Polygonum aviculare

INTRODUCTORY

Photo by Richard Old, XID Services, Inc., Bugwood.org

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FEIS ABBREVIATION:
POLAVI

NRCS PLANT CODE [147]:
POAV

COMMON NAMES:
prostrate knotweed
doorweed
knotgrass

wiregrass
yard knotweed

TAXONOMY:
The scientific name of prostrate knotweed is *Polygonum aviculare* L. (Polygonaceae) [57,80]. The Flora of North America recognizes 6 subspecies:

Polygonum aviculare subsp. *aviculare*
Polygonum aviculare subsp. *boreale* (Lange) Karlsson
Polygonum aviculare subsp. *buxiforme* (Small) Costea & Tardif
Polygonum aviculare subsp. *depressum* (Meisner) Arcangeli
Polygonum aviculare subsp. *neglectum* (Besser) Arcangeli
Polygonum aviculare subsp. *rurivagum* (Jordan ex Boreau) Berher [57]

Except for *Polygonum aviculare* subsp. *boreale*, the subspecies listed above overlap in distribution and exhibit complex intergradation, resulting in populations with intermediate characteristics [57]. Because identification at the subspecies level is difficult, and sources either rarely report subspecies or identification may be suspect, this review synthesizes information about prostrate knotweed at the species level. For a review of the taxonomic issues of the prostrate knotweed complex, see [32].

SYNONYMS:
None

LIFE FORM:
Forb

DISTRIBUTION AND OCCURRENCE

SPECIES: Polygonum aviculare

GENERAL DISTRIBUTION:
Prostrate knotweed is one of the most widespread weeds in the world (review by [32]). Its widespread distribution is attributed to several plant characteristics, including high genetic polymorphism, high phenotypic plasticity [104], prolific seed production [123], multiple means of seed dispersal, formation of a persistent seed bank, and allelopathy (review by [32]).

Prostrate knotweed is native to Europe [98,138] or Eurasia [81]. It was likely introduced to North America with the first colonists and was first collected in Canada in 1821 (review by [32]). One source suggests that it was introduced as a contaminant in agricultural seeds [96]. As of 2010, prostrate knotweed occurs in all 50 of the United States, though as of 2010, Plants Database does not report prostrate knotweed occurring in California. However, several other sources report it occurring there [14,25,59,64,100,129]. Plants Database provides a distribution map of prostrate knotweed in Canada and the United States.

HABITAT TYPES AND PLANT COMMUNITIES:
The following plant community descriptions represent locations where prostrate knotweed may occur, based on information available in the literature as of 2010. Because prostrate knotweed is so widely distributed, it likely occurs in plant communities other than those discussed here and listed in the Fire Regime Table.

Wetland or riparian plant communities: Prostrate knotweed occurs in plant communities associated with water, including wetlands, wet meadows, and riparian or floodplain forests.

Wetlands: Prostrate knotweed is reported in wetlands in Arizona [134,172], California [14,100], Colorado [6], New Mexico [168], and Oregon [108]. It occurred in a marshy area dominated by flatsedges (*Cyperus* spp.), spikerush (*Eleocharis* sp.), and rushes (*Juncus* spp.) in southeastern Arizona [172]. Along the Colorado River in Arizona, prostrate knotweed occurred in a wet marsh dominated by Canadian horseweed (*Conyza canadensis*) and Bermuda grass (*Cynodon dactylon*) [134]. "Smartweeds", including prostrate knotweed, grew on lowland and levee habitats around wetlands in northern California. The area was dominated by large stands of hardstem bulrush (*Schoenoplectus acutus*), with Bermuda grass, blackberry (*Rubus* sp.), dock (*Rumex* sp.), and saltgrass (*Distichlis spicata*) in adjacent upland areas [14]. Prostrate knotweed occurred on the dry edges of wet meadows in subalpine areas surrounding Lake Tahoe, California [129]. In northwestern Colorado, prostrate knotweed occurred at low levels (1.5% cover) in common spikerush (*E. palustris*) wetlands [6].

Riparian or floodplain forests: Prostrate knotweed occurs in riparian or floodplain forest communities in the Northeast, Midwest, Intermountain West, and the Southwest.

Northeast: In Washington, DC, prostrate knotweed occurred in riparian forests dominated by boxelder (*Acer negundo*), red maple (*A. rubrum*), yellow-poplar (*Liriodendron tulipifera*) and American sycamore (*Platanus occidentalis*) [55]. In eastern Maryland, prostrate knotweed was uncommon on creek floodplains and river lowland forests. Forests were wet to mesic, often occurring near the edges of swamps. Dominant canopy trees included swamp white oak (*Quercus bicolor*), pin oak (*Q. palustris*), sweetgum (*Liquidambar styraciflua*), and red maple [132]. In West Virginia, prostrate knotweed occurred in riparian forests dominated by American sycamore, river birch (*Betula nigra*), green ash (*Fraxinus pennsylvanica*), and silver maple (*A. saccharinum*) [139].

Midwest: Prostrate knotweed was an uncommon species in floodplain and backwater sites along the Illinois River, Illinois. Floodplain forests were dominated by silver maple and eastern cottonwood (*Populus deltoides*). Backwater areas contained semiaquatic plants, including lovegrass (*Eragrostis* spp.), flatsedge, cockspur grass (*Echinochloa* spp.), knotweed (*Polygonum* spp.), and cutgrass (*Leersia* spp.) [118]. In southeastern Missouri, prostrate knotweed was found on moist, sandy soil along creeks. Riparian forests included river birch, swamp cottonwood (*Populus heterophylla*), willows (*Salix* spp.), and American sycamore [141].

Intermountain West: Prostrate knotweed occurred on the South Platte River floodplain in eastern Colorado. Floodplains were dominated by eastern cottonwood and willows [94]. Prostrate knotweed occurred on shorelines and riverbanks in the Bighorn Canyon National Recreation Area in Wyoming and Montana. Floodplain forests were dominated by plains cottonwood (*P. deltoides* ssp. *monilifera*), peachleaf willow (*S. amygdaloides*), and Russian-olive (*Elaeagnus angustifolia*) [84].

Southwest: In central Arizona, prostrate knotweed occurred but was rare in several riparian plant communities including streamside gravel bars; streamside herbaceous communities; floodplain terraces and overflow channels with mule-fat (*Baccharis salicifolia*), tamarisk (*Tamarix* spp.), and burro bush (*Hymenoclea monogyra*); mature Fremont cottonwood (*P. fremontii*) and Goodding willow (*S. gooddingii*) gallery forests; flooded mesquite (*Prosopis* sp.) terraces; and disturbed terraces where mesquite was removed [166]. Prostrate knotweed was present in the soil seed bank but not in the extant vegetation of disturbed deciduous riparian forests in the Huachuca Mountains of southeastern Arizona. Dominant vegetation included Arizona sycamore (*Populus wrightii*), bigtooth maple (*A. grandidentatum*), velvet ash (*F. velutina*), and gray oak (*Q. grisea*) [120].

Upland plant communities: Prostrate knotweed occurs in a wide range of upland plant communities, including grasslands, salt pans, shrublands, savannas, and upland forests.

Grasslands: Prostrate knotweed occurs in grassland plant communities from the Great Plains west to eastern Washington, including shortgrass [149], mixed-grass [53,93,119,124], and tallgrass [115,143] prairies. In the Great Plains, species composition varies regionally, but the following are dominant species: big bluestem (*Andropogon*

gerardii var. *gerardii*) [37,49,115,143], little bluestem (*Schizachyrium scoparium*) [2,37,49,143], western wheatgrass (*Pascopyrum smithii*) [2,3,53,56,119,124], purple threeawn (*Aristida purpurea*) [53,56,119,149], buffalo grass (*Buchloe dactyloides*) [2,56,126,149], blue grama (*Bouteloua gracilis*) [3,37,53,56,119,124,126,149], sideoats grama (*B. curtipendula*) [37,115], hairy grama (*B. hirsuta*) [37], indiangrass (*Sorghastrum nutans*) [2,49,143], needle-and-thread grass (*Hesperostipa comata*) [2,3,53,119], prairie dropseed (*Sporobolus heterolepis*) [49], sand dropseed (*S. cryptandrus*) [119], Heller's rosette grass (*Dichanthelium oligosanthes*) [115], prairie Junegrass (*Koeleria macrantha*) [2], and needleleaf sedge (*Carex duriuscula*) [149]. In eastern Washington, prostrate knotweed occurred in wheatgrass-bluegrass (*Agropyron* sp.-*Poa* sp.) and fescue-snowberry (*Festuca* sp.-*Symphoricarpos* sp.) plant communities [36].

Salt pans: In northeastern Ohio, prostrate knotweed was not present in the extant vegetation but occurred in the soil seed bank of a highly saline (3.5% NaCl) salt pan dominated by salicornia (*Salicornia* sp.) [51]. In Nebraska, prostrate knotweed was widely scattered along the borders of salt pans dominated by saltgrass [148]. Prostrate knotweed occurred on dryland saline areas in the northern Great Plains of Canada. The most frequently occurring species included Pursh seepweed (*Suaeda calceoliformis*), summer-cypress (*Kochia scoparia*), red swampfire (*Salicorna rubra*), and Nuttall's alkaligrass (*Puccinellia nuttalliana*) [15].

Shrublands: Prostrate knotweed is reported from salt desert shrub communities in Wyoming [72] and Montana [16,17] and sagebrush communities in Colorado [33,89], Montana [16,17], Utah [112], Washington [36], and Wyoming [3,27,33,72]. Prostrate knotweed occurred in several salt desert shrub communities in northeastern Montana, including those dominated by big sagebrush (*Artemisia tridentata*), Gardner's saltbush (*Atriplex gardneri*), rubber rabbitbrush (*Chrysothamnus nauseosus*), prairie rose (*Rosa arkansana*), buckwheat (*Eriogonum* sp.), Nuttall's povertyweed (*Monolepis nuttalliana*), and the nonnatives perennial pepperweed (*Lepidium latifolium*), European stickseed (*Lappula squarrosa*), and lambsquarters (*Chenopodium album*) [16,17].

In central Montana, prostrate knotweed occurred on shale slopes with rubber rabbitbrush (*Chrysothamnus nauseosus*) and prairie rose (*Rosa arkansana*) [161]. It occurred in black greasewood (*Sarcobatus vermiculatus*) plant communities in northeastern Montana [18].

In central California, prostrate knotweed occurred in a chaparral plant community dominated by oaks (*Quercus* spp.), ceanothus (*Ceanothus* spp.), mariposa manzanita (*Arctostaphylos manzanita*), California bay (*Umbellularia californica*), flannelbush (*Fremontodendron californicum*), California buckeye (*Aesculus californica*), and jack pine (*Pinus banksiana*) [64]. Prostrate knotweed occurred in coyote bush (*Baccharis pilularis*) scrub communities on Santa Rosa Island, Channel Islands National Park, California [25]. At Death Valley National Monument, prostrate knotweed occurred on sandy dunes. Dominant perennial vegetation included creosotebush (*Larrea tridentata*), desertholly (*Atriplex hymenelytra*), white bursage (*Ambrosia dumosa*), and brittle bush (*Encelia farinosa*) [59].

Savannas or woodlands: Prostrate knotweed occurred in a post oak (*Q. stellata*) savanna in east-central Texas [128]. In New Mexico, prostrate knotweed was reported in Emory oak-Mexican pinyon (*Q. emoryi*-*Pinus cembroides*) woodlands, Colorado pinyon-oneseed juniper (*Pinus edulis*-*Juniperus monosperma*) woodlands, Colorado pinyon-alligator juniper (*J. deppeana*) woodlands, gray oak (*Q. grisea*) woodlands, and ponderosa pine/Colorado pinyon-gray oak woodlands [103]. Prostrate knotweed occurred in a Gambel oak (*Q. gambelii*) woodland in Colorado. Common species included chokecherry (*Prunus virginiana*), Saskatoon serviceberry (*Amelanchier alnifolia*), common snowberry (*Symphoricarpos albus*), and big sagebrush [89]. Prostrate knotweed was found infrequently in Utah juniper (*J. osteosperma*)-Colorado pinyon woodlands in central Utah. Trees and shrubs of the area included Utah juniper, Colorado pinyon, big sagebrush, antelope bitterbrush (*Purshia tridentata*), broom snakeweed (*Gutierrezia sarothrae*), and green rabbitbrush (*Chrysothamnus viscidiflorus*) [112].

Upland forests: Prostrate knotweed occurs in upland forest communities in both the eastern and western United States. It occurred along oak-hickory (*Carya* spp.) forest edges at Mt Vernon, Virginia [159]. In Washington, DC, prostrate knotweed was common in deciduous forests dominated by American beech (*Fagus grandifolia*), white oak (*Q. alba*), northern red oak (*Q. rubra*), southern red oak (*Q. falcata*), chestnut oak (*Q. prinus*), black oak (*Q. velutina*), yellow-poplar, bitternut hickory (*C. cordiformis*), pignut hickory (*Carya glabra*), and mockernut hickory

(*Carya tomentosa*) [55]. In eastern Maryland, prostrate knotweed was uncommon on upland slopes where forests contained southern red oak, black oak, and American holly (*Ilex opaca*) [132]. In northwestern Ohio, prostrate knotweed was common in oak forests [50]. In southern Ontario, seeds of prostrate knotweed were found at a low density in the seed bank of a forested "woodlot" dominated by white ash (*Fraxinus americana*), sugar maple (*Acer saccharum*), quaking aspen (*Populus tremuloides*), and black cherry (*Prunus serotina*) [21]. In New Hampshire, prostrate knotweed occurred in disturbed areas surrounding a backcountry shelter in a matrix of old-growth balsam fir (*Abies balsamea*) forest [54].

Prostrate knotweed was reported in ponderosa pine forests in Arizona [26,35,60,88,133] and Colorado [38]. In the northern Rocky Mountains, prostrate knotweed occurred in subalpine fir-grouse whortleberry (*A. lasiocarpa-Vaccinium scoparium*) forests and subalpine meadows containing Idaho fescue (*Festuca idahoensis*) and slender wheatgrass (*Elymus trachycaulus*) [156].

Rocky outcrops: Prostrate knotweed occurs in both high- and low-elevation plant communities on rocky outcrops. Prostrate knotweed occurred in high-elevation wavy hairgrass-filmy angelica (*Deschampsia flexuosa-Angelica triquinata*) communities on rock outcrops in the Southern Appalachian Mountains of western North Carolina and eastern Tennessee [164]. In northern Alabama, prostrate knotweed occurred in limestone glades. Glades were described as open areas of rock pavement, flagstone, and/or shallow soil (<10 inches (25 cm) deep) dominated by annual grasses, annual and perennial dicots, mosses, and lichens [8]. Prostrate knotweed dominated the vegetation (75% cover) where it occurred on shallow, gravelly soils on treeless rocky outcrops on the ridges of Monument Peak, Oregon. Other abundant species included cascade desertparsley (*Lomatium martindalei*), Olympic onion (*Allium cascadense*), common woolly sunflower (*Eriophyllum lanatum*), slender phlox (*Microsteris gracilis*), red fescue (*Festuca rubra*), seashore bentgrass (*Agrostis diegoensis*), pinemat manzanita (*Arctostaphylos nevadensis*), littleleaf minerslettuce (*Montia parvifolia*), rustyhair saxifrage (*Saxifraga rufidula*), and spreading phlox (*Phlox diffusa* var. *longistylis*) [4].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Polygonum aviculare

GENERAL BOTANICAL CHARACTERISTICS: Much of the information presented in this section comes from a comprehensive review of the biology of prostrate knotweed in Canada. For more information on this source, see Costea and Tardiff 2005 [32].

Botanical description: This description covers characteristics that may be relevant to fire ecology and is not meant for identification. Keys for identification are available (e.g., [32,46,47,48,61,73,98,99,109,116,138,154,165,169]). For a key to the prostrate knotweed subspecies recognized in North America, see: [32].

Prostrate knotweed is generally considered an annual [32,65,69,99,160], though some sources report it as occasionally perennial [44,70,116].

Prostrate knotweed plants exhibit highly variable architecture depending on both genetic and environmental factors [32]. In general, prostrate knotweed is a mat-forming plant [65], with mats reaching 4 to 48 inches (10-122 cm) in diameter [113]. Prostrate knotweed stems are prostrate to erect, 2 to 80 inches (6-200 cm) long. Leaves are alternate and vary in size and shape, but are generally ovate. Inflorescences are axillary cymes with 2 to 6 flowers. Flowers are bisexual [32]. Prostrate knotweed fruits are one-seeded nuts [105]. Seeds are achenes, 1.7 to 4.0 mm long [32].

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Prostrate knotweed has a taproot [32,65,116]. Taproots of mature prostrate knotweed plants in alluvial soil reached depths of 30 inches (70 cm). Dense horizontal secondary roots were distributed in the upper 5 to 10 inches (15-25 cm) of soil (Kutschera 1960 cited in [32]). On sand dunes in the deserts of Death Valley National Monument, prostrate knotweed taproots penetrated approximately 5 inches (13 cm) in the soil and roots exhibited very little lateral spread (approximately 1 inch (3 cm)). Ten plants had an average root to shoot ratio of 0.09 [59].

Raunkiaer [117] **life form:**
Therophyte

SEASONAL DEVELOPMENT:
The seasonal development of prostrate knotweed varies by both population and genotype [32,105]. In southern Canada, most prostrate knotweed seeds lose dormancy in March and April and germinate in a single flush between March and May [32]. In North America, prostrate knotweed flowers from March to November depending on location.

Flowering date of prostrate knotweed in locations throughout North America	
Location	Flowering date
Arizona	March to October [113]
Great Plains	June to October [65]
Illinois	June to October [109]
Kentucky	June to November [69]
New England	June to September [98]
North and South Carolina	May to November [116]
Texas	May to November [44]
West Virginia	June to October [138]

In southern Canada, prostrate knotweed plants produced seeds approximately 2 months after seedling emergence and produced both summer and autumn achenes [32]. In Pennsylvania, prostrate knotweed plants began producing seeds by late May and continued fruiting until killed by frost in the fall [71]. In north-central Arizona, prostrate knotweed produced seeds from early September to mid-November.

Prostrate knotweed plants are killed by frosts in the fall. A weed identification guide reports that clusters or mats of dead stems persist through the winter [150].

REGENERATION PROCESSES:

Prostrate knotweed reproduces by seed [32,113].

Pollination and breeding system: Prostrate knotweed flowers are hermaphroditic. Chasmogamous and cleistogamous flowers may occur on the same plant. Most sources suggest that prostrate knotweed self-pollinates, though the presence of chasmogamous flowers suggests that cross-pollination is possible. There are numerous reports of flower visitation by insects [32]. In the Sacramento Valley of California, representatives of more than 36 insect taxa were observed feeding on the nectar of prostrate knotweed. Because flowers are often at or near ground level, they attract both aerial and terrestrial insects [22].

Seed production: A single prostrate knotweed plant may produce 125 to 6,400 achenes, depending on resource availability [32]. In Pennsylvania, early-season seed crops were greater than late-season seed crops, though some seeds were produced throughout the growing season [71]. In North Dakota, 2 prostrate knotweed plants collected in different years produced 4,600 seeds [136] and 6,380 seeds [135]. Growing conditions for collected plants were not described, though it was noted that the plants were of "average" size and free of "competition" from other plants [135,136]. In the deserts of Death Valley National Monument, prostrate knotweed reproduction was limited by lack of precipitation or soil moisture [59].

Seed dispersal: Prostrate knotweed seeds are dispersed by birds, mammals, and water [32,157]. Its seeds may also be dispersed by vehicles [153] or other mechanical means. Prostrate knotweed seeds may contaminate crop seeds and be spread upon planting. They may be ingested and spread by livestock [32] or through the spreading of cow manure [111]. Prostrate knotweed seeds were found floating in irrigation water in Nebraska [163] and Washington [82].

Seed banking: Prostrate knotweed seeds form a persistent seed bank [32]. Some prostrate knotweed seeds (<1%) were viable after 19.7 years of burial in subarctic conditions near Fairbanks, Alaska. Seeds buried at shallower depths lost viability faster than those buried at greater depths; over the course of the study, the annual rate of viability decline was 40% for seeds buried at 1 inch (2 cm) and 29% for seeds buried at 6 inches (15 cm) [30]. From mine sites in the United Kingdom, prostrate knotweed seeds germinated from soil samples stored for 4 years, and germinated from samples taken from as deep as 7 feet (2 m) in the soil [43].

The density of prostrate knotweed seeds in the soil seed bank is variable, and may be high even in areas where prostrate knotweed does not occur in the extant vegetation. At saline sites in Ohio, the mean number of seeds found in 100 cm^2 of soil ranged from approximately 50 to 225 [58]. Seeds of prostrate knotweed were found at a low density (4.3 seeds/m^2) in the seed bank of a forested woodlot in southern Ontario [21]. In northeastern Ohio, prostrate knotweed was not present in the extant vegetation but occurred in the soil seed bank (2,631.6 seeds/m^2) of a highly saline saltpan [51]. In Argentina, prostrate knotweed was present in the soil seed bank of 2- to 4-year-old successional fields but was not present in the extant vegetation. It was a dominant species in nearby croplands [39].

Germination: Prostrate knotweed seeds require moist-cold stratification for germination [9]. One source suggests that achenes produced in different seasons (summer and autumn) are fundamentally different in their dormancy and

germination characteristics, but most studies do not specify which type of seed was tested. Personal observations of the authors suggested that the small, summer achenes have a strong primary dormancy and may constitute the persistent seed bank. These seeds must undergo a moist-cold stratification at 35 °F to 54 °F (1.6 °C-12 °C) for 12 to 110 days to break dormancy. In contrast, autumn achenes are larger, have a weak innate dormancy, and are capable of germinating immediately if exposed to temperatures of 70 °F to 80 °F (20-25 °C). If temperatures are lower, they germinate in the spring in a single flush at temperatures as low as 40 °F (5 °C). The authors suggested that most germination studies likely refer to summer seeds [32].

Temperature: Low winter temperatures release seed dormancy while high summer temperatures reinforce dormancy [9,10,11,34]. In laboratory experiments, prostrate knotweed seeds required a 40 °F (5 °C) treatment in the dark to germinate. Optimum germination (100%) was obtained after a 90-day cold-stratification at 40 °F (5 °C) [83].

Moisture: Prostrate knotweed seed germination is favored by moisture [11,28]. Laboratory germination tests showed that seeds exposed to low moisture had low germination (<5%) and showed no response to light treatments. Fluctuating soil moisture improved germination rates. Seeds exposed to constant moisture at 35 °F (1.6 °C) had low germination rates (<5%) while those exposed to fluctuating soil moisture had higher germination rates (approximately 40%). Fluctuations in soil moisture also improved germination rates of seeds kept in the dark, suggesting that such fluctuations may allow prostrate knotweed seeds to bypass the light requirement for germination in some situations. The authors suggested that deeply buried seeds would not be exposed to such moisture fluctuations [11].

Light: While some sources report that prostrate knotweed seeds require light to break dormancy [10,11], one study suggests that light is not required but improves germination rates. In laboratory germination tests in Kentucky, prostrate knotweed seeds exposed to several thermoperiods germinated from January to June, at rates of 70% to 90% for seeds exposed to light, and 1% to 26% for seeds kept in the dark [7].

Depth: Seed burial depth may influence germination rates, though results from experiments are not consistent. A review states that most seedlings emerge from the top 1 inch (3 cm) of soil and emergence declines with depth of burial [32]. In growth chamber experiments, shallow burial (<0.5 inches (1.25 cm) increased germination while deep burial (1 to 4 inches (2.5-10 cm)) decreased it [66]. In contrast, other laboratory experiments showed that germination rates were higher for prostrate knotweed seeds buried from 5.5 to 6 inches (14-15 cm) compared to those buried at depths ranging from 0 to 4 inches (0-10 cm). Dormancy was induced earlier for seeds closer to the soil surface than those buried at various depths beneath the soil. The authors suggested that dry conditions near the soil surface could induce dormancy [34].

Disturbance: Soil disturbance and scarification may improve germination rates. In field experiments using potted seeds in Ireland, germination began in late February, peaked in April, and ceased by the end of May. Soil disturbance in March increased seed germination (from 4% to 21%), though germination still ceased by the end of May. Soil disturbance at times other than late March or early April had no impact on seed germination, nor did it impact the timing of seedling emergence the following year. Mechanical or sulfuric acid removal of the pericarp increased germination rates [34].

Salinity: The impacts of salinity on germination are not clear. In laboratory experiments, exposure of prostrate knotweed seeds to highly saline conditions led to higher germination rates; germination rates were higher at electrical conductivities of 200 mS/m and 250 mS/m compared to electrical conductivities ranging from 0 to 150 mS/m (P=0.05) [130]. Other laboratory experiments also showed prostrate knotweed seeds to be moderately salt tolerant; the cumulative germination percentage of seeds decreased as salinity increased, though some seeds did germinate at the highest salinity (300 mM NaCl) [83]. In contrast, germination of seeds removed from saline soils in Ohio varied little in relation to soil salinity, and laboratory trials showed germination rates decreasing with increasing salinity [58].

Seedling establishment and plant growth:

Seedlings: A weed identification guide reports that prostrate knotweed seedlings grow slowly [150]. Prostrate knotweed seedlings may reach high densities, though as of this writing (2010) there were no quantitative descriptions of seedling densities in natural plant communities. In experimental winter wheat (*Triticum* sp.) fields in Spain,

prostrate knotweed seedling density was 3 times higher in tilled than untilled fields (P<0.05), exceeding 100 seedlings/m². A few new seedlings were observed after precipitation events in all tillage systems and precipitation appeared to increase survival [152]. In laboratory experiments, high salinity appeared to improve the growth of prostrate knotweed seedlings [130]. In garden experiments in Pennsylvania, a fungal rust caused the mortality of an entire seedling population [71].

Mature plants: One flora describes prostrate knotweed as "vigorous" [121]. In dense lawns of Bermuda grass, prostrate knotweed patches increased 5 feet (1.5 m) in diameter in a growing season [1]. In garden experiments in Pennsylvania, prostrate knotweed had a higher survival rate in plots where it was planted with native species than where it was planted in monocultures (P<0.05) [71]. In the deserts of Death Valley National Monument, prostrate knotweed survival and reproduction was limited by precipitation and/or soil moisture [59].

Vegetative regeneration: Prostrate knotweed does not reproduce vegetatively [32,113], though one flora describes it as "often rooting at the nodes" [155].

SITE CHARACTERISTICS:

Site types: A weed identification guide reports that prostrate knotweed is commonly found in areas with trampled, compacted soil, and persists in areas where other species do not grow well or are damaged [150]. Floras report that prostrate knotweed occurs on a variety of disturbed sites [44,46,47,48,121,154,155,165,169] including roadsides [69,81,98,121,154], railroad embankments [154], and sidewalk cracks [98,154]. Prostrate knotweed also establishes in disturbed areas associated with hiking trails [93], eroded or overgrazed mountain meadows [113], and mine sites [72,125]. Prostrate knotweed is also common in cultivated fields [61,65,69,70,113,138], pastures [155], lawns [98,154], gardens [69], and near dwellings [116].

Elevation: Prostrate knotweed occurs at a wide range of elevations (100 to 10,120 feet (30-3,080 m) in North America.

Elevation of sites with prostrate knotweed in North America	
Location	Elevation (feet)
Arizona	100 to 8,500 [113]
Colorado	5,000 to 9,500 [70]
Hawaii	3,280 to 6,820 [40,155]
Montana	2,200 [17]
Nevada	8,600 to 9,500 [142]
New Hampshire	3,800 [54]
New Mexico	2,700 [168]
Utah	2,495 to 10,120 [160]

Soil: Prostrate knotweed tolerates a wide range of soil conditions, the extremes of which may not be favorable to other plants. One review states that prostrate knotweed grows well in soils that are compacted, poorly aerated, poor to rich in nutrients, and of all types and textures. Prostrate knotweed also tolerates soils with a high salt content, high calcium content, heavy metal contamination, and a range of pH (5 to 8.4) [32]. In China, prostrate knotweed established and grew "prolifically" in soils with pH 3.5 [174]. Observations from Colorado suggest that prostrate knotweed was one of few species able to establish in heavily eroded areas following severe sheet erosion [77]. In Iran, prostrate knotweed established on dried lead and zinc mine waste pools that had elevated levels of cadmium, copper, iron, nitrogen, lead, and zinc [24]. Also in Iran, prostrate knotweed grew at higher densities than any other plant on soils contaminated with petroleum products, and contamination did not prevent germination [110].

Prostrate knotweed is reported on soils of various types and textures in North America. Several studies report it growing on sandy soil. In central Arizona, prostrate knotweed occurred on riparian silt and sand [166]. Along the

Colorado River in Arizona, it established on loamy sand [134]. In northeastern Wyoming it occurred on sandy loam [3]. Prostrate knotweed also established on a sand bar in Lake Superior, Minnesota [90] and on exposed lake sediment in northwestern New Mexico [168]. In northwestern Colorado, is established on alluvial soil with a heavy clay content [6]. On the ridges of Monument Peak, Oregon, prostrate knotweed occurred in shallow, gravelly soils on rocky outcrops [4].

Several sources report prostrate knotweed growing on shallow soils [4,8,71]. Prostrate knotweed grows on both dry and moist soils [113]. In northwestern New Mexico, prostrate knotweed established adjacent to a lakebed and survived for a year despite partial submergence [168].

Prostrate knotweed occurs on saline sites [15,16,17,51,58,148]. In Nebraska, prostrate knotweed was widely scattered along the borders of salt pans, establishing in areas with low salinity (0.5% to 0.7% total salts) compared to areas where it did not establish [148]. On brine spill sites in Ohio, prostrate knotweed tolerated moderate salinity levels, though an increase in salinity was correlated with lower prostrate knotweed abundance, higher mortality, earlier senescence, lower aboveground biomass, and lower germination rates [58]. In northeastern Ohio, prostrate knotweed was not present in the extant vegetation but occurred in the soil seed bank of a highly saline (3.5% NaCl) saltpan [51].

Climate: Prostrate knotweed occurs in a wide range of climates, from subtropical to subarctic [32]. Precipitation varies across the range of prostrate knotweed.

Average annual precipitation for locations with prostrate knotweed in North America	
Location	Average annual precipitation (mm)
Arizona	215 [134]
	444 [88]
Colorado	310 [56]
	540 [167]
Idaho	280 [27]
Montana	305 [17]
Nebraska	686 [2]
Ohio	1,010 [58]
Oregon	1,780 [108]
Texas	1,040 [128]
Wyoming	226 [72]

Prostrate knotweed can withstand drought [2,18,32,113], though slow growth and low survivorship was linked to low precipitation and soil moisture in the deserts of Death Valley National Monument [59].

SUCCESSIONAL STATUS:
Prostrate knotweed establishes in early successional plant communities, though it may persist into later successional stages. Prostrate knotweed established in early succession on heavily eroded buttes in the Badlands region of western North Dakota [79]. In abandoned fields in Colorado, prostrate knotweed occurred in a full range of field ages, including fields abandoned 3 months prior to sampling, and fields abandoned for 62 years [77]. In blue grama and buffalo grass grasslands in eastern Colorado, prostrate knotweed dominated abandoned roads in the early stages of succession. Prostrate knotweed density was highest on roadbeds 2 years after abandonment. It occurred infrequently >5 years after road abandonment [126]. In mixed-grass prairies in southeastern Wyoming, prostrate knotweed was one of several annuals dominating the vegetation in the first years following plowing or scraping and was seldom observed 10 years after disturbance [124]. At mine sites in Wyoming, prostrate knotweed was a dominant species 1 to 4 years following plantings of native shrubs and grasses at one location [72] and established within 2 years of soil placement in another location [125]. Prostrate knotweed has also been reported at numerous sites in the first few years following

fire [27,35,42,60,64,88,106,112,115,143,167]. See Plant response to fire for more information.

Several sources report a preference for open sites [50,116,160] and light is generally though to improve germination.

Prostrate knotweed establishes on disturbed sites, including logged areas [156], revegetating mine sites [72,125], scraped and plowed mixed-grass prairie [124], roads, hiking trails [93], ski runs [142], backcountry shelters [54], heavily eroded areas [77,79], exposed sand bars [90], and lake shores [168]. Prostrate knotweed is often associated with locations disturbed by domestic and wild animals. It tolerates trampling [113,160,168] and is found in areas heavily grazed by cattle [149] and bison [143,158]. In old fields in Germany, prostrate knotweed established in areas grubbed by wild boars [107]. Prostrate knotweed also commonly establishes in the highly disturbed areas surrounding black-tailed prairie dog towns [93,149].

Some sources report prostrate knotweed occurring in disturbed areas but not in adjacent undisturbed plant communities. In southern Nevada, prostrate knotweed established on ski runs but did not spread into surrounding forests [142]. In deciduous riparian forests in southeastern Arizona, prostrate knotweed was present in the soil seed bank in areas that had some human disturbance but was absent from the seed bank in undisturbed areas [120].

Though examples of prostrate knotweed spreading from disturbed areas into undisturbed areas are lacking in the literature (2010), some sources report it occurring in adjacent disturbed and undisturbed areas, suggesting that such spread is possible. Prostrate knotweed occurred both along roadsides and in the interior of ponderosa pine forests in Arizona, though populations were more dense and occurred more frequently along roadsides [60]. In the northern Rocky Mountains, prostrate knotweed occurred in both disturbed areas (e.g., ditch banks and logged areas) as well as nearby undisturbed areas (e.g., subalpine meadows) [156].

FIRE EFFECTS AND MANAGEMENT

SPECIES: Polygonum aviculare

FIRE EFFECTS:

Immediate fire effect on plant: As of this writing (2010), no information was available about the immediate effects of fire on prostrate knotweed. It is likely that fire would kill entire plants. Information was also lacking on fire effects on prostrate knotweed seeds.

Postfire regeneration strategy [137]:
Ground residual colonizer (on site, initial community)
Initial off-site colonizer (off site, initial community)

Fire adaptations and plant response to fire:

Fire adaptations: As of 2010, there was no published information regarding prostrate knotweed adaptations to fire. The information presented here is inferred from reported botanical traits.

Prostrate knotweed does not regenerate vegetatively (See Vegetative regeneration), so on-site plants would likely be

killed by fire. Available literature suggests prostrate knotweed may establish after fire, either from seed in the soil or dispersed from off-site sources; prostrate knotweed forms a persistent seed bank and seeds may germinate from depths > 4 inches (10 cm), where heat damage from fire is unlikely. Prostrate knotweed seedlings were found as soon as 2 to 3 months following prescribed fire in a Kansas tallgrass prairie [115] and 6 months after prescribed fire in a Wisconsin prairie [42]. However, it is also possible that fire may create dry conditions (e.g., through litter consumption and soil exposure) that would inhibit prostrate knotweed seed germination and seedling survival, despite other postfire conditions (e.g., full sun, disturbance (see Successional status)) that may appear conducive to prostrate knotweed establishment in burned areas. This topic warrants further study.

Plant response to fire: As of 2010, several studies documented prostrate knotweed occurring in burned areas. However, limited inferences can be made regarding the response of prostrate knotweed to fire because few studies present information on prefire conditions, fire characteristics vary between studies or are not described, and details regarding prostrate knotweed response are lacking.

Several studies document prostrate knotweed establishing soon after fire in a wide range of plant communities. In interior Alaska, prostrate knotweed was found 2 years following wildfire in several roadside locations [31]. Prostrate knotweed was reported approximately 1 year following a high-severity fire in a chaparral plant community in central California [64]. In east-central Arizona, prostrate knotweed occurred in >5% of study plots, in areas of both high and low burn severity, 2 to 3 years after after a wildfire in ponderosa pine forests [88]. In central Kansas, prostrate knotweed occurred in trace amounts in 2 tallgrass prairie sites that were seasonally grazed and burned every 1 to 3 years; the most recent fire occurred 2 to 3 months prior to sampling [115]. In restoration plantings of native prairie grasses in Wisconsin, prostrate knotweed occurred at low frequency (≤2% cover) in all treatments 6 months after mowing, mowing-and-burning, and no treatment. The fire consumed all living and dead material on the plot [42]. At Saratoga National Historic Park, New York, prostrate knotweed occurred in old fields routinely managed with mowing and prescribed fire [131].

It is not clear whether or not fire favors prostrate knotweed populations. One study reports prostrate knotweed increasing in response to fire. Compared to pretreatment conditions, the frequency of prostrate knotweed detection increased from 0 to 0.17 (SE=0.12) 3 years after thinning and 2 years after low- to moderate-severity spring prescribed fire in Douglas-fir and ponderosa pine forests in western Montana. The authors suggested that prostrate knotweed likely established from off-site seed. See the Research Project Summary for more information on treatments and conditions for this study [106]. Another study reports no change in prostrate knotweed densities in sites sampled before and after prescribed fire in Arizona ponderosa pine forests. One year after a low-severity prescribed fire, prostrate knotweed populations did not show any significant change in density or frequency compared to prefire levels in either roadside or forest interior sampling areas [60]. A third study reports prostrate knotweed disappearing by the 2nd year after fire. In a Wyoming big sagebrush/bluebunch wheatgrass plant community in Idaho, prostrate knotweed occurred at low levels (1% cover) the 1st year following a mixed-severity autumn prescribed fire. It was not reported the 2nd year after fire [27].

Several studies report prostrate knotweed occurring in burned areas but not in nearby unburned areas. Two years following wildfire in Arizona ponderosa pine forests, prostrate knotweed was not present in unburned forest but occurred at low levels (<0.5% cover) on sites that experienced moderate- and high-severity fires. It established in areas with little litter but high levels of bare soil [35]. Prostrate knotweed was found infrequently 2 years after an autumn wildfire in Utah juniper-Colorado pinyon woodlands in central Utah. It was not found 1 or 3 years after fire, nor was it found in adjacent unburned areas in 3 years of sampling [112]. In montane grasslands in Rocky Mountain National Park, Colorado, prostrate knotweed established in study plots 1 year after they were burned with a propane torch until all aboveground biomass was consumed. It did not establish in unburned study plots [167].

One study suggests that prescribed fire favors prostrate knotweed and that fire-return intervals may influence its presence. On the edge of bison wallows in northeastern Kansas tallgrass prairie, prostrate knotweed had 1.19% cover on annually burned sites and was absent from sites burned at 4-year intervals and from adjacent unburned grazed prairie [143].

FUELS AND FIRE REGIMES:

Fuels: As of 2010, little is known about the fuel characteristics of prostrate knotweed. The potential for prostrate knotweed to alter fuel characteristics likely varies by plant community. It is not clear whether the persistence of dead mats of vegetation or stems from year to year would represent an increased fuel load or fire hazard.

Fire regimes: It is not known what type of fire regime prostrate knotweed is best adapted to. Results from a study in a northeastern Kansas tallgrass prairie suggest that annual prescribed fire is more favorable to prostrate knotweed than fire at 4-year intervals or no fire [143]. However, it is impossible to make valid generalizations from a single study from a single plant community. As the Fire Regime Table indicates, prostrate knotweed occurs in a wide range of North American plant communities that exhibit a full range of fire regime characteristics. It is also likely that prostrate knotweed occurs in plant communities and associated fire regimes not presented in this table. See the full Fire Regime Table for information on fire regimes of other plant communities of interest. The impacts of prostrate knotweed on these fire regimes are unknown.

FIRE MANAGEMENT CONSIDERATIONS:

Potential for postfire establishment and spread: Though there are many accounts of prostrate knotweed occurring in areas burned by prescribed fire [27,60,106,115,143] and wildfire [31,35,64,88,112], it is not clear whether postfire conditions favor or limit prostrate knotweed populations. As of this writing (2010) no studies have documented major increases in prostrate knotweed populations following fire. Similarly, no studies document the use of prescribed fire to control prostrate knotweed populations.

Prostrate knotweed's documented affinity for disturbed sites (see Successional status), and reports of its presence in disturbed areas within a fire perimeter (e.g., roadsides [31,60], bison wallows [143]) suggest that disturbed areas within a fire perimeter are likely places for prostrate knotweed to establish. The results of one study also suggest that prostrate knotweed establishment may be facilitated by human activities or disturbance in or near burned areas. One to 3 years following wildfire in Glacier National Park, Montana, prostrate knotweed was found in trace amounts in bulldozed firelines constructed in wildfire suppression efforts. It was not found in adjacent burned or unburned areas [13]. It is not known whether or not prostrate knotweed eventually spread from firelines into adjacent burned or unburned areas.

Preventing postfire establishment and spread: Preventing invasive plants from establishing in weed-free burned areas is the most effective and least costly management method. This may be accomplished through early detection and eradication, careful monitoring and follow-up, and limiting dispersal of invasive plant seed into burned areas. General recommendations for preventing postfire establishment and spread of invasive plants include:

- Incorporate cost of weed prevention and management into fire rehabilitation plans
- Acquire restoration funding
- Include weed prevention education in fire training
- Minimize soil disturbance and vegetation removal during fire suppression and rehabilitation activities
- Minimize the use of retardants that may alter soil nutrient availability, such as those containing nitrogen and phosphorus
- Avoid areas dominated by high priority invasive plants when locating firelines, monitoring camps, staging areas, and helibases
- Clean equipment and vehicles prior to entering burned areas
- Regulate or prevent human and livestock entry into burned areas until desirable site vegetation has recovered sufficiently to resist invasion by undesirable vegetation
- Monitor burned areas and areas of significant disturbance or traffic from management activity
- Detect weeds early and eradicate before vegetative spread and/or seed dispersal
- Eradicate small patches and contain or control large infestations within or adjacent to the burned area
- Reestablish vegetation on bare ground as soon as possible
- Avoid use of fertilizers in postfire rehabilitation and restoration
- Use only certified weed-free seed mixes when revegetation is necessary

For more detailed information on these topics see the following publications: [5,19,62,146].

Use of prescribed fire as a control agent: Though several studies document prostrate knotweed occurring after prescribed fire [27,60,106,115,143], there is no information available on the use of prescribed fire to specifically control prostrate knotweed. Its annual habit and lack of vegetative regeneration suggest that prescribed fire would kill established prostrate knotweed plants. However, its presence following prescribed fire suggests that either on-site seeds survive fire or its dispersal mechanisms facilitate establishment from off-site sources. In control treatments targeting nonnative annual grasses in native prairies in Wisconsin, prostrate knotweed occurred at low frequency 6 months following mowing (2%), mowing-and-burning combinations (2%), and no treatment (1%) [42]. Pretreatment occurrence of prostrate knotweed was not reported so it is not known if prostrate knotweed increased following treatments. However, its low frequency in both treated and untreated areas suggest that the treatments did not result in major changes in prostrate knotweed frequency. In northeastern Kansas, prostrate knotweed's presence in annually burned tallgrass prairies and not in prairies burned every 4 years or in unburned prairies [143] suggests that prescribed fire conducted at short return intervals may encourage prostrate knotweed on these sites. However, it is not clear what conditions (e.g., constant soil disturbance, lack of other vegetative cover) promoted prostrate knotweed's establishment in annually burned areas.

Results from post-wildfire weed control attempts in Alaska suggest that the combination of fire with other control methods may be effective at controlling prostrate knotweed. In interior Alaska, prostrate knotweed was found 2 years following wildfire in several roadside locations. At one site, approximately 25 prostrate knotweed seedlings established along a trail 2 years after fire. Observers described the seedlings as having "very low aggressiveness". The seedlings were manually pulled from the site in approximately 15 minutes. The following year, no prostrate knotweed seedlings were observed [31].

MANAGEMENT CONSIDERATIONS

SPECIES: Polygonum aviculare

FEDERAL LEGAL STATUS:
None

OTHER STATUS:
Information on state-level noxious weed status of plants in the United States is available at Plants Database.

IMPORTANCE TO WILDLIFE AND LIVESTOCK:
Prostrate knotweed is consumed by a variety of wildlife species as well as some livestock. However, in Australia, the death of several horses from nitrite toxicity was attributed to eating prostrate knotweed [85].

Palatability and/or nutritional value: Prostrate knotweed seeds are consumed by birds [32,138] including the American coot [14], mallard, killdeer [41], rock dove [114], sharp-tailed grouse [140], California quail [36], and American tree sparrow [12]. Leaves may be consumed by birds [138] such as the sharp-tailed grouse [140]. Small mammals may also consume parts of prostrate knotweed [101]. One black-tailed prairie dog stomach contained >20,000 prostrate knotweed seeds [86]. Eastern cottontails consumed prostrate knotweed in Missouri [87]. Prostrate knotweed is browsed by mule deer [38,75] and pronghorn [161,173]. Insects feed on the seeds [101] and nectar [22].

In Australia, prostrate knotweed is used as a fodder plant for pigs (review by [32]). Free-ranging domestic cattle

consumed prostrate knotweed while foraging in ponderosa pine forests in central Colorado [38]. Domestic geese did not feed on prostrate knotweed in feeding trials, even when it was the only food available [170].

Cover value: No information is available on this topic.

OTHER USES:
Prostrate knotweed is reported to have many medicinal uses, including the treatment of gingivitis, cardiovascular conditions, infections, and immunity disorders (review by [32]). Prostrate knotweed tea has been used to treat asthma [44] and diarrhea [70]. One source reports that exposure to prostrate knotweed may cause dermatitis [78]. According to English medieval superstition, an infusion of prostrate knotweed stems and leaves could stunt the growth of young boys or animals. Such properties were recognized by Shakespeare, who referred to "knot-grass" in *A Midsummer Night's Dream*: "Get you gone, you dwarf;/You minimus, of hindering knot-grass made" (review by [32]).

Prostrate knotweed seeds are edible to humans, either whole or ground into flour [70,98]. In China, people eat young prostrate knotweed shoots and leaves and drink prostrate knotweed tea (review by [32]).

Prostrate knotweed has been used in phytoremediation of soils contaminated with heavy metals [24] or crude oil [110]. It may also be used in erosion control (review by [32]). In China, parts of prostrate knotweed are used as an insecticide to control the pear leaf weevil (*Rhynchites coreanus*) and to treat maggots and roundworms in pigs [171]. Prostrate knotweed is a valued honey plant in Greece [45] and Australia. In China, flowering stems are used as a textile dye (review by [32]).

IMPACTS AND CONTROL:
Impacts: Most reported impacts of prostrate knotweed are related to its establishment in crop fields [123]. Prostrate knotweed is problematic in >60 crop species worldwide. Its density in agricultural fields was as high as 28.3 plants/m², as was recorded in a barley field in Alberta. Prostrate knotweed establishment reduces yield for some crops. Its stems may inhibit the mechanical harvest of other crops (e.g., onions, carrots) (review by [32]) and may act as an alternate host for crop pathogens [123]. Prostrate knotweed is also considered a nuisance in lawns, sidewalks, and paved areas (review by [32]).

Prostrate knotweed's impact on native plant communities is not well documented. A weed information guide suggests that dense mats of prostrate knotweed may smother herbaceous species and small shrubs [157]. Prostrate knotweed also has allelopathic qualities (review by [32]). In laboratory tests, soil collected from under prostrate knotweed inhibited the growth of several plant species, including Bermuda grass, Madagascar dropseed (*Sporobolus pyramidatus*), lambsquarters, sorghum (*Sorghum bicolor*), and Creole cotton (*Gossypium barbadense*). The soil used in this study was collected 4 months after prostrate knotweed plants died in the fall, suggesting that toxins may persist in the soil. Prostrate knotweed aboveground parts, roots, and root exudates also inhibited germination and growth of several crop and nonnative plant species [1].

Control: In all cases where invasive species are targeted for control, no matter what method is employed, the potential for other invasive species to fill their void must be considered [20]. 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 [97].

Fire: For information on the use of prescribed fire to control this species, see Fire Management Considerations.

Prevention: It is commonly argued that the most cost-efficient and effective method of managing invasive species is to prevent their establishment and spread by maintaining "healthy" natural communities [97,127] (e.g., avoid road building in wildlands [145]) and by monitoring several times each year [76]. Managing to maintain the integrity of the native plant community and mitigate the factors enhancing ecosystem invasibility is likely to be more effective than managing solely to control the invader [74].

Weed prevention and control can be incorporated into many types of management plans, including those for logging and site preparation, grazing allotments, recreation management, research projects, road building and maintenance, and

fire management [146]. See the Guide to noxious weed prevention practices [146] for specific guidelines in preventing the spread of weed seeds and propagules under different management conditions.

Cultural control: Laboratory studies report that extracts from some cover crops, including rye (*Secale cereale*) and brown mustard (*Brassica juncea*), reduced germination of prostrate knotweed seeds and rootlet and shoot length of prostrate knotweed seedlings [52].

Physical or mechanical control: Mechanical control methods alone are usually not effective at controlling prostrate knotweed, but integration with other control methods (e.g., chemical) may improve treatment effectiveness. Soil solarization controlled prostrate knotweed in some areas (review by [32]). In interior Alaska, roadside prostrate knotweed seedlings establishing 2 years after fire were manually pulled in approximately 15 minutes. The following year, no prostrate knotweed seedlings were observed [31]. To prevent seed dispersal, a weed information guide suggests cutting plants prior to seed set [157] (e.g., late May in Pennsylvania [71]).

Prostrate knotweed's low stature makes mowing treatments largely ineffective [154]. Bark mulching favored prostrate knotweed in apple orchards (review by [32]). Flaming and hot-steaming did not control prostrate knotweed in Nova Scotia and Slovakia (Rifai and others 2001 as cited in [32])

Biological control: As of this writing (2010) no biological control agent has been identified to control prostrate knotweed. In North America, prostrate knotweed hosts several insects, nematodes, fungi, and viruses (review by [32]). In garden experiments in Pennsylvania, a fungal rust killed all prostrate knotweed seedlings. Seedlings emerging the following year also died, and the entire prostrate knotweed population was killed [71].

Biological control of invasive species has a long history that indicates many factors must be considered before using biological controls. Refer to these sources: [151,162] and the Weed control methods handbook [144] for background information and important considerations for developing and implementing biological control programs.

Chemical control: Both pre- and postemergent herbicides are effective at controlling prostrate knotweed (review by [32]), though a flora reports that prostrate knotweed resists herbicides [44]. The effectiveness of chemical control decreased with time in one cropping system experiment [175]. In commercial agricultural fields in California, exposure to several soil fumigants reduced the percentage of viable prostrate knotweed seeds. In areas exposed to the fumigant, 2.7% of seeds were viable, compared to 36.4% viability in areas not exposed to the fumigant [67].

Herbicides are effective in gaining initial control of a new invasion or a severe infestation, but they are rarely a complete or long-term solution to weed management [23]. See the Weed control methods handbook [144] for considerations on the use of herbicides in natural areas and detailed information on specific chemicals.

Integrated management: No information is available on this topic.

APPENDIX: FIRE REGIME TABLE

SPECIES: Polygonum aviculare

The following table provides fire regime information that may be relevant to prostrate knotweed habitats. Follow the links in the table to documents that provide more detailed information on these fire regimes.

Fire regime information on vegetation communities in which prostrate knotweed may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [92], which were developed by local experts using available literature, local data, and/or expert opinion. This table summarizes fire regime characteristics for each plant community listed. The PDF file linked from each

plant community name describes the model and synthesizes the knowledge available on vegetation composition, structure, and dynamics in that community. Cells are blank where information is not available in the Rapid Assessment Vegetation Model.

Pacific Northwest	California	Southwest	Great Basin	Northern and Central Rockies
Northern Great Plains	Great Lakes	Northeast	South-central US	Southern Appalachians

Pacific Northwest

- Northwest Grassland
- Northwest Shrubland
- Northwest Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northwest Grassland					
Marsh	Replacement	74%	7		
	Mixed	26%	20		
Bluebunch wheatgrass	Replacement	47%	18	5	20
	Mixed	53%	16	5	20
Idaho fescue grasslands	Replacement	76%	40		
	Mixed	24%	125		
Alpine and subalpine meadows and grasslands	Replacement	68%	350	200	500
	Mixed	32%	750	500	>1,000
Northwest Shrubland					
Low sagebrush	Replacement	41%	180		
	Mixed	59%	125		
Northwest Forested					
Sitka spruce-western hemlock	Replacement	100%	700	300	>1,000
Pacific silver fir (high elevation)	Replacement	69%	500		
	Mixed	31%	>1,000		

California

- California Grassland

- California Shrubland
- California Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
California Grassland					
Herbaceous wetland	Replacement	70%	15		
	Mixed	30%	35		
California Shrubland					
Coastal sage scrub	Replacement	100%	50	20	150
Chaparral	Replacement	100%	50	30	125
Montane chaparral	Replacement	34%	95		
	Mixed	66%	50		
California Forested					
Mixed conifer (North Slopes)	Replacement	5%	250		
	Mixed	7%	200		
	Surface or low	88%	15	10	40
Sierra Nevada lodgepole pine (dry subalpine)	Replacement	11%	250	31	500
	Mixed	45%	60	31	350
	Surface or low	45%	60	9	350

Southwest

- Southwest Shrubland
- Southwest Woodland
- Southwest Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Southwest Shrubland					
Gambel oak	Replacement	75%	50		
	Mixed	25%	150		

Southwest Woodland					
Mesquite bosques	Replacement	32%	135		
	Mixed	67%	65		
Pinyon-juniper (mixed fire regime)	Replacement	29%	430		
	Mixed	65%	192		
	Surface or low	6%	>1,000		
Pinyon-juniper (rare replacement fire regime)	Replacement	76%	526		
	Mixed	20%	>1,000		
	Surface or low	4%	>1,000		
Ponderosa pine/grassland (Southwest)	Replacement	3%	300		
	Surface or low	97%	10		
Southwest Forested					
Riparian deciduous woodland	Replacement	50%	110	15	200
	Mixed	20%	275	25	
	Surface or low	30%	180	10	
Ponderosa pine-Gambel oak (southern Rockies and Southwest)	Replacement	8%	300		
	Surface or low	92%	25	10	30
Ponderosa pine-Douglas-fir (southern Rockies)	Replacement	15%	460		
	Mixed	43%	160		
	Surface or low	43%	160		

Great Basin

- Great Basin Woodland
- Great Basin Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Great Basin Woodland					
Juniper and pinyon-juniper steppe woodland	Replacement	20%	333	100	≥1,000
	Mixed	31%	217	100	≥1,000
	Surface or low	49%	135	100	
Great Basin Forested					
Spruce-fir-pine (subalpine)	Replacement	98%	217	75	300
	Mixed	2%	>1,000		

Northern and Central Rockies

- Northern and Central Rockies Grassland
- Northern and Central Rockies Shrubland
- Northern and Central Rockies Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northern and Central Rockies Grassland					
Mountain grassland	Replacement	60%	20	10	
	Mixed	40%	30		
Northern and Central Rockies Shrubland					
Riparian (Wyoming)	Mixed	100%	100	25	500
Salt desert shrub	Replacement	50%	>1,000	500	>1,000
	Mixed	50%	>1,000	500	>1,000
Wyoming big sagebrush	Replacement	63%	145	80	240
	Mixed	37%	250		
Basin big sagebrush	Replacement	60%	100	10	150
	Mixed	40%	150		
Low sagebrush shrubland	Replacement	100%	125	60	150
Mountain shrub, nonsagebrush	Replacement	80%	100	20	150
	Mixed	20%	400		
Northern and Central Rockies Forested					
Douglas-fir (warm mesic interior)	Replacement	28%	170	80	400
	Mixed	72%	65	50	250
Grand fir-Douglas-fir-western larch mix	Replacement	29%	150	100	200
	Mixed	71%	60	3	75
Western larch-lodgepole pine-Douglas-fir	Replacement	33%	200	50	250
	Mixed	67%	100	20	140
Lower subalpine lodgepole pine	Replacement	73%	170	50	200
	Mixed	27%	450	40	500

Lower subalpine (Wyoming and Central Rockies)	Replacement	100%	175	30	300
Upper subalpine spruce-fir (Central Rockies)	Replacement	100%	300	100	600

Northern Great Plains

- Northern Plains Grassland

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northern Plains Grassland					
Northern mixed-grass prairie	Replacement	67%	15	8	25
	Mixed	33%	30	15	35
Southern mixed-grass prairie	Replacement	100%	9	1	10
Central tallgrass prairie	Replacement	75%	5	3	5
	Mixed	11%	34	1	100
	Surface or low	13%	28	1	50
Northern tallgrass prairie	Replacement	90%	6.5	1	25
	Mixed	9%	63		
	Surface or low	2%	303		
Southern tallgrass prairie (East)	Replacement	96%	4	1	10
	Mixed	1%	277		
	Surface or low	3%	135		

Great Lakes

- Great Lakes Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Great Lakes Forested					
Northern hardwood maple-beech-eastern hemlock	Replacement	60%	>1,000		
	Mixed	40%	>1,000		
Great Lakes floodplain	Mixed	7%	833		

forest	Surface or low	93%	61		
Oak-hickory	Replacement	13%	66	1	
	Mixed	11%	77	5	
	Surface or low	76%	11	2	25

Northeast

- Northeast Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northeast Forested					
Northern hardwoods (Northeast)	Replacement	39%	≥1,000		
	Mixed	61%	650		
Northern hardwoods-eastern hemlock	Replacement	50%	≥1,000		
	Surface or low	50%	≥1,000		
Appalachian oak forest (dry-mesic)	Replacement	2%	625	500	≥1,000
	Mixed	6%	250	200	500
	Surface or low	92%	15	7	26
Beech-maple	Replacement	100%	>1,000		
Northeast spruce-fir forest	Replacement	100%	265	150	300

South-central US

- South-central US Grassland
- South-central US Woodland
- South-central US Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
South-central US Grassland					
Southern tallgrass prairie	Replacement	91%	5		
	Mixed	9%	50		
Oak savanna	Replacement	3%	100	5	110
	Mixed	5%	60	5	250

	Surface or low	93%	3	1	4
South-central US Woodland					
Oak-hickory savanna	Replacement	1%	227		
	Surface or low	99%	3.2		
South-central US Forested					
Southern floodplain	Replacement	42%	140		
	Surface or low	58%	100		

Southern Appalachians

- Southern Appalachians Woodland
- Southern Appalachians Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Southern Appalachians Woodland					
Oak-ash woodland	Replacement	23%	119		
	Mixed	28%	95		
	Surface or low	49%	55		
Southern Appalachians Forested					
Bottomland hardwood forest	Replacement	25%	435	200	≥1,000
	Mixed	24%	455	150	500
	Surface or low	51%	210	50	250
Southern Appalachian high-elevation forest	Replacement	59%	525		
	Mixed	41%	770		

*Fire Severities—
Replacement: Any fire that causes greater than 75% top removal of a vegetation-fuel type, resulting in general replacement of existing vegetation; may or may not cause a lethal effect on the plants.
Mixed: Any fire burning more than 5% of an area that does not qualify as a replacement, surface, or low-severity fire; includes mosaic and other fires that are intermediate in effects.
Surface or low: Any fire that causes less than 25% upper layer replacement and/or removal in a vegetation-fuel class but burns 5% or more of the area [68,91].

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