeding system:** Field bindweed is self-incompatible [98] and thus an obligate out-crosser, which may play an important role in maintaining the high degree of phenotypic variation observed in this species.

**Pollination:** Field bindweed flowers persist only 1 day and are insect pollinated [144]. Observations in Kansas determined that field bindweed flowers were fully open by 8 am during late June and early July. Nectar, produced at the base of the tube of fused petals, attracted various pollinators including Halictid bees, honeybees, bumblebees, butterflies, and moths. Halictid foraging was highest from 8:30 to 11:30 am. The flowers wilted by early afternoon [142].

### Seed production:

Seed production by field bindweed is variable and dependent upon environmental conditions. There is little information on the amount and relative reproductive importance of seeds produced by field bindweed. Literature reviews and observations over 3 years in Iowa [22] indicate that seed set in field bindweed is favored in seasons of high temperature and low rainfall, especially on calcareous soils. Periods of cloudy weather and fine-textured, poorly drained soils restrict blossoming and seed production. Individual flowers may fail to set seed or to mature seed that has been set, and capsules that appear normal frequently contain no viable seed. Under favorable conditions the number of seeds per capsule varies from 1 to 4 with an average of 2; however, 10 seeds per capsule have been reported from Russian material. Seed is often not produced by plants in frequently cultivated soils. In one count, 157 capsules collected from plants in cultivated fields yielded 41 seeds. Few estimates of seed production per plant are available, as the spatial limit of an individual plant is often difficult to determine due to the extensive root system. Estimates of 12 to 300 seeds per plant are reported, and estimates of number of seeds produced per unit area in a pure field bindweed stand range from 50,000 to 20 million seeds per hectare, though it is unclear under what conditions these estimates were made [22,144].

According to a review by Weaver and Riley [144], field bindweed seldom sets seed during the 1st year of growth, although plants grown in the greenhouse will flower within 6 weeks of emergence based on unpublished data of the author. According to Brown and Porter [22], germinability of field bindweed seeds began 10 to 15 days after pollination, when moisture content was 81%. Sripleng and Smith [120] provide a detailed description of the anatomy and development of field bindweed seed, and their observations suggest that field bindweed seeds mature about 25 days after fertilization.

**Seed dispersal:** Field bindweed seeds generally fall near the parent plant but can be dispersed by water [22], as contaminants in crop seed [66], by animals after ingestion [57,104,111], by animals' feet, and by vehicles or machinery. Long-distance dispersal by birds is possible because seeds of field bindweed can remain viable in the digestive tracts of some birds for up to 144 hours [104].

Harmon and Keim [57] tested the viability of weed seeds recovered in the feces of several domestic animals. Field bindweed had the highest percentage recovery and germination of all weed seeds tested, resulting in an average of 11.7% viable seeds recovered from all animals. Percent germination of field bindweed seeds before feeding and without acid scarification, after a 2-week germination period, was 9.3%; and with acid scarification, after a 4-week germination period was 84%. Some data are as follows:

| Animal | % of 1000 field bindweed seeds recovered | % germination (2 weeks, no acid treatment) | % germination (4 weeks, with acid treatment) |
|---|---|---|---|
| calves | 38.7 | 4.5 | 57.5 |
| horses | 10.4 | 11.0 | 60.0 |
| domestic sheep | 15.4 | 8.0 | 59.0 |
| domestic pigs | 51.2 | 18.0 | 41.0 |
| chickens | 0 | -- | -- |
| average | 23.1 | 10.4 | 54.4 |

### Seed banking:

Field bindweed produces impermeable seed, giving it a physical exogenous dormancy which may or may not be combined with other dormancy mechanisms [22,111]. A review by Rolston [111] indicates that seed longevity is often, but not always, associated with impermeable seed, so that impermeable seeds are distributed in time as well as space. Rolston describes in detail the anatomy of the seed coat of field bindweed seed and other seeds with impermeable seed coats. Seed impermeability varies with time and place of collection [22] as a result of differences in relative humidity, temperature, light, soil fertility, and genetic factors [111].

Many impermeable seeds survive ingestion, allowing dispersal by animals and birds (see Seed dispersal above). Under natural conditions increments of a seed population become permeable to water and germinate in successive intervals [111]. Permeability in field bindweed seeds is increased by various laboratory treatments, including storage at both high 104 °F (40 °C) and low 33 °F (0.5 °C) temperatures, soaking in concentrated $H_2SO_4$ for 45 to 60 minutes, immersion in hot water at temperatures ranging from 126 to 212 °F (52-100 °C), soaking in ethyl alcohol, and mechanical scarification [22,111]. Rolston [111] speculates that in the field, field bindweed's seed coat may be broken down or punctured by mechanical abrasion, especially during cultivation, by passage through the digestive tract of mammals and birds, by high temperatures or temperature fluctuations, by fire, and possibly by microbial degradation. However, results presented by Leishman and others [85] suggest that fungi do not play a major role in field bindweed seed degradation. Other data indicate that as much as 48% of impermeable field bindweed seeds may become permeable in 1 winter if the seeds are not more than 3 inches (8 cm) deep in the soil. Impermeable seeds of field bindweed retained a considerable degree of viability and impermeability for 4 years after burial at 6 and 18 inches (15-46 cm) [22].

It is generally accepted that field bindweed seeds remain viable in the soil seed bank for many years, with estimates ranging from 20 to 50 years [14,78,86,144]. Timmons [133] wrote in 1949 "the ability of seed of field bindweed, to remain dormant in cultivated soil for a considerable time and eventually germinate is quite generally known." Brown and Porter [22] found that as much as 62% of 50-year-old field bindweed seeds stored and tested in the laboratory were viable, with 8% germinable, 54% impermeable, and 38% dead. Timmons [133] observed field bindweed seedlings emerging in a field from which field bindweed plants had been eradicated 20 years earlier, and suggested that the seed had survived in the seed bank for those 20 years. However, it is not clear whether there may have been seed or root fragments imported from off-site. Timmons also observed seedling emergence and adult plant establishment under different cropping systems, and he concluded that completely ridding infested land of field bindweed may require 30 years or more of persistent attention to a rigid program of field management until all dormant seeds have been germinated and destroyed [133]. Research is needed to better understand field bindweed seed longevity under various field conditions, especially in natural areas.

Field bindweed was among many plants that emerged from soil samples taken from a blue grama-needle-and-thread grass-western wheatgrass (*Bouteloua gracilis-Hesperostipa comata-Pascopyrum smithii*) mixed grass community in eastern Montana and incubated to determine seed bank composition. It was not reported whether adult field bindweed plants were present on the site [63].

## Germination:

Differences in percent germination, impermeability, and viability have been noted for seed lots of field bindweed collected in different years and from different sites. The mean percentage of germinable seeds produced by field bindweed plants varies from 5% to 25%, of impermeable seeds from 60% to 80%, and of viable seeds from 87% to 99% [22,144]. Germination of impermeable seeds can be promoted by chemical or mechanical scarification. Seeds of field bindweed that have been scarified will germinate over a wide range of temperatures (41 to 104 °F (5-40 °C)) with maximum and most rapid germination at alternating temperatures of 95/68 °F (35/20 °C) [22]. Exposure to light does not much improve germination of freshly harvested seeds (Weaver, unpublished data cited in [144]). According to Brown and Porter [22], exposure to both high (104 °F (40 °C)) and low (33 °F (0.5 °C)) temperatures promotes germination in field bindweed. Similarly, Jordan and Jordan [69] ran tests in which field bindweed seeds were prechilled in the dark at 41°F (5 °C) for 21 to 42 days and then moistened and germinated at 84 °F (29 °C) at 96% relative humidity, in darkness. Percentage seed germination increased as the prechilling time increased. The increase in germination was accompanied by morphological changes in the seed coat, as observed with scanning electron microscopy [69]. Conversely, viability of field bindweed seed was not reduced, nor was permeability increased, after 50 days in loosely stacked, composting chicken manure where temperatures reached approximately 149 to 158 °F (65-70 °C). Viability and permeability were also unchanged after 4 months in moistened, compacted chicken manure, where temperatures reached about 113 °F (45 °C) [125].

Over 5 years of dry storage in the laboratory at room temperature, the percentage of germinable seeds did not vary greatly, although the average percentage of dead seeds increased from 8% to 47% as the percentage of impermeable seeds decreased from 87% to 38% during the 5 years. The percentage of total live seed decreased from 87% to 49%. Germination rate averaged 31.8% in field bindweed seeds that had overwintered in the soil at 3 inches (8 cm) depth, an increase of 17.8% over average germination rate (14%) in a laboratory test. Seeds buried 4 to 6 inches (10-15 cm) deep had germination rates that ranged from 0.4% to 6.8%. Oxygen concentrations below 10.5% and above 53% are unfavorable, and concentrations between 21% and 53% are favorable for field bindweed seed germination. Impermeable seeds of field bindweed were not affected by changes in the amount of oxygen [22]. Germination of field bindweed seeds was low (mostly between 0.2% and 9%) before, during, and after both dry storage and storage in water (up to 22 months) [23]. In a 2nd, similar study, the percentage germination of field bindweed seed appeared to increase with the length of time in water storage [24].

Field bindweed germinated and established better on bare ground than on sites with litter on rangeland in western Nevada [42].

### Seedling establishment/growth:

The ability of field bindweed to establish from seed may be underestimated. Seeds are usually responsible for the introduction of field bindweed to a new area, and lateral roots and rhizomes play the primary role in spreading an infestation locally [144].

By 6 weeks after emergence a field bindweed taproot may reach a depth of 18 to 24 inches (45-62 cm) and have 3 to 6 lateral roots, usually within 12 inches (30 cm) of the soil surface (Riley, unpublished data as cited by [144]). Seeds of field bindweed, scarified and planted in Iowa at 2-week intervals from 25 April to 26 September, germinated and produced seedlings at each planting. Emergence was greatest in the spring (60-75%) and late summer (43-57%) and least in midsummer (1-10%). Roots of field bindweed seedlings emerging in the spring and early summer penetrated to depths of 51 to 67 inches (1.3-1.7 m) by November, whereas seedlings produced in August and September had a maximum root penetration of 10 to 20 inches (25-50 cm) [22].

In Saskatchewan, Best [16] found that 25 shoots had emerged from a 2 inch (5 cm) root fragment 4 months after planting. The nearest shoot was 18 inches (46 cm) from the parent plant and the furthest 52 inches (132 cm). After 15 months a shoot was observed 114 inches (290 cm) from the parent plant.

Frazier [47] describes, in detail, the growth of a field bindweed plant growing in a deep silt loam soil in Kansas, under known climatic conditions, with little or no competition (none from other plant species). The taproot rapidly penetrated directly down from the germinating seed. Many branch roots arose throughout the length of the taproot, a few of which grew extensively and became permanent lateral roots. Permanent lateral roots tended to radiate away from the point of origin, thus together occupying an area somewhat circular in shape. All shoot development was derived from root-borne stem buds that developed on any part of the permanent root system. Regardless of where these root-borne buds formed, if they developed underground they gave rise to rhizomes. If the buds were borne at or above the soil surface they gave rise to leafy shoots. By 120 weeks after emergence, practically all the vertical roots observed penetrated the 34- to 39-inch (86-99 cm) layer. No soil layer was found in this study that impeded vertical penetration of the roots [47]. Other descriptions of field bindweed growth and development are available from England [34] and Nebraska [75].

### Asexual regeneration:

Field bindweed reproduces vegetatively by means of endogenous root buds that develop into rhizomes and establish new shoots upon reaching the soil surface. Root buds at or above the soil surface develop into shoots [47,74]. Roots develop on rhizomes, allowing daughter plants to survive if severed from the parent plant [74]. New field bindweed plants may also develop from root fragments [16,17,75,117]

In cultivated fields and in old, well-established areas of bindweed, field bindweed's creeping roots are often inconspicuous. Because of their slenderness and their proximity to the surface, they are easily destroyed by cultivating tools and by heavy freezing. New growth after cultivation is made from the vertical root immediately below the point of injury [75]. Whenever the taproot has become broken or cut, as in deep cultivation or plowing, the rhizomes connect it to the growing shoots. Field bindweed rhizomes vary in length from a few inches to several feet. Roots severed at various depths below the soil surface often develop rhizomes several feet in length. In many instances, old roots that have been cut off successively for several years may produce a thousand or more slender rhizomes from the severed end and give rise to a peculiar and striking bunchy form of leafy growth above ground. In localities where there is a high water table, the taproot may branch at a depth of 2 feet (0.6 m) or less, while in other localities, it may penetrate to a depth of 10 feet (3 m) or more before branching profusely [74]. Seedlings grown in the greenhouse were regenerated from the root when the aboveground portion was removed 19 days after emergence (Weaver, unpublished data as cited by [144]).

Sherwood [117] conducted experiments to determine if new field bindweed infestations could be initiated by root fragments. The larger the diameter and/or length of the root section, the more likely it is to grow. Fragments less than 3 inches in length were weak or failed to grow, and fragments obtained from below the plow depth were more likely to grow than those taken from shallower depths. Fragments from starved roots with low root reserves (i.e. roots from plants whose top growth was prevented for a growing season) had poor growth. Root fragments from previously disturbed plants are less likely to grow than are those from undisturbed plants [117]. Results presented by Swan and Chancellor [130] suggest that regeneration of field bindweed from root fragments varies by season, and is highest in spring and lowest in late summer. Interpretation of results presented by Swan and Chancellor suggest that regeneration is primarily from fragments of vertical roots and rhizomes (more so than horizontal root fragments) [78].

SITE CHARACTERISTICS:

Field bindweed is primarily an agricultural weed, and occurs in cultivated fields and other disturbed sites such as pastures, gardens, lawns, and along roadsides and railways. Natural area managers are most likely to find it in moist locations (e.g. riparian corridors and irrigated areas) on tracts once used for agriculture [86].

Field bindweed was among several nonnative plant species identified in a tallgrass prairie study in Kansas, where nonnative species were most common at the town site and along human and livestock travel corridors. A gradient was observed with a high abundance of nonnative species in town to low abundance in prairie sites, with the distribution of native plants forming a reverse gradient. Sources of nonnative plant introduction were related to early cattle trails through the community, railroad and stockyard locations, gardens, cultivated fields, livestock and wildlife activity. Nonnative plants occurred on truck trails into the upland prairie but had not yet invaded the surrounding grassland [40]. On study sites on open annual grassland and blue oak savannah in California, field bindweed was found on both serpentine and nonserpentine soil types. It was most frequent near roads on nonserpentine soils and its frequency of occurrence decreased with increasing distance from the road. This pattern was not observed on serpentine soils [68].

Field bindweed is found in dry or moderately moist soils and can survive long periods of drought due to its extensive root system. It grows best on rich, fertile soils but persists on poor, gravelly soils as well [66]. In Quebec, field bindweed is found primarily on sandy soils in warm, dry areas (Rousseau 1968 as cited by [144]). In northern California and the Great Plains, field bindweed persists into autumn under severely dry conditions when most other plants are unable to sustain growth. Strong sunlight and moderate-to-low moisture appear to be optimal conditions for field bindweed growth and reproduction [22,78].

Field bindweed appears to be somewhat cold tolerant. Plants extracted from frozen ground in Michigan had roots that appeared to be severely injured or dead in the uppermost layers of soil. However, a laboratory test indicated that about 30% of field bindweed roots survived 21 °F (-6 °C) for 8 hours, but were unable to survive 18 °F (-8 °C) for any time period tested [36].

Elevation range: Field bindweed has reportedly been found in the Himalayas at altitudes of 10,000 feet (3,000 m) ([95] and references therein). Field bindweed is found in several plant communities in riparian corridors in Wyoming, at 7,000 to 7,500 feet (2,100-2,300 m). Elevation ranges are given by area as follows:

| Area | Elevation range | Reference |
|---|---|---|
| CA | generally < 5,000 feet (1,500 m) | [60,99] |
| CO | 4,000 to 8,000 feet (1,200-2,400 m) | [58] |
| NV | 2,200 to 6,500 feet (700-2,000 m) | [71] |
| NM | 4,000 to 8,000 feet (1,200-2,400 m) | [88] |
| UT | 3,100 to 9,200 feet (930-2,800 m) | [146] |
| Intermountain | usually below 6,600 feet (2,000 m) | [30] |

SUCCESSIONAL STATUS:
Field bindweed tends to be an early successional species, as it establishes well on bare ground under open conditions. Disturbed sites are common habitat for field bindweed throughout its range (e.g. [37,50,96,106,127,141,146,151,153]). On a site in western Nevada, field bindweed germinated and established better on microsites with bare ground than on microsites with litter, and occupied early successional stages (mostly grazing disturbance) in some rangeland plant communities [42].

It is unclear how long field bindweed plants may persist in native plant communities. Field bindweed plants were still present in an abandoned farm field 30 years after it was last farmed in tallgrass mixed hardwood forest in Minnesota [59].

A review by Holm and others [66] suggests that competition for sunlight places field bindweed at a disadvantage, and that, if adequate soil moisture is present, several crop plants will force it into abnormal growth and dormancy by shading. When crop plants are removed, field bindweed resumes active growth [66]. Similarly, on a site in western Nevada, scattered plants of field bindweed were observed growing intermixed with, but suppressed by a medusahead (*Taeniatherum caput-medusae*) population. When medusahead was reduced by a variety of methods (herbicide, disk-harrow, furrow), medusahead reduction was followed by heavy infestations of field bindweed [155].

Bakke (1939, as cited by [9]) reports that shaded field bindweed plants lose their prostrate habit and become twining plants. In general, the lower the light intensity reaching field bindweed plants, the more rapid the elimination of above- and belowground parts and the more reduction of available root carbohydrates [9]. Dall'Armellina and Zimdahl [32] found that flower production, leaf area, and dry matter of shoots, roots, and rhizomes of field bindweed grown from seed declined as light level decreased. The only response to reduced light levels of plants grown from rhizome segments was complete inhibition of rhizome production [32]. A study by Mashhadi and others [89] characterized the photosynthetic rate of field bindweed under varied light levels, measured as photosynthetic photon flux (PPF). Field bindweed showed a linear response to PPF levels. Photosynthesis and transpiration both decreased at the same rate in response to decreasing PPF. There was a small amount of transpiration in darkness. The authors also noted that field bindweed growing under a dense juniper canopy had mostly abscised or chlorotic lower leaves and long internodes on stems far from sunlight. They speculated that field bindweed plants were able to establish in this low light environment either because the leaves had adapted to low light and/or root reserves were used to support the initial growth stages.

The competitive ability of field bindweed is due largely to its extensive root system. One plant is able to reduce the available soil moisture in the top 24 inches (60 cm) of soil below the "wilting point" (Wiese, unpublished data in [144]). Bakke [8] characterized the competitive interaction between corn and field bindweed in Iowa, noting that field bindweed is a superior competitor for water under conditions of low soil moisture, and that corn plants growing with field bindweed were smaller and had lower yields. How the competitive ability of field bindweed might affect successional trajectories native plant communities is unknown.

SEASONAL DEVELOPMENT:
Seeds of field bindweed germinate throughout the growing season when adequate moisture is available, and a germination peak usually occurs in late spring or early summer. In southern Ontario, seedlings usually emerge in early May and quickly develop a taproot followed by lateral roots and numerous thin feeding roots. Rapid growth of rhizomes and shoots begins when day temperatures are near 57 °F (14 °C) and night temperatures at least 36 °F (2 °C) (Whitesides, 1979 as cited by [144]).

Flowering dates are given by area as follows:

| Area | Dates | References |
|---|---|---|
| AZ | May-July | [72] |
| CA | May-October | [99] |
| FL | spring-summer | [153] |
| IL | May-September | [96] |
| NV | May-September | [71] |
| NM | May-July | [88] |
| ND | June 17-July 6 | [123] |
| TX | May-July, less freely later | [37] |
| WV | June-August | [127] |
| Blue Ridge (NC, SC, TN, VA) | May-October | [151] |
| Carolinas | June-frost | [106] |
| Great Plains | June-August | [54] |
| Intermountain | June-August | [30] |
| Northeast | May-September | [50] |
| Pacific Northwest | mid-spring-late fall | [65] |
| Baja CA | April-August | [149] |

In southern Ontario, plants begin flowering in late June and continue as long as conditions permit [144]. Flowers last for only one day, opening in the morning and wilting by early afternoon [142].

Field bindweed roots and rhizomes develop winter hardiness during autumn. The shoots are killed back to the roots by freezing temperatures, but hardened roots will withstand temperatures as low as 21 °F (-6 °C) [36]. Field bindweed overwinters by means of its root and rhizome system as well as by seeds on or below the surface of the soil.

In the 2nd and subsequent years new growth arises from endogenous root buds formed in the fall on the vertical roots and on any lateral roots that survive winter. The endogenous root buds, unlike adventitious buds, may remain dormant or develop into shoots or roots. While Davidson [34] found developing buds at all times of the year on field bindweed plants grown from root cuttings in Oxford, England, others suggest that regenerative capacity of root buds varies throughout the year (e.g. [130,144]). Buds on the larger roots begin to enlarge and develop rhizomes in early spring [144]. The number of shoots formed from lateral root segments is greatest in early spring and least in late summer [130]. Davison observed new shoots emerging until late October, with those emerging after late August accounting for half the annual radial increase in shoot emergence of 10 feet (3 m) [34].

Storage capacity of field bindweed roots and rhizomes also varies throughout the year. The percentage of starch in the roots reaches a maximum in August or September and thereafter rapidly declines as it is converted to sugar. The percentage of sugars in the roots reaches a maximum in late October and a minimum in May (Barr 1940, as cited by [144]). The percentage of root carbohydrates is lowest at the prebloom stage of growth (Gigax 1978, as cited by [144]).

Frazier [45] provides details on the amount, distribution, and seasonal trend of carbohydrate and nitrogen fractions in the root system of field bindweed in Kansas. All of the carbohydrate fractions, except the reducing sugar fraction, reached low points in all of the root portions during the interval of 15 April to 15 May. Sugars attained a seasonal maximum the 1st of November in most parts of the root system; starch-dextrin fraction attained maximum levels in all root parts between mid-August and the 1st of October; the readily available carbohydrate fraction followed the trend of the starch-dextrin fraction closely. The general trend of the nitrogen fractions in practically all portions of the plant showed an early season rise to 15 April (from 1 April), followed by a decline to a low point sometime between 15 May and 15 June. See Frazier [45] for further details.

# FIRE ECOLOGY

SPECIES: Convolvulus arvensis



FIRE ECOLOGY OR ADAPTATIONS:

**Fire adaptations:**

There is no information available in the literature regarding fire adaptations of field bindweed. Some inferences can be made regarding the likely response of field bindweed to fire based on its reproductive strategies. Field bindweed has a deep and extensive root system with abundant food reserves and can sprout repeatedly following removal of aboveground growth [74,75].

Goodwin and others [51] present the following generalization about rhizomatous weeds and fire, although they provide no supporting evidence. "Growth of rhizomatous weeds is especially enhanced through the survival of underground reproductive structures that have access to large energy reserves. When above-ground weed growth is removed, such as by fire, vegetative shoot production is strongly stimulated, directly producing great numbers of individual weeds. Because of the established root reserves, these shoots are immediately aggressive and highly competitive.

Field bindweed also produces varying amounts of long-lived, durable seed that survives passing through the digestive tracts of various animals [57,104,111], and long periods of composting and ensilage [148,156] (see Discussion and Qualification of Fire Effect). Considering its survival under such conditions, one might predict that field bindweed seed would survive low- to moderate-severity fires; however, more information is needed.

**Fire regimes:**

There is no information on fire regimes in areas where field bindweed is native or on the effects of fire regimes on field bindweed in areas where it is invasive. The response of field bindweed to native and imposed fire regimes probably varies among geographic locations, plant community types, fire adaptations of native species, and other disturbance and management regimes imposed at a particular site. More information on the effects of native and imposed fire regimes on the establishment, persistence, and spread of field bindweed are needed.

Frequent fire may deter field bindweed and other nonnative invasive species in temperate grasslands. According to Knapp and Seastedt [77], fire and grazing are necessary, integral ecosystem processes that maintain productivity of tallgrass prairie by removing standing and fallen litter. Similarly, Leach and Givnish [84] recommend prescribed burning (with specific guidelines) in Wisconsin prairie remnants to maintain native plant diversity. A review by Grace and others [53] suggests fire is only 1 type of disturbance that may affect the establishment and spread of invasive species in temperate grasslands. Since fire return intervals have been and will continue to be heavily influenced by land use, fire suppression, and grazing, these other disturbances can be expected to continue to play important roles in the future.

A 15-year study in $C_4$-dominated grasslands (dominated by big bluestem (*Andropogon gerardii*) and indiangrass (*Sorghastrum nutans*) and supporting many nonnative species, including field bindweed) in Konza Prairie Research Natural Area in eastern Kansas, indicated that patterns of disturbance (i.e. grazing and fire) strongly affected nonnative plant cover and richness. In particular, long-term annually burned sites had low cover and few, if any, nonnative species, whereas richness and cover of exotic species was as much as 5 times higher in long-term unburned sites. Although the effects of grazing could not be tested directly, higher nonnative species richness was associated with both annually burned and unburned grazing treatments. The authors suggest in their review that annual burning increases the dominance (i.e. production and abundance) of $C_4$ grasses and decreases production and abundance of the subdominant grasses and $C_3$ forbs in this grassland, and may indirectly prevent establishment of nonnative species [119].

The following table provides fire return intervals for important plant communities and ecosystems in which field bindweed may occur. 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 [143] |
| bluestem prairie | *Andropogon gerardii* var. *gerardii-Schizachyrium scoparium* | < 10 [79,101] |
| Nebraska sandhills prairie | *Andropogon gerardii* var. *paucipilus-Schizachyrium scoparium* | < 10 |
| bluestem-Sacahuista prairie | *Andropogon littoralis-Spartina spartinae* | < 10 |
| sagebrush steppe | *Artemisia tridentata/Pseudoroegneria spicata* | 20-70 [101] |
| basin big sagebrush | *Artemisia tridentata* var. *tridentata* | 12-43 [113] |
| mountain big sagebrush | *Artemisia tridentata* var. *vaseyana* | 15-40 [4,25,94] |
| Wyoming big sagebrush | *Artemisia tridentata* var. *wyomingensis* | 10-70 (40**) [140,154] |
| desert grasslands | *Bouteloua eriopoda* and/or *Pleuraphis mutica* | 5-100 [101] |
| plains grasslands | *Bouteloua* spp. | < 35 [101,152] |
| blue grama-needle-and-thread grass-western wheatgrass | *Bouteloua gracilis-Hesperostipa comata-Pascopyrum smithii* | < 35 [101,112,152]* |

| | | |
|---|---|---|
| blue grama-buffalo grass | *Bouteloua gracilis-Buchloe dactyloides* | < 35 [101,152]* |
| grama-galleta steppe | *Bouteloua gracilis-Pleuraphis jamesii* | < 35 to < 100 |
| blue grama-tobosa prairie | *Bouteloua gracilis-Pleuraphis mutica* | < 35 to < 100 [101] |
| cheatgrass | *Bromus tectorum* | < 10 [103,147] |
| California montane chaparral | *Ceanothus* and/or *Arctostaphylos* spp. | 50-100 [101] |
| sugarberry-America elm-green ash | *Celtis laevigata-Ulmus americana-Fraxinus pennsylvanica* | < 35 to 200 [143] |
| curlleaf mountain-mahogany* | *Cercocarpus ledifolius* | 13-1,000 [5,114] |
| mountain-mahogany-Gambel oak scrub | *Cercocarpus ledifolius-Quercus gambelii* | < 35 to < 100 [101] |
| California steppe | *Festuca-Danthonia* spp. | < 35 [101,126] |
| 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 |
| cedar glades | *Juniperus virginiana* | 3-7 |
| Ceniza shrub | *Larrea tridentata-Leucophyllum frutescens-Prosopis glandulosa* | < 35 [101] |
| wheatgrass plains grasslands | *Pascopyrum smithii* | < 5-47+ [101,105,152] |
| pinyon-juniper | *Pinus-Juniperus* spp. | < 35 [101] |
| Colorado pinyon | *Pinus edulis* | 10-400+ [44,52,73,101] |
| Jeffrey pine | *Pinus jeffreyi* | 5-30 |
| Pacific ponderosa pine* | *Pinus ponderosa* var. *ponderosa* | 1-47 [3] |
| interior ponderosa pine* | *Pinus ponderosa* var. *scopulorum* | 2-30 [3,7,83] |
| Arizona pine | *Pinus ponderosa* var. *arizonica* | 2-15 [7,29,115] |
| galleta-threeawn shrubsteppe | *Pleuraphis jamesii-Aristida purpurea* | < 35 to < 100 |
| eastern cottonwood | *Populus deltoides* | < 35 to 200 [101] |
| aspen-birch | *Populus tremuloides-Betula papyrifera* | 35-200 [39,143] |
| quaking aspen (west of the Great Plains) | *Populus tremuloides* | 7-120 [3,56,92] |
| mesquite | *Prosopis glandulosa* | < 35 to < 100 [91,101] |
| mountain grasslands | *Pseudoroegneria spicata* | 3-40 (10**) [2,3] |
| California oakwoods | *Quercus* spp. | < 35 [3] |
| oak-hickory | *Quercus-Carya* spp. | < 35 [143] |
| oak-juniper woodland (Southwest) | *Quercus-Juniperus* spp. | < 35 to < 200 [101] |
| northeastern oak-pine | *Quercus-Pinus* spp. | 10 to < 35 [143] |
| coast live oak | *Quercus agrifolia* | 2-75 [55] |
| white oak-black oak-northern red oak | *Quercus alba-Q. velutina-Q. rubra* | < 35 [143] |

| | | |
|---|---|---|
| canyon live oak | *Quercus chrysolepis* | <35 to 200 |
| blue oak-foothills pine | *Quercus douglasii-P. sabiniana* | <35 |
| Oregon white oak | *Quercus garryana* | < 35 [3] |
| California black oak | *Quercus kelloggii* | 5-30 [101] |
| bur oak | *Quercus macrocarpa* | < 10 [143] |
| oak savanna | *Quercus macrocarpa/Andropogon gerardii-Schizachyrium scoparium* | 2-14 [101,143] |
| black oak | *Quercus velutina* | < 35 [143] |
| little bluestem-grama prairie | *Schizachyrium scoparium-Bouteloua* spp. | < 35 [101] |
| elm-ash-cottonwood | *Ulmus-Fraxinus-Populus* spp. | < 35 to 200 [39,143] |

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

POSTFIRE REGENERATION STRATEGY [124]:
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)
Secondary colonizer (on-site or off-site seed sources)

# FIRE EFFECTS

SPECIES: Convolvulus arvensis



IMMEDIATE FIRE EFFECT ON PLANT:
There is no information available regarding the immediate effects of fire on field bindweed. It is likely that fire removes aboveground growth, while leaving the root system and buried seeds undamaged. More research is needed to determine the effects of fires of different severities under varied site conditions on field bindweed roots and seeds.

DISCUSSION AND QUALIFICATION OF FIRE EFFECT:
While no information is available regarding the direct effects of fire on field bindweed plants and seeds, some information on the effects of various heat treatments on viability of field bindweed seed is available.

Harmon and Keim [57] tested the longevity of several weed seeds after burial in horse and cow manure over a period of 1 to 4 months. The temperature in the horse and cow manure reached 158 °F (66 °C) and 150 °F (70 °C), respectively, in 2 weeks. Percent germination of field bindweed seed before burial was 84%. In horse manure, germination was 6% after 1 month (without acid treatment), 8% after 2 months (with acid treatment), and 0% thereafter. In cow manure, germination was 4% after 1 month (without acid treatment), 22% after 2 months (with acid treatment), 1% after 3 months (1 weak bindweed seedling was obtained), and 0% thereafter. Field bindweed seeds retained viability longer than all other weed seeds tested. Similarly, most weed seeds tested by Wiese and others [148] were killed after 3 days or more exposure at 120 °F (49 °C) in compost; it required 7 days of exposure at 180 °F (83 °C) to kill all field bindweed seed in compost. In dry air, all species survived 140 °F (60 °C) for 30 days. All seeds except field bindweed were killed in dry air by 160 °F (72 °C) for 3 days, while it took 7 days of exposure at 180 °F (83 °C) to reduce viability of field bindweed seed from about 30% to 7%, and 30 days to reduce field bindweed seed viability to 5%. Field bindweed seed was killed by a 12-day exposure in an outside storage pile of compost. Ensiling field bindweed seed seemed to have no effect on its viability [156]. These results suggest that field bindweed seed may survive low severity fire.

PLANT RESPONSE TO FIRE:
There is no information available regarding field bindweed response to fire. Field bindweed probably sprouts from roots and rhizomes if top-killed by fire. Response of field bindweed populations to fire depends on a number of factors, including native and imposed fire regimes, site conditions (e.g. soil, moisture, temperature), associated plant communities, management history, and disturbance regimes at a particular site.

In a study on the effects of litter on germination and establishment of cheatgrass and medusahead, field bindweed germinated and grew well without litter, suggesting that field bindweed may do well in a postfire environment. When litter was present, and with increased competition from grasses, yields of field bindweed were "drastically curtailed" [42].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE:
No additional information is available on this topic.

FIRE MANAGEMENT CONSIDERATIONS:
**Fire as a control agent:**
Prescribed fire alone is not likely to control field bindweed, but it may be useful in combination with other methods (Callihan and others 1990, as cited by [86]). The effectiveness of prescribed fire as a control method for field bindweed may vary with the invaded plant community and interactions with other types of disturbance.

In $C_4$-dominated grasslands, for example, long-term annually burned watersheds had lower cover of nonnative species (including field bindweed) than unburned watersheds, and fire reduced nonnative species richness by 80% to 90% [119]. Langstroth [82] recorded the presence of field bindweed on experimental plots in a California grassland that were grazed by domestic sheep (short duration) in the summer, but unburned. All other plots (ungrazed/unburned, spring grazed/unburned, and all burning treatments) had no field bindweed present.

It is unclear from these results how fire and grazing affect field bindweed populations over the long term.

**Postfire colonization potential:**
Field bindweed has the potential to invade an area following fire. Fire provides a suitable seedbed for field bindweed [42] by removing shade and exposing mineral soil. Therefore, if field bindweed is present on or near the site prior to burning, there is potential for its establishment and spread. It is a good idea to survey the surrounding area for field bindweed and control plants that may contain seed that could be dispersed into the burn.

**Preventing postfire establishment and spread:**
The USDA Forest Service's "Guide to Noxious Weed Prevention Practices" [137] provides several fire management considerations for weed prevention in general that apply to field bindweed.

Preventing invasive plants from establishing in weed-free burned areas is the most effective and least costly management method. This can be accomplished through careful monitoring, early detection and eradication, and limiting invasive plant seed dispersal into burned areas by [51,137]:

- re-establishing vegetation on bare ground as soon as possible
- using only certified weed-free seed mixes when revegetation is necessary
- cleaning equipment and vehicles prior to entering burned areas
- regulating or preventing human and livestock entry into burned areas until desirable site vegetation has recovered sufficiently to resist invasion by undesirable vegetation
- detecting weeds early and eradicating before vegetative spread and/or seed dispersal
- eradicating small patches and containing or controlling large infestations within or adjacent to the burned area

In general, early detection is critical for preventing establishment of large populations of invasive plants. Monitoring in spring, summer, and fall is imperative. Managers should eradicate established field bindweed plants and small patches adjacent to burned areas to prevent or limit seed dispersal into the site [51,137].

The need for revegetation after fire can be based on the degree of desirable vegetation displaced by invasive plants prior to burning and on postfire survival of desirable vegetation. Revegetation necessity can also be related to invasive plant survival as viable seeds, root crowns, or rhizomes capable of reproduction. In general, postfire revegetation should be considered when desirable vegetation cover is less than about 30% [51].

When prefire cover of field bindweed is absent to low, and prefire cover of desirable vegetation is high, revegetation is probably not necessary after low- and medium-severity burns. After a high-severity burn on a site in this condition, revegetation may be necessary (depending on postfire survival of desirable species), and intensive monitoring for invasive plant establishment is necessary to detect and eradicate newly established invasives before they spread [51].

When prefire cover of field bindweed is moderate (20-79%) to high (80-100%), revegetation may be necessary after fire of any severity if cover of desired vegetation is less than about 30%. Intensive weed management is also recommended, especially after fires of moderate to high severity [51].

Fall dormant broadcast seeding into ash will cover and retain seeds. If there is insufficient ash, seedbed preparation may be necessary. A seed mix should contain quick-establishing grasses and forbs (exclude forbs if broadleaf herbicides are anticipated) that can effectively occupy available niches. Managers can enhance the success of revegetation (natural or artificial) by excluding livestock until vegetation is well established (at least 2 growing seasons) [51]. See Integrated Noxious Weed Management after Wildfires for more information.

When planning a prescribed burn, managers should preinventory the project area and evaluate cover and phenology of any field bindweed and other invasive plants present on or adjacent to the site, and avoid ignition and burning in areas at high risk for field bindweed establishment or spread due to fire effects. Managers should also avoid creating soil conditions that promote weed germination and establishment. Weed status and risks must be discussed in burn rehabilitation plans. Also, wildfire managers might consider including weed prevention education and providing weed identification aids during fire training; avoiding known weed infestations when locating fire lines; monitoring camps, staging areas, helibases, etc., to be sure they are kept weed free; taking care that equipment is weed free; incorporating weed prevention into fire rehabilitation plans; and acquiring restoration funding. Additional guidelines and specific recommendations and requirements are available [137].

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# MANAGEMENT CONSIDERATIONS

SPECIES: Convolvulus arvensis

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

IMPORTANCE TO LIVESTOCK AND WILDLIFE:
Very little information is available regarding the use of field bindweed by livestock and wildlife. According to Bell [13], various research reports published by the Experiment Stations of Kansas, Iowa, Utah and Texas from 1920 to 1952 suggest that farm animals, including sheep and pigs, were used to eat bindweed as a control method in some places during that time, but that cattle are "nearly useless" for this purpose (see Biological control). In Minnesota, sheep grazed bindweed in preference to wheat, rye (*Secale* spp.), or Sudan grass (*Sorghum bicolor* ssp. *drummondii)*, and they grazed alfalfa (*Medicago sativa*), brome grass (*Bromus* spp.), or bindweed without discrimination but preferred these to reed canarygrass (*Phalaris arundinacea*) [122].

Field bindweed comprised 1.7 percent of mule deer diets during the spring-summer-fall grazing season on a central Colorado ponderosa pine-bunchgrass range [31]. Field bindweed was found in the rumens of white-tailed deer in summer and fall on Missouri River bottomlands in north-central Montana [1].

**Palatability/nutritional value:** According to a review by Bell [13], field bindweed is highly palatable to pigs, while sheep will eat it but do not prefer it, and cattle do not eat it.

The palatability of field bindweed for wildlife species in Montana and Utah is rated as follows [38]:

| | MT | UT |
|---|---|---|
| Pronghorn | fair | good |
| Elk | --- | good |
| Mule deer | --- | good |
| White-tailed deer | poor | good |
| Small mammals | poor | fair |
| Small nongame birds | poor | fair |
| Upland game birds | poor | fair |
| Waterfowl | --- | fair |

OTHER USES:
Dioscorides (circa A.D. 50) recommended drinking tea made from field bindweed seeds for 40 days to cure spleen problems, weariness, and hiccups. However, he warned, it had the inconvenient side effects of causing one to urinate blood after the 6th day and making one permanently sterile after the 37th (as cited by [95]). According to Kearney and others [72], an antihemorrhagic substance has been discovered in field bindweed, although the source of this information is not given.

Extracts from field bindweed leaves and stems show high larvacidal activity against mosquito larvae [20].

IMPACTS AND CONTROL:
**Impacts:** A 1998 review by Lyons [86] indicates that the impact of field bindweed on agricultural lands is well documented, especially in the central U.S., but the threat it poses to rangelands and natural areas is unclear. Almost all research on field bindweed pertains to agriculture. When surveyed in 1982 and 1988, farmers and ranchers in north-central Idaho considered field bindweed to be one of the 3 most serious weeds in their area [27]. The Eastern Region of the U.S. Forest Service ranks field bindweed as a Category 3 plant: often restricted to disturbed ground, and not especially invasive in undisturbed natural habitats [136]. Natural area managers are most likely to find it in moist locations (e.g. riparian corridors and irrigated areas) on tracts once

used for agriculture [86].

Field bindweed is found on several of The Nature Conservancy's preserves and may pose a threat to restoration efforts. Stewards at the Phantom Canyon Preserve in Colorado report that field bindweed is most likely to invade and reduce cover of native grasses and forbs in areas that are degraded due to past land use, current human activity, and fire suppression. Stewards at Garden Creek Preserve in northern Idaho report that field bindweed threatens native plant communities by "decreasing biodiversity," and is a direct threat to several species [86]. At the Thousand Springs Preserve in Idaho, field bindweed thrives under cultivated and irrigated conditions, and managers there suggest that field bindweed "outcompetes" native grasses [86,109].

Field bindweed competition for nutrients and water may reduce productivity of native plants, although this has only been studied with crop plants, where yield reductions range from 0 to 100% [128]. Competition from field bindweed for soil moisture may have greater impact in dry years [8].

It has been suggested that field bindweed may be mildly toxic to some grazing animals, and that the amount of field bindweed that can be safely eaten by domestic sheep, cattle, and goats is not known. It is reported to cause distress in domestic pigs that eat it (Callihan and others 1990, as cited by [86]). Field bindweed contains alkaloids that may be toxic to horses [134]. Other authors report a history of using sheep and pigs to eat field bindweed and thereby help control infestations [13,122] (see Biological control).

## Control:

Field bindweed has a deep, extensive root system that stores carbohydrates and proteins and allows it to sprout repeatedly following removal of aboveground growth. Field bindweed may also produce abundant, long-lived seed. Strategies to control field bindweed infestations must include removing established plants and preventing seed production and seedling establishment. Alcock and others (1974, as cited by [86]) suggest the following as general goals for field bindweed control: 1) reduce seed in soil 2) prevent seedling growth, 3) deplete food reserves in the root system 4) prevent its spread.

Eradication of an established invader is rare, and control efforts vary enormously in their efficacy. Successful control depends more on commitment and continuing diligence than on the efficacy of specific tools themselves. Control of biotic invasions is most effective when it employs a long-term, ecosystem-wide strategy rather than a tactical approach focused on battling individual invaders [87]. A long-term perspective is important where total eradication is not a realistic short-term goal. Even with intensive management, field bindweed can persist as seed for several years, and some authors suggest that 3 to 5 growing seasons are required in agricultural settings to eliminate seedlings (Callihan and others 1990, as cited by [86]). The key to implementing a successful control program is to continue treatment even after it appears the infestations are seriously reduced [86].

Successful control of field bindweed is most likely if aboveground biomass is removed multiple times over at least 2 growing seasons (e.g. [13]), or by planting of competitive species following aboveground removal and continuously monitoring for and killing sprouts and seedlings. In agriculture, control has been most successful where tillage is combined with herbicide application, although herbicide application alone may also be effective (see Chemical control) [86].

### Prevention:

The most efficient and effective method of managing invasive species is to prevent their invasion and spread [116]. Preventing the establishment of weeds in natural areas is achieved by maintaining healthy natural communities and by conducting aggressive monitoring several times each year. Monitoring efforts are best concentrated on the most disturbed areas in a site, particularly along roadsides, parking lots, fencelines, and waterways. When a field bindweed infestation is found, the location can be recorded and the surrounding area surveyed to determine the size and extent of the infestation, so these sites can be revisited on follow-up surveys [67]. It is important to kill any field bindweed plants that are found, followed by some combination of mechanical, chemical and/or biological control. Prevention of new invasions is much less costly than postinvasion control [87].

Avoid management activities that encourage invasion and be prepared to eradicate small infestations that may follow such disturbances. Factors indicated by Nature Conservancy managers as encouraging field bindweed invasion include cultivation and irrigation in Idaho grassland and road grading and haying in Oregon along roadsides and riparian areas [109]. Weed prevention and control can be incorporated into all types of management plans, including logging and site preparation, management of grazing allotments, recreation management, research projects, road building and maintenance, and fire management [137]. See the USDA "Guide to noxious weed prevention practices" [137] for specific guidelines and recommendations for preventing the spread of weed seeds and propagules under different management conditions.

Roads act as dispersal corridors for many invasive species. Avoid road building in nature reserves, and when unavoidable, redeposit original topsoil in roadside ditches. Road construction projects should not be considered complete until native vegetation is fully established. Road construction projects in nature reserves should be treated and funded as 10- to 20-year biological projects rather than 1-2 year engineering projects, with biologists and resource managers consulting on road construction. Roadsides should be actively managed by regular monitoring for establishment of nonnative species, and reseeding roadsides with natives [135].

### Integrated management:

A combination of complementary control methods may be helpful for effective control of field bindweed. Integrated management includes not only killing the target plant, but establishing desirable species and discouraging nonnative, invasive species over the long term. Components of any integrated weed management program are sustained effort, constant monitoring and evaluation, and the adoption of improved strategies. An integrated management plan includes efforts to place continual stress on undesirable plants.

In agriculture, most effective programs for the control of field bindweed combine cultivation and crop rotation with the use of herbicides. A review by Weaver and Riley [144] summarizes this information as follows: Cultivation at frequent intervals results in a gradual and continuous reduction in the concentration of total available carbohydrates and a decrease in root quantity. However, 1 to 5 years of repeated tillage may be required to exhaust the root reserves and effectively control populations of field bindweed. Competitive crops such as winter wheat or perennial forages are able to reduce field bindweed infestation after 3 to 5 years, particularly when combined with the application of herbicides.

In North Dakota, 2 fields were prepared for planting to native grasses by burning once and summer fallowing for 2 years. Summer fallowing effectively killed all aboveground vegetation. Within 2 months after drill seeding native grasses, perennial weeds, including field bindweed, were very dense. Fields were then sprayed with 2 applications of 2,4-D. Results of these treatments are not given [62].

Managers at Thousand Springs Preserve in Idaho had success controlling field bindweed in an agricultural site undergoing restoration, using a combination of tilling and planting competitive plants. In the 1st year the field was burned and planted with peas and oats. After the crop was harvested in the spring, the field was tilled and irrigated to encourage germination of weeds. Glyphosate was applied in October, although this had little effect because it was quickly followed by a killing frost. Native perennial bunchgrass seeds were no-till drilled in late fall, and seedlings emerged in February and March. The native grasses were irrigated and cheatgrass was suppressed using glyphosate. Annual weeds were controlled by mowing around the bunchgrasses. Mowing and irrigation continued for 1 year. After 5 years the perennial grasses were well established, the annual weeds continued to persist, and the perennial weeds (e.g. field bindweed) were minor components. Field bindweed grows most successfully only where there are irrigation leaks and generally does poorly if not irrigated. See the review by Lyons [86] for more details.

In a greenhouse study on the combined effects of the bindweed gall mite (*Aceria malherbae*) and herbicide (2,4-DB or glyphosate) on field bindweed height and biomass, mite feeding alone reduced field bindweed shoot biomass 37% to 48% and root biomass 46% to 50%. Herbicide alone reduced field bindweed root biomass 25% to 52%, and combining mite feeding with either 2,4-DB or glyphosate reduced root biomass more than mites or either herbicide alone. Combination of bindweed gall mite with sublethal doses of herbicide may allow for field bindweed suppression while reducing potential herbicide injury to desirable plants and maintaining mite populations. The herbicides did not appear to negatively affect the mites [21].

### Physical/mechanical:

Removing aboveground parts of field bindweed repeatedly to starve the roots is commonly suggested as a control method in agricultural settings (e.g. [11,13,17]). Common methods for removing top-growth include tillage, hoeing, cutting, or mowing. Tillage is usually not recommended for natural areas, as it may damage desirable vegetation and/or increase soil erosion. On rangelands or natural areas that were previously used for agriculture, tilling may be useful for ridding infestations. For small areas this may be done using hand-held tools, but for large areas machinery is often required [86].

The study and use of tillage or cultivation for control of field bindweed has a long history, particularly in the midwestern United States, as reviewed by Bell [13]. The biological basis of this research was that field bindweed could be killed if the roots were starved by cutting off the leaves on a regular routine. Food reserves in the surface roots (upper 12 inches (30 cm)) are rapidly depleted by cultivation, but in deep roots (6 to 8 feet (1.8-2.4 m) deep), reserves are exhausted only after long continued cultivation at the emergence of new sprouts. Only a small quantity of reserves is necessary to regenerate new growth [10].

Recommendations of intensive, repeated cultivation for control of field bindweed are common. One recommendation was to cut off field bindweed plants about 3 inches (8 cm) below soil surface "for the whole season" (15-27 cultivations, every 8-10 days, through the spring, summer, and early fall (until frost), and another dozen cultivations the next year). Cultivations should extend 16.5 feet (5 m) from the population boundary because of invasive roots. Another recommendation was to cultivate 8 days after the weed re-emerges, based upon careful studies of the rhizome system that showed that the emerging shoots relied upon food stored in the root system for 8 days before photosynthesis started to replenish the root. For a cultivation tool, a duckfoot sweep was the desired implement [13].

Shallow hoeing and deeper cultivations were equally effective when made every time the 1st shoots of field bindweed emerged. Hoeing at regular 14-day intervals was just as effective as hoeing every 7 or 10 days. All 3 techniques eradicated field bindweed in 2 seasons (Sherwood and Fuelkeman 1948, and Timmons and Bruns 1951, as cited by [6]). The percentage of total sugars, carbohydrates, polysaccharides, starch, and readily available carbohydrates in field bindweed roots cultivated at 3-week intervals was markedly lower than that found in the roots of undisturbed plants. Additional decreases were observed in the roots in the top 12 inches (30 cm) of plants cultivated bi-weekly and weekly [12]. The relative depletion of food reserves, supplied by underground parts of the plant, by cultivation every 7th day as compared with cultivation every 14th day, was calculated. From this it appears that cultivation every 14 days would destroy a 5th more of the readily available carbohydrates and more than double the loss of protein nitrogen in the 2 parts as compared with 2 cultivations at intervals of 7 days in the same unit of time [46]. Caution must be used with cultivation, because much of the root system is concentrated near the surface of the soil [34,133,144], and mechanical tillage may cut and disseminate root fragments [78].

At the Bosque del Apache National Wildlife Refuge on the Rio Grande in New Mexico, 3 techniques were employed in an effort to increase native chufa (*Cyperus esculentus*) tuber production: 1) mowing early in the growing season; 2) shallow disking 30 days after wetland drawdown; and 3) periodic sustained flooding during the growing season. There was no control in this study. Field bindweed mass (g/m2) appeared unaffected by mowing, and appears to have decreased slightly but not significantly ($p<0.10$) after disking or flooding treatments [131].

Even under cultivation, field bindweed seedlings may continue to emerge for many seasons. After 6 weeks, a new seedling has a root system large enough to regenerate stems if it is cut [13]. Studies by Swan [129] indicate that field bindweed seedlings can be killed by tillage or cutting at a depth of 4 inches (10 cm) if done within 3 weeks of emergence.

Mulches are effective for controlling field bindweed if no light reaches the soil surface. Black plastic is recommended. Complete death of field bindweed plants under mulch takes about 3 to 5 years [13]. Similarly, 6 to 9 weeks of solarization in California field plots reduced the number of field bindweed seedlings, and regrowth from established field bindweed plants was suppressed for 6 weeks after treatment [41].

Fire: See Fire Management Considerations.

Biological:
Several natural enemies of field bindweed have been identified in its home range and several tested for host-specificity. Unfortunately, nearly all of the biocontrol agents tested so far also eat native morning-glories in California, some of which are rare or not abundant [13]. According to Rees and Rosenthal [108], 2 biological control agents have been released in the U.S.:

| Agent | Locations released or established | References |
|---|---|---|
| bindweed gall mite | MT, TX, AB | [90,108] |
| bindweed moth (*Tyta luctuosa*) | released in AZ, IA, MO, OK, and TX; not recovered (i.e. not established) | [108] |

Larvae and adults of the Argus tortoise beetle (*Chelymorpha casidea*) feed on the leaves of members of the morning-glory family. The Argus tortoise beetle is native to the U.S. and also occurs in Canada. In New York, it has been observed to defoliate infestations of field bindweed and false bindweed (*Calystegia sepium*) completely, while leaving the associated rye and corn crops untouched. It was being investigated as a potential biological control agent in 1979 (Selleck 1979, as cited by [144]); the outcome of these investigations is unknown.

Grazing: In Minnesota, domestic sheep grazing on field bindweed infested land sown to several crops (wheat, rye, and Sudan grass) consistently eliminated bindweed in 2 seasons, while grazing of perennial pasture mixtures consisting of alfalfa and brome grass or reed canary grass did not eliminate bindweed in any of 3 experiments. Grazing of pure bindweed reduced the stand somewhat, but was much less effective than was the grazing of infested land on which crops were being grown [122]. According to a review by Bell [13], cattle do not eat field bindweed, sheep will eat it but do not prefer it, and pigs are the field bindweed gourmands. Pigs will eat the whole plant, given a chance. Pigs are said to nearly eradicate the root system of bindweed if the field is plowed before they are let into the field. However, their snouts must be free of nose rings or slits.

Chemical:
Herbicides commonly recommended for the control of field bindweed include 2,4-D (alone and in combination), glyphosate, dicamba, picloram, quinclorac, and paraquat. See the Weed Control Methods Handbook or the field bindweed ESA
for more information on specific chemicals, their efficacy, and recommendations for use in controlling field bindweed.

In general, herbicides should be applied when they will be most effectively absorbed and translocated to field bindweed roots, but before plants produce seed and new buds. The optimum time for the application of foliar-applied herbicides is the bud to full-bloom stage which coincides with the maximum translocation of assimilates downward and root metabolic activity. However, the application of herbicides in late summer, if the vines are actively growing, may also be effective [86,144].

Moisture availability may impact the effectiveness of chemicals applied for field bindweed control. A laboratory test indicated that field bindweed is more resistant to glyphosate action when plants are drought stressed [33]. Similarly, a review by Meyer [93] indicates that field bindweed growing in semiarid conditions (rainfall of 11 to 20 inches (280-500 mm)) may be more resistant to weed control efforts (herbicides and cultural control) than field bindweed growing in more humid conditions (rainfall >25 inches (640 mm)). This is especially apparent for foliar-applied herbicides, possibly due to lower leaf area, thicker cuticle with higher wax content, slower biological processes, and smaller leaf:root ratios under semiarid conditions. But it may also be due, in part, to different cropping and cultural practices employed in the different areas.

According to a review by Lyons [86], repeated use of the same or similar herbicides can result in herbicide-resistant strains of field bindweed. Investigators have unsuccessfully tried to correlate the morphology of field bindweed strains with their herbicide resistance. When planning on using herbicides to control field bindweed, it is useful to know whether field bindweed strains in the area have demonstrated any herbicide resistance [86]. Evidence of resistance of field bindweed to 2,4-D isooctylester after 3 consecutive years of spraying is suggested by Zengin [157]. Field bindweed 1st demonstrated resistance to 2,4-D in Kansas in 1964, and apparently, research has shown that these particular biotypes may be resistant to other synthetic auxin herbicides. See the International Survey of Herbicide Resistant Weeds for more information.

### Cultural:

In agricultural systems, smother crops are often used to control invasive species such as field bindweed. Competition for light reduces field bindweed vigor [9,13]. According to a review by Lyons [86], light reaching field bindweed plants must be reduced to about 50% shade or more for 3 years to control field bindweed growth.

In agricultural systems suggested smother crops include millet, sorghum, Sudan grass, or alfalfa [66,86]. Winter wheat is often a good competitor with field bindweed because it grows rapidly during the early spring when bindweed is not using soil moisture (Wiese and Rea 1959, as cited by [144]). Summer-planted crops that grow vigorously and provide early shade offer competition to field bindweed at a time when it is normally making its best growth [66].

It may be difficult to find native species that can compete effectively with field bindweed. The outcome of competition between species can be complicated and unpredictable. Managers at Phantom Canyon Preserve were unable to establish native species to compete with field bindweed, while those at Thousand Springs Preserve successfully established perennial grasses [86].

A review by Lyons [86] suggests that, in general, species that grow vigorously during the winter and early spring may offer the best competition to field bindweed, because they force field bindweed plants to compete for light later in the season. Competitive crops may be most effective in humid/shady areas where solar radiation is diminished and shading has larger consequences (Wilson and others 1955, as cited by [86]). Therefore competitive planting or restoration efforts in low light riparian habitats, where the available light is reduced by tree canopies, may work to control field bindweed [86].

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## Convolvulus arvensis: References

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