Holcus lanatus

INTRODUCTORY

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AUTHORSHIP AND CITATION:
Gucker, Corey L. 2008. Holcus lanatus. 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/ [2010, January 29].

FEIS ABBREVIATION:
HOLLAN

NRCS PLANT CODE [148]:
HOLA

COMMON NAMES:
common velvet grass
sweet velvet grass
Yorkshire fog

TAXONOMY:
The scientific name of common velvetgrass is *Holcus lanatus* L. (Poaceae) [9,78]. A review reports that common velvetgrass and creeping velvetgrass (*H. mollis*) hybridize. Hybrids closely resemble creeping velvetgrass [157].

SYNONYMS:
None

LIFE FORM:
Graminoid

FEDERAL LEGAL STATUS:
None

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

DISTRIBUTION AND OCCURRENCE

SPECIES: Holcus lanatus

- GENERAL DISTRIBUTION
- HABITAT TYPES AND PLANT COMMUNITIES

GENERAL DISTRIBUTION:
Common velvetgrass is nonnative but widespread in North America. On the west and east coasts of North America and in Hawaii, common velvetgrass is a widespread nonnative species. Populations are less common in more inland states and provinces [70]. In southeastern Alaska, common velvetgrass was cultivated and had established outside cultivation by 1959 [3]. Common velvetgrass is common to abundant at low elevation sites in the Pacific Northwest [114,134]. In California, it occurs in all but the desert regions [125], and some have referred to it as a "new native" [67]. In Baja California, Nevada, and Arizona, common velvetgrass is likely restricted to northern habitats [79,80,141,165]. Common velvetgrass is essentially absent from the Great Plains [164] and may only occur in Missouri and eastern Kansas [57]. Scattered populations occur in Illinois [98]. In the northeastern United States and adjacent Nova Scotia, common velvetgrass is well established [53,134]. Populations are scattered in southern Quebec and Ontario [134] but common along the Atlantic Coast from North Carolina to Nova Scotia [37]. In Hawaii, common velvetgrass is widely distributed in all but the driest habitats [127] and is often found in pastures, wet disturbed areas, and on roadsides [153]. Grass Manual on the Web provides a distribution map of common velvetgrass in North America.

Common velvetgrass is native to Europe, western Asia, northwestern Africa, and the Canary Islands and is very common throughout temperate Europe [14,15]. A review reports that it was likely introduced several times to both the east and west coasts of North America as a contaminant or an intentional component of imported forage seed [113,134]. As of 1800, common velvetgrass occurred in many parts of North America [9]. Based on early North American floras, it occurred in Pennsylvania by 1755 and was frequent in 1814 [163]. In New England, common velvetgrass introductions probably occurred in the 17th century [92]. The first known collection of common velvetgrass from London, Ontario, occurred in 1879 [134]. In Hawaii, it was first collected in 1909 [153].

HABITAT TYPES AND PLANT COMMUNITIES:
In both its native and nonnative ranges, common velvetgrass occupies a wide range of habitats. In Europe common velvetgrass occurs in pastures, grasslands, wet to mesic meadows, and open forests and woodlands [14,161].

Pacific Coast: Most of the information about North American common velvetgrass populations comes from the

Pacific Coast states, British Columbia, and Hawaii. In the Pacific Coast states, common velvetgrass occurs in the north coastal shrub cover type that is discontinuous from Washington's Olympic Peninsula to Santa Cruz, California, and in the coastal prairie cover type that occurs from Oregon to Monterey, California [8,12,67,107]. In Washington's Puget Trough, common velvetgrass is a typical understory species in Douglas-fir–Pacific madrone/pink honeysuckle (*Pseudotsuga menziesii-Arbutus menziesii* /*Lonicera hispidula*) forests if grazed or near a disturbed or developed area [25]. In the Oregon Coast ranges, common velvetgrass is often dominant in the understory of red alder (*Alnus rubra*) stands before the understory becomes shrub dominated (Henderson 1970, as cited in [49]). In the Willamette Valley, common velvetgrass is frequent in Oregon white oak (*Quercus garryana*) woodlands and tufted hairgrass (*Deschampsia caespitosa*) grasslands (review by [49]).

Common velvetgrass is recognized in the following vegetation classifications:

- common velvetgrass-Queen Anne's lace (*Daucus carota*) community type on moderately disturbed sites in Seattle, Washington's Montlake wildlife area [72]
- common velvetgrass-sweet vernalgrass (*Anthoxanthum odoratum*) community type in Oregon coastal grasslands from northern Tillamook to southern Curry County [119]
- redtop (*Agrostis gigantea*)-common velvetgrass community type on the Salmon River Estuary in Lincoln County, Oregon; restoration of a high water table resulted in high common velvetgrass mortality. For more information, see Flooding/salinity [97]

Hawaii: Common velvetgrass is often associated with grazed areas or sites with feral pig activity. The following vegetation types are potential common velvetgrass habitat in Hawaii: koa-mamane (*Acacia koa*-*Sophora chrysophylla*) forests, koa-`ohi`a (*Metrosideros polymorpha*) montane mesic forests, `ohi`a montane wet forests, Hawaii blackberry (*Rubus hawaiensis*) shrublands, pukiawe-`ohelo `ai (*Styphelia tameiameiae*/*Vaccinium reticulatum*) shrublands, and alpine hairgrass (*Deschampsia nubigena*) grasslands [153].

Atlantic Coast: In Massachusetts, common velvetgrass occurs in little bluestem (*Schizachyrium scoparium*) and "weedy" sandplain grasslands [39]. In West Virginia, it is common in maintained hay meadows [48]. In the southern Appalachians of North Carolina, common velvetgrass cover was 17% in old fields dominated by common cinquefoil (*Potentilla simplex*) [27].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Holcus lanatus

Photo ©Forest and Kim Starr, photo taken in Maui, HI

GENERAL BOTANICAL CHARACTERISTICS:

Botanical description: This description provides characteristics that may be relevant to fire ecology and is not meant for identification. Keys for identification are available (e.g., [69,73,115,152,153]).

Common velvetgrass is typically a pubescent, tufted, perennial grass. However, in the Carolinas and Atlantic Coastal regions, common velvetgrass behaves as an annual [37,115]. European studies revealed that life span and life history can vary with environmental conditions. Plants grown from seed collected from dry, southern European habitats flowered in their first year and died within 2 to 4 years. Plants grown from seed collected in northern Europe failed to flower in their first year and were longer lived. Plants grown from seed collected in exposed maritime habitats displayed a low, spreading growth form and produced leaves that were only 13 inches (32 cm) long, but plants from seed collected from continental habitats were erect and reached 28 to 35 inches (70-90 cm) tall [19].

Aboveground description: Common velvetgrass stems are generally erect, hollow, and grow to 12 to 39 inches (30-100 cm) tall [3,9,73,114,153]. At the base, stems may be somewhat prostrate and produce roots at the nodes [9,31,85]. Leaf blades are flat and measure 4 to 12 mm wide and 2 to 8 inches (5-20 cm) long [31,69,114,153]. Common velvetgrass produces a dense, compact panicle that can reach 6 inches (15 cm) long [3,114,153]. Spikelets are generally 2-flowered. Upper florets are staminate with fairly robust awns that become hooked when dry. Lower florets are perfect [149,153,164]. Common velvetgrass seeds measure 1.5 to 2.5 mm long [115,149].

Belowground description: The common velvetgrass root system is fibrous and concentrated at shallow depths.

Boogie and others (1958, as cited in [134]) indicated that, while common velvetgrass roots may reach 35 inches (90 cm) deep, most roots occur in the top 4 inches (10 cm) of soil. In a heavily grazed pasture in Germany, 51% of common velvetgrass roots were in the top 4 inches (10 cm) of soil, and 16%, 18%, 11%, and 4% of the roots occurred in the subsequent 4-inch (10 cm) depth intervals (Klapp 1943, as cited in [14]).

Site conditions may affect root development. When widely spaced, common velvetgrass may produce "a dense network of fine, whitish, surface roots" on the ground beneath the shading of its own canopy. When water tables are high, root penetation is limited [14]. During a field experiment in the University of York experimental garden, shading reduced common velvetgrass root number and root dry biomass [42].

On Hartz Mountain in Germany, a researcher reported that common velvetgrass produced "subterraneous, elongated creeping rhizomes". Soils on this site had high metal concentrations. While this characteristic was not mentioned elsewhere in the literature, the researcher's examination of herbarium specimens revealed rhizomes on other European collections not associated with heavy metal concentrations (abstract in [40]).

Raunkiaer [116] life form:

Hemicryptophyte
Therophyte

SEASONAL DEVELOPMENT:
Common velvetgrass flowers are possible from May to September in California, Nevada, and Baja California [79,101,165]. In the northeastern United States common velvetgrass typically flowers from June to August [149]. Along the Atlantic Coast, common velvetgrass flowers are possible from May to October [37,115,131]. Anthesis and flowering progress from the apex of the common velvetgrass panicle downwards. Flowering along the entire panicle is typically complete in 4 to 6 days [15]. At the end of the growing season, nutrients are relocated and stored below ground [21].

REGENERATION PROCESSES:
Common velvetgrass reproduces primarily from seed, but tillering is also common and can be important to clump size increases.

- **Pollination and breeding system**
- **Seed production**
- **Seed dispersal**
- **Seed banking**
- **Germination**
- **Seedling establishment and plant growth**
- **Vegetative regeneration**

Pollination and breeding system: A review reports that common velvetgrass flowers are cross pollinated by wind [14]. Experiments have shown that common velvetgrass is "highly self-sterile" [15].

Seed production: A review reports that although seed is generally only produced by lower florets, common velvetgrass is "notoriously a prolific seed producer".

Studies conducted in native and nonnative habitats indicate that common velvetgrass seed production can vary by vegetation type and sowing date. In Britain, common velvetgrass produced 63 to 611 spikelets/panicle in a greenhouse setting [15]. In a "closed" common velvetgrass-dominated grassland in Bangor, United Kingdom, the average number of common velvetgrass seeds/panicle was 270 but ranged from 100 to 380. Average seed production was 19,000 seeds/m² (Mortimer 1974, as cited in [157]). In coastal prairies of Sonoma County, California, common velvetgrass seed rain was 82,300 seeds/m² in a patch type where 91% of the relative cover was common velvetgrass. Seed rain was less than 6,000 seeds/m² in a patch where the relative cover of common velvetgrass was 4.6% [107]. For more on common velvetgrass seed production on newly colonized sites, see Impacts.

During field experiments in Oxford, England, sowing date affected common velvetgrass panicle and seed production. Plants from seed sown in November or December failed to flower. Plants from seed sown from January to June produced large numbers of panicles and seeds/plant. Panicle/plant production decreased from 759 on plants from June-sown seed to 184 on plants from July-sown seed. The greatest number of seeds produced per plant was 240,000 on plants from March-sown seed. The summer was very hot and dry and the winter very mild during these field experiments [156].

Seeds are generally viable soon after they are produced. When researchers tested seed germination at increasing time since anthesis, they found viable seeds 9 days after seed shed. Twenty days after anthesis, germination was 100% [14]. Another review notes that successful flowering depends on vernalization, and that longer cold periods often translate into a longer flowering period [134].

Seed dispersal: There are many potential common velvetgrass seed dispersal vectors. Seeds are easily shed [14], and a large spikelet surface area encourages wind dispersal [14,134]. In a field study in northern California coastal grasslands, 90% of common velvetgrass seeds dispersed within a 17-foot (5.2 m) radial distance from the parent plant. Half of all seeds fell within a 5.6-foot (1.7 m) distance [110]. Water dispersal may be possible, and human and other animal vectors likely aid in seed dispersal.

Water: Buoyancy of comon velvetgrass seed suggests that it may be dispersed by water. In stagnant water, 54% of common velvetgrass seeds remained floating after 25 days and 9% after 90 days. In moving water, 47% remained floating after 25 days and 2% after 90 days. Germination of floating seeds was not tested [150].

Human activities: Mowing equipment was likely an important dispersal vector for common velvetgrass in the Netherlands. After mowing in common velvetgrass-dominated grasslands, 86% of seeds removed from equipment were common velvetgrass [132].

Animals: Worms, birds, rabbits, and cattle are possible dispersers of common velvetgrass seed. McRill (1974, as cited in [121]) reported that common velvetgrass seed was a major component of earthworm castings collected from grasslands in North Wales. Worms are likely important in the burial and unearthing of common velvetgrass seed (McRill 1974, as cited in [156]). Not all birds are likely to disperse common velvetgrass seed. Common velvetgrass seeds that passed through the digestive tract of sparrows were killed, but seeds passing through the digestive tract of rooks had only slightly reduced viability (Krach 1959, as cited in [157]). A small number of common velvetgrass seedlings emerged from rabbit pellets collected from an acidic grassland in Norfolk, United Kingdom. Although field and greenhouse studies indicated that the seed bank was most important to the colonization of bare patches, dispersal and establishment from rabbit pellets was possible [103]. For more on this study, see Seed banking. Common velvetgrass also germinated from cattle dung collected from heather (*Calluna* spp.) moorland in northeastern Scotland [162].

Predation: In a coastal prairie in Sonoma County, California, predation of common velvetgrass seed was low. When petri dishes of common velvetgrass seed were left out for 3 weeks in an annual grassland, only 6% were removed [107].

Seed banking: Studies from native and nonnative ranges indicate that common velvetgrass produces an abundant seed bank that is important to population persistence. A review of studies conducted in northwestern Europe reported that common velvetgrass seed may remain viable in the soil for more than 12 years. In one study, a maximum number of 16,900 common velvetgrass seeds/m² occurred in a sample of the top 2 inches (5 cm) of soil from a natural habitat. Another study reported collecting viable common velvetgrass seeds from a depth of 20 inches (50 cm) [136]. In other reviews, 5% of common velvetgrass seed reportedly germinated after 12 years of storage in a laboratory [14], and at the Welsh Plant Breeding Station, 14% of common velvetgrass seeds germinated after 10 years of burial beneath 5 inches (125 mm) of mineral soil [157].

Native habitats: Common velvetgrass seed banks can be extensive in disturbed and undisturbed habitats. A review reports that 70,000 common velvetgrass seedlings/acre emerged from the top 7 inches (20 cm) of soil collected in an undisturbed bentgrass-fescue (*Agrostis-Festuca* spp.) grassland in Kerry Hills, United Kingdom. No seedlings emerged from soil samples collected at depths below 7 inches (20 cm) [14]. When seed banks from 38 western European sites were compared, common velvetgrass was most common in the "extensively managed" grasslands [16]. Field and greenhouse studies conducted in Norfolk, United Kingdom, showed that common velvetgrass colonized artificially created gaps from soil-stored seed. Although common velvetgrass cover was less than 0.3% in the field, an average of 150 common velvetgrass seedlings/m² emerged from soil samples taken to 2-inch (5 cm) depths. Three common velvetgrass seedlings/m² emerged from soil samples collected from 12- to 14-inch (30-35 cm) depths. When gaps were created, common velvetgrass establishment was lowest on sites where vegetation was removed and soil was inverted to a depth of 14 inches (35 cm) [103].

Nonnative habitats: There is little evidence that seed bank dynamics are different between native and nonnative common velvetgrass habitats. If common velvetgrass is present in the aboveground vegetation, banked seed is nearly certain. On the University of British Columbia research forest, common velvetgrass seed was not recovered from seed traps or soil in old-growth mixed-conifer forests. In recent clearcuts, however, the frequency of common velvetgrass was 21.9% in the aboveground vegetation, 6.3% in seed trap collections, and 3.1% in the seed bank [81]. Although clipping reduced common velvetgrass seed set by 97% in a coastal prairie in Van Damme State Park, California, common velvetgrass seedlings emerged at a high rate, suggesting germination of soil-stored seed. On clipped plots, about 29 common velvetgrass seedlings/m² emerged, and on unclipped plots about 5 common velvetgrass seedlings/m² emerged [17]. It is possible that removal of aboveground vegetation improved germination and establishment conditions on clipped sites. In coastal prairies of Sonoma County, California, common velvetgrass emergence occurred with and without seed rain. On plots where seed rain was allowed, 1.8 common velvetgrass seedlings/m² emerged from soil collected in a common velvetgrass-dominated patch type and 12.0 seedlings/m² emerged from a Pacific hairgrass (*Deschampsia holciformis*)-dominated patch type. In the Pacific hairgrass patch, cover of common velvetgrass was almost 85% lower than in the common velvetgrass patch. When seed rain was excluded, 2.6 and 3.9 seedlings/m² emerged from soils collected in the common velvetgrass patch and the Pacific hairgrass patch, respectively. The researcher suggested that common velvetgrass may be invading Pacific hairgrass patches as succession proceeds [107].

Germination: Greenhouse and field studies indicate that common velvetgrass germinates best in full light conditions and fluctuating temperatures. Low temperatures, dry conditions, and burial can decrease or delay germination. In a review, Beddows [14] reports that common velvetgrass germinates "readily". In the laboratory, 100% of common velvetgrass seeds collected from an encina (*Quercus ilex* subsp. *rotundifolia*) woodland in central-western Spain germinated [112]. Germination rates of common velvetgrass seeds collected from a permanent pasture in England ranged from 90% to 99% after up to 48 weeks of dry storage [167].

Light requirements: While full light and exposed conditions are typically best for common velvetgrass germination, some germination also occurs when seeds are buried and/or in the dark. Large temperature fluctuations may increase germination in dark conditions. At nearly constant temperatures of 54 °F (12 °C) and 75 °F (24 °C), common velvetgrass germination percentages in the dark were 48% and 30%, respectively [44]. After conducting numerous laboratory studies on common velvetgrass seed germination, Thompson and others [135] found that common velvetgrass germination was greater than 75% when temperatures fluctuated from 0 to 22 °F (0-12 °C). Emergence rates and germination percentages of common velvetgrass seed in the greenhouse were not different between shading levels of 0%, 33%, 53%, and 78% [64].

Depth of burial: Increasing depths of burial beneath soil or litter typically decrease common velvetgrass germination. In the greenhouse, maximum common velvetgrass germination was 89% under 0.4 inch (1 cm) of soil, 75% under 1.2 inches (3 cm) of soil, and 26% under 2 inches (5 cm) of soil [167]. In cleared coastal prairie plots in northern Marin County, California, common velvetgrass germinated at nearly 90% on sites without litter. Under 0.4 inch (1 cm) of litter, germination decreased to about 50% but was still significantly greater than that of 4 native prairie grasses (*P*-value not reported). Germination of common velvetgrass was about 30% under 1.2 inches (3 cm) of litter, which was not different than germination of the native species [117]. This study is also discussed in Litter accumulation.

Temperature, moisture: Cold temperatures and dry conditions can reduce or delay common velvetgrass germination. Common velvetgrass seed collected from a California coastal prairie had the lowest germination (nearly 30%) when growth chamber temperature fluctuatations were slight, between 37 and 48 °F (3-9 °C). At higher and greater fluctuations of temperatures (46 to 68 °F (8-20 °C)), germination was near or just below 50% [117]. In the greenhouse, common velvetgrass seeds from a grassland in Oxford, England, germinated best when temperatures alternated below and above 68 °F (20 °C). Germination percentages were lowest at a constant temperature of 68 °F (20 °C) [166]. Diurnal temperature requirements may function as a "gap-detecting mechanism", allowing common velvetgrass seeds to sense gaps in the canopy through temperature changes (Thompson and others 1977, as cited in [166]). When common velvetgrass was exposed to high temperatures of 180 to 230 °F (80-110 °C) for up to 10 minutes, germination was not affected. Germination was inhibited after 10 minutes at 300 °F (150 °C), although seeds were not "destroyed". Smoke exposure did not affect germination [120].

Common velvetgrass emergence was affected by sowing date, which was related to temperature and moisture field conditions in Oxford, England. Generally seedlings emerged 1 to 2 weeks after sowing. When temperatures were low or conditions were dry, emergence was delayed. Emergence was evaluated in each month of the year and was lowest for seeds sown from April to July. Mild winter and hot, dry summer conditions prevailed during this experiment [156]. In nonirrigated western Oregon pastures, common velvetgrass typically germinates with fall rains. In a field study, emergence was delayed when fall moisture was low [64].

Seedling establishment and plant growth: In its nonnative range, common velvetgrass is known as a rapid growing seedling. Late-fall sowing dates and shading can decrease seedling growth and survival, but spring moisture can increase seedling establishment and survival. While common velvetgrass establishment is often associated with disturbances in both its native and nonnative ranges [7,45,102,142], the bulk of information about seedling establishment and survival on disturbed sites comes from native habitats.

Seedling growth: Common velvetgrass seedlings develop rapidly, making them competitive at this early stage. After 20 weeks of growth in a greenhouse, common velvetgrass produced the greatest overall root biomass and root:shoot biomass of 6 coastal prairie species grown from seed collected in Marin County, California. Species included in this experiment were bulbous canarygrass (*Phalaris aquatica*), tall fescue (*Schedonorus phoenix*), red fescue (*Festuca rubra*), Oregon bentgrass (*Agrostis oregonensis*), and purple needlegrass (*Nassella pulchra*). In the first 5 weeks of growth, common velvetgrass' estimated growth rate exceeded that of any other species. When grown in the presence of others, common velvetgrass seedlings were considered the "least responsive to the presence of a neighbor". The relative yield/neighbor plant was significantly smaller for plants grown with common velvetgrass than with any other species ($P<0.05$) [140]. In greenhouse and field experiments conducted in British Columbia, common velvetgrass grew most rapidly, was most abundant, and resisted invasion best as a seedling. When transplanted as tillers from 11-year-old and 49-year-old pastures, common velvetgrass growth, abundance, and resistance to invasion were lower [143].

Associated vegetation effects: While the growth of common velvetgrass can decrease in the presence of associated vegetation, decreases may not occur at the seedling stage. After the 1st year of growth in a California coastal prairie field study, common velvetgrass produced the greatest shoot biomass of any species when grown in a monoculture and when grown with an equal proportion of native grasses. Aboveground biomass of common velvetgrass decreased in the 2nd and 3rd years of the experiment (Corbin and D'Antonio, in preparation, cited in [140]). In the Danebo Wetlands of West Eugene, Oregon, the relative performance of common velvetgrass was lower in mixed species field plots than in monoculture field plots. Two years after seeding, average common velvetgrass biomass in a monoculture was 10.2 to 19.6 g/plant and in mixed plots was 0.45 to 1.33 g/plant. Biomass values reported are only for those plots in which common velvetgrass established [36].

Germination date: In both native and nonnative habitats, earlier germination dates are associated with increased seedling establishment, growth, and survival of common velvetgrass. In the United Kingdom, earlier sowing dates related to increased common velvetgrass establishment in the field. Sowing began on 19 July and continued at weekly intervals (Mortimer 1974, as cited in [157]). In field studies conducted in western Oregon, common velvetgrass growth and survival were best at the earliest fall planting date [63,64].

Common velvetgrass survival and growth at different planting dates [63,64]					
Sowing date	Sept. 26	Oct. 7	Oct. 16	Oct. 25	Nov. 8
Seedlings surviving to mid-March (%)	96a	67b	71b	64b	41c
Seedling dry weight in mid-March (mg)	314a	168b	73c	27c	7c
Within a row, values followed by different letters are significantly different (*P*<0.05).					

Shade effects: Increasing shade reduced seedling growth and survival during field studies in western Oregon. In 0%, 33%, 53%, and 78% shade, 5- to 6-week-old common velvetgrass seedlings had dry weights of 9.2 mg, 3.8 mg, 2.5 mg, and 2 mg, respectively. Shading of 33% or greater significantly reduced seedling growth ($P<0.05$) [63,64].

Moisture: While moisture may increase seedling survival and establishment, both drought and long periods of inundation can decrease seedling establishment. Added spring moisture increased seedling establishment and survival in an annual coastal prairie in the University of California's South Meadow in Mendocino County. Control, winter-irrigated, or spring-irrigated plots (each 900 cm^2) were seeded in fall. Irrigation treatments added 17 inches (42 cm) of water. Common velvetgrass seedling establishment was 80% on spring-irrigated plots, 55% on winter-irrigated plots, and 30% on control plots. Of the 28 common velvetgrass seedlings that survived most of the subsequent summer drought and growing season, 1 occurred on the control plot, 4 on the winter-irrigated plot, and 23 on the spring-irrigated plot. On spring-irrigated plots, 17 common velvetgrass plants flowered and were described as "large" and "robust" [139]. In field experiments in the Danebo Wetlands common velvetgrass established in plots inundated for 12 to 14 weeks from January to June but failed to establish in plots inundated for 24 to 27 weeks during the same period [36].

Herbivory and disturbance effects: In native habitats, studies indicate that disturbances can increase common velvetgrass seedling establishment and survival, but the effects of simulated and natural herbivory on seedling establishment and survival were mixed. Mechanical soil disturbances may increase establishment more than canopy removal. In a fen meadow and a rush (*Juncus* spp.) pasture in Devon, southwestern England, common velvetgrass seedling emergence and survival generally increased with disturbances that involved inversion of the top 2.8 inches (7 cm) of soil. In the pasture, clipping dramatically decreased common velvetgrass seedling surival but in the fen, seedling survival was not affected by clipping. Common velvetgrass seedling survival was greatest in the fen with soil disturbance alone and in the pasture with soil disturbance and irrigation and without clipping. Field conditions were "exceptionally dry" in June and July [74].

Emergence and survival of common velvetgrass seedlings on treatment plots with and without irrigation, canopy vegetation, and soil disturbance [74]						
Treatment			Seedling emergence (%)		Seedling survival May-October* (%)	
Irrigation	Clipping	Soil disturbance	Fen	Pasture	Fen	Pasture
-	-	-	18	16	97	75
-	-	+	12	21	100	96
-	+	-	12	2	70	0
-	+	+	21	25	58	35
+	-	-	17	18	93	98
+	-	+	20	23	98	100
+	+	-	11	1	60	0
+	+	+	23	19	90	0

*Researchers noted that conditions were "exceptionally dry" in June and July.

The absence of vegetation cover reduced the probability of successful seedling establishment in a field study in the Treborth Botanic Garden of North Wales. The fate of 275 common velvetgrass seeds was tracked for 8 months on a plowed plot, an herbicide-treated plot, and a relatively undisturbed plot. Just 37% of the seeds developed into seedlings. The probability of survival to adulthood was much lower. Probablity of establishing an adult was 0.0329 on the plowed plot, 0.0333 on the undisturbed plot, and 0.0048 on the herbicide-treated plot when small mammals, birds, and invertebrates were not excluded. Probablity of establishing an adult increased to 0.0518, 0.0592, and 0.0148 on plowed, undisturbed, and herbicide-treated plots, respectively, when small mammals, birds, and invetebrates were excluded [100].

Four years of rabbit exclusion increased common velvetgrass cover, flowering, and seedling emergence but not seedling survival in an acidic, species-poor grassland in Silwood Park, Berkshire, United Kingdom. Common velvetgrass cover, flower production, and seedling emergence from soil samples in rabbit-exclusion plots were more than double that of unfenced plots; however, the proportion of common velvetgrass seedlings surviving from fall 1995 to mid-winter 1997 was 0.18 in exclusion plots and 0.32 in unfenced plots. All differences were significant ($P<0.01$) [43].

Additional information on common velvetgrass seedling establishment, plant growth, and spread is available in Impacts.

Vegetative regeneration: Common velvetgrass clumps expand through tillering or the growth and development of prostrate rosette shoots (Tansley 1949, as cited in [14]). In reviews, vegetative growth of common velvetgrass has been described as producing a "blanket of runners or stolons" on the soil surface [158] and as "aggressive tillering" that allows clumps to "enlarge rapidly" [149]. Claims of rhizome production [40] and sprouting following top-kill [51] were not substantiated by the available literature.

While vegetative growth commonly occurs, recruitment of seedlings is typically the primary method of common velvetgrass reproduction. In field and greenhouse studies conducted in British Columbia, seedlings grew more rapidly and resisted invasion better than tillers collected from 11- and 49-year-old pastures. In the greenhouse, common velvetgrass was least abundant in patches grown from tillers collected in the 49-year-old pasture and most abundant in seeded patches. Common velvetgrass seedling patches were the most difficult to invade by other nonnative pasture grasses, but patches grown from tillers collected in the 11- and 49-year old pastures were invaded easily. In the field, common velvetgrass tiller patches expanded at a rate of 8.28 cm^2/week, while seedling clumps expanded at a rate of 16.0 cm^2/week [143].

In frequently mowed habitats, the importance of tillering increases. In the North Wales Treborth Botanic Garden, nearly all species, including common velvetgrass, colonized cleared patches through vegetative growth in frequently mowed grassland (1-2 times/2 weeks). Seedlings (of any species) were extremely rare [5]. At 4 weeks old, common velvetgrass tillers can survive apart from the parent plant. Researchers collected common velvetgrass plants from a pasture in Cheshire, United Kingdom, potted them in a greenhouse and evaluated the survival of severed tillers. Four-week old tillers survived, but 1- and 2-week old tillers did not [24].

SITE CHARACTERISTICS:
In North America, common velvetgrass habitats include pastures, cultivated fields, meadows, ditch banks, lawns, roadsides, and other disturbed sites [9,31,73,79,114,153].

Climate: A review reports that common velvetgrass tolerates a wide range of moisture conditions within temperate climate regimes. While common velvetgrass grows best in moist areas, it grows well in very wet conditions and tolerates "moderate" periods of drought [134]. The northern limit for common velvetgrass is near the January isotherm of 28.4 °F (-2 °C). The 80 °F (26.7 °C) July isotherm approximates common velvetgrass' southern boundary in Europe and the Mediterranean. Beyond this southern boundary, precipitation from May to October is typically less than 5 inches (130 mm) and is likely the reason for common velvetgrass' absence [14].

Climates are similar in common velvetgrass' nonnative North American habitats. In British Columbia, common velvetgrass is common in temperate cool semiarid and mesothermal climates. Evaporation exceeds transpiration and the average annual temperature is less than 64 °F (18 °C) in semiarid habitats. In mesothermal habitats the average temperature in the warmest month is less than 73 °F (23 °C) and fewer than 4 months see temperatures below 39 °F (4 °C) [83]. Common velvetgrass is common in the Willamette Valley, where winters are cool and wet, and summers are warm and dry. Temperatures in January and July average 46 °F (8 °C) and 82 °F (27.5 °C), respectively. Based on 30 years of records, annual precipitation averages 43 inches (1,100 mm) [126]. In Pacific coastal areas, environmental conditions are more harsh and include wind, salt spray, and fog [8]. On the Bodega Marine Reserve, in Sonoma California, annual precipitation, most of which occurs from November through March, averages 34 inches (860 mm). Frequent fog moderates drought conditions [13], and common velvetgrass utilizes fog as a water source [29]. Humid climates prevail in the montane rain forest zone in Hawaii Volcanoes National Park, where common velvetgrass is common. Annual precipitation averages 98 inches (2,500 mm) at high elevations and 59 inches (1,500 mm) at low elevations [4].

Climate change: Common velvetgrass may experience increased growth with elevated CO_2 levels. In a controlled study, common velvetgrass monocultures grown in elevated CO_2 produced significantly more biomass than when grown in ambient conditions ($P<0.001$). After 2 months at elevated CO_2 levels, aboveground biomass of common velvetgrass increased by 44% and belowground biomass increased by 135%. Researchers also noted changes in nitrogen cycling, which, depending on native species responses to elevated CO_2, could affect competitive outcomes in mixed communities [10,11]. Increases in common velvetgrass biomass were also noted by Jongen and Jones [77]. When common velvetgrass was grown with 3 other grasses at elevated CO_2 levels, increases in common velvetgrass biomass exceeded those of the other grasses. Common velvetgrass tillering increased by 25% with elevated CO_2.

Elevation: Throughout North America, common velvetgrass occurs from sea level to 7,500 feet (2,300 m) [9]. In British Columbia, occurrence of common velvetgrass decreases with increasing elevation [83].

Common velvetgrass elevation range by state	
State	Elevational range (feet)
Arizona	4,500-7,000 [80]
California	below 7,500 [69,101]
Hawaii	2,500-10,700 [153]
Nevada	3,500-6,800 [79]
northern New Mexico	5,000-6,000* [93]
Utah	4,990 [164]
*As of 1981, common velvetgrass was not described in New Mexico; this is an expected distribution.	

Soils: Although common velvetgrass tolerates a wide range of soil conditions [9], it is often described as occurring on moist sites [125,149]. In British Columbia, common velvetgrass is most common on fresh to very moist soils [83]. In California, common velvetgrass is found in all but the desert regions and grows best in moist, rich soils [125]. In the coastal prairies of California, common velvetgrass is rare on hilltop or steep sites that dry out early in the season (Thomsen, personal observation, cited in [140]). In the eastern United States, common velvetgrass often occurs on damp, moist, or poorly drained sites [149]. In controlled studies, as the water table height increased, common velvetgrass growth decreased. However, on sites with elevated water tables, common velvetgrass developed fine roots at the soil surface and adventitious roots at the plant base, suggesting a possible long-term adaptation to a high water table [160].

Native habitats: A review reports that although common velvetgrass may be absent from shallow soils in areas that experience severe drought, a wide range of soil types is tolerated. Coastal areas that receive salt-spray are occupied by common velvetgrass [14]. In waterlogged soils, growth of common velvetgrass is often reduced [44]. Near Sheffield, England, common velvetgrass grew on soils with pH levels of 3.5 to 8 but was most abundant where the pH was 5 to 6 (Grime and Hodgson, personal communication, cited in [157]).

Nonnative habitats: In North America, soils vary in common velvetgrass habitats. In one review, common velvetgrass is reportedly frequent on poor, moist soils [113]. In a review from Canada, common velvetgrass is considered most common in infertile grasslands [134]. In British Columbia, common velvetgrass often occurred on nitrogen-medium and exposed mineral soils [83]. Sandy or gravelly soils were preferred habitat in Baja California [165]. After analyzing the vegetation and environmental data for 184 plots in Oregon white oak savannas in the Cowichan Valley of southeastern Vancouver Island, researchers found that common velvetgrass occurred most often on sites with shallow soils, 4 to 8 inches (10-20 cm) deep [91]. The common velvetgrass-sweet vernalgrass community type in Oregon was most common on deep soils with thick litter layers that averaged 2.6 inches (6.5 cm) deep. Soil pH averaged 5.7, and soil depth averaged 57 inches (146 cm). Soils averaged 13% clay, 31% silt, 56% sand, and 15.5% organic matter [119].

SUCCESSIONAL STATUS:
While often a component of newly disturbed, open communities, common velvetgrass may also occur in stable savannas or heavily shaded mid- and late-seral forest types. In a review, Beddows [14] reported that common velvetgrass "readily colonizes bare soil and disturbed ground", but that plant size and abundance often decrease with increasing severity of common velvetgrass defoliation. Grime [58] classified common velvetgrass as a "competitive ruderal" that is often present as a seedling in the colonization of bare ground but is typically most abundant when disturbances are "less immediate or catastrophic". Researchers in British Columbia described common velvetgrass as "scattered to plentiful" in early-seral communities and/or disturbed sites [83]. In the Puget Trough of Washington, common velvetgrass is typical in Douglas-fir–Pacific madrone/pink honeysuckle vegetation if grazed in the past or near a severely disturbed area [25]. In grasslands and savannas of Hawaii Volcanoes National Park, common velvetgrass established soon after and was often abundant on recent pig digs and artificially created disturbances [129]. Disturbance-related succession is discussed below.

Shade relationships: Although some consider common velvetgrass shade intolerant [83] and studies have shown that shade may decrease seedling growth and plant biomass [52,63], common velvetgrass may occur in heavily shaded woodlands with high tree density [90], especially with soil disturbance.

Field studies in western Oregon revealed that increasing shade reduced common velvetgrass seedling growth and survival [63,64]. For details, see Shade effects. In dune grasslands in the Newborough Warren National Nature Reserve of Wales, the density of common velvetgrass was 0.6 plants/200 cm^2 in plots shaded by surrounding vegetation and 2.6 plants/200 cm^2 in plots where vegetation was held back. Total common velvetgrass biomass was 0.02 g/200 cm^2 in shaded plots and 1.1 g/200 cm^2 in unshaded plots [52]. When the vegetation and environmental data were analyzed for 184 plots in Oregon white oak savannas in Vancouver Island's Cowichan Valley, common velvetgrass was most frequent on partly shaded sites. On a scale from 0 (completely shaded) to 1 (completely unshaded), common velvetgrass' shade preference ranked near 0.3 [91]. On the Hoh River in Washington's Olympic National Park, common velvetgrass cover and frequency were 4.4% and 30%, respectively, in 14-year-old red alder stands; less than 1% and 3% in 24-year-old stands; and common velvetgrass was absent from 65-year-old stands. Shading was heaviest and tree density greatest in 14-year-old stands; canopy openness increased with increasing stand age [90].

Hydrarch succession: Common velvetgrass is typically found in the last and driest stages of hydrarch succession of temporary ponds in the Willamette Valley. Common velvetgrass occurred in the "grassland-composite" stage that appeared only after water levels decreased with root and litter accumulations of submerged and emergent vegetation [89].

Old-field succession: Pastures and abandoned fields are important common velvetgrass habitats. As succession proceeds to shrublands, woodlands, and forests, common velvetgrass may become less frequent. On pastures near Aldergrove, British Columbia, common velvetgrass cover was 9.5% on a 2-year-old pasture, 20.6% on a 21-year-old pasture, 37.9% on a 40-year-old pasture, and 15.1% on a 65-year-old pasture (Aarssen 1983, as cited in [134]). In the northeastern United States, common velvetgrass decreased in frequency with increased time since last disturbance. On an abandoned agricultural field that was last cultivated in 1945 and last grazed in 1951, the frequency of common velvetgrass was 60% in 1954, 48% in 1960, 10% in 1973, and was absent after that. Vegetation of the old field changed from an open perennial meadow in 1954 to a shrub-dominated thicket in 1973 and to a young hardwood forest or woody vine community by 1992 [45].

Forest Succession: Common velvetgrass is possible in heavily shaded, shrub- or hardwood-dominated seral forests but rarely occurs in old-growth forests without disturbance. Many studies from Oregon and Washington indicate that common velvetgrass is typical in the understory of red alder stands and thickets. In these studies, red alder stands with common velvetgrass ranged from 2 to 75 years old ([47,61,68], Henderson 1970, as cited in [49]). While common velvetgrass occurred in the understory of red alder and Scouler willow (*Salix scouleriana*) thickets on recent river terraces of the Hoh River in Olympic National Park, it did not occur in forest-dominated terraces [47]. In the lower Fraser Valley and southern Vancouver Island, British Columbia, common velvetgrass was frequent in western hemlock/goose neck moss (*Tsuga heterophylla*/*Rhytidiadelphus loreus*) forests logged less than 5 years previously and in stages prior to closure of the sapling canopy. Frequency was lower in the closed-canopy sapling phase, and common velvetgrass was lacking in late immature pole stands, mature stands, and old-growth stands [84].

Disturbance-related succession: Common velvetgrass is often more abundant on disturbed than undisturbed sites. As time since disturbance increases, common velvetgrass abundance often decreases.

Logging: An increased occurrence of common velvetgrass is common following forest logging operations. Increases may be greater on more heavily disturbed sites. Soil scarification may be more important to common velvetgrass establishment and growth than canopy removal. Common velvetgrass was more common in the understory of thinned than untreated Douglas-fir forests on Washington's Ft. Lewis Military Reservation. One year after thinning, the indicator value of common velvetgrass was 36 on the thinned site and 0 on the untreated site. Three years after thinning, the indicator value of common velvetgrass was 59 on thinned and 2 on untreated sites. Average cover of native woody species was not much different on thinned (41.9%) and untreated (45.8%) stands 3 years after thinning [142]. Common velvetgrass occurred in Douglas-fir/western sword fern-redwood-sorrel (*Polystichum munitum-Oxalis oregana*) habitat types in the southern Oregon Coast Range 4 to 25 years after clearcutting. Common velvetgrass cover was greater on severely disturbed than on relatively undisturbed clearcuts. Severely disturbed sites experienced soil disturbances from skid trails and other operations [7]. Common velvetgrass frequency was much greater on unburned clearcut sites than on burned clearcut sites in other Douglas-fir forests in the Oregon Coast Range. Unburned sites were evaluated 3 years after clearcutting, and burned sites were evaluated 2 years after slash burning. More on this study is presented in Fire adaptations and plant response to fire [30].

Grazing: Reviews report that common velvetgrass is susceptible to trampling [158] and that plant size and abundance often decrease with increasing defoliation severity. In an England pasture, common velvetgrass seedling establishment and survival were much lower on clipped sites than on undisturbed sites or sites with mechanically disturbed soils [74]. In several western US studies, common velvetgrass abundance or growth was less on grazed or clipped than on ungrazed or unclipped sites [1,65,66,124,144].

Although susceptible to trampling [158], decreases in common velvetgrass abundance may be short-lived. When common velvetgrass in a North Carolina old-field was trampled up to 500 times by people wearing lug-soled boots, relative cover of common velvetgrass was 32% two weeks after trampling but was 85% a year after trampling [28].

When 42 paired grazed and ungrazed sites were compared in central coastal California prairies, common velvetgrass cover was substantially less on cattle-grazed than ungrazed sites. On sites visited in 2000, common velvetgrass cover averaged 10.8% on grazed and 23.7% on ungrazed sites. For sites visited the next year, common velvetgrass cover averaged 8.4% on grazed and 36.5% on ungrazed sites. Differences were significant on sites visited in 2001 ($P<0.01$). Precipitation levels were slightly below normal for the study period [65,66]. On the Tomales Point Elk Reserve in Marin County, California, elk grazing reduced abundance of common velvetgrass in open grasslands, but abundance was not reduced when plants grew beneath coyote bush (*Baccharis piluaris*). Poor accessibility was likely the reason for reduced grazing beneath shrubs [75]. In perennial grasslands of northwestern California, the cover of common velvetgrass was 0.1% in perennial grasslands grazed by cattle for 8 months of the year and 1.7% in grasslands grazed for 4 months of the year. Cover was nearly equal on Oregon oak woodland sites grazed for 8 and 4 months [124]. In a greenhouse study, increased exposure to grazing appeared to improve common velvetgrass' regrowth following clipping. Plants were collected from 2-year-old, 21-year-old, and 40-year-old pastures in the lower Fraser Valley of British Columbia. In general, biomass production was lower for clipped than unclipped plants, but clipped plants produced more tillers than unclipped plants. Total biomass, shoot biomass, and tiller number of clipped plants from the oldest pasture were significantly greater ($P<0.05$) than those of clipped plants from 2- and 21-year-old pastures. Common velvetgrass from the oldest pasture was exposed to grazing pressure for the longest time. Differences in common velvetgrass regrowth between the oldest and younger pastures suggest that plants developed a tolerance to grazing on the oldest pasture [1].

Other: A variety of disturbances can impact the establishment and spread of common velvetgrass. Generally open sites with favorable moisture provide for the best common velvetgrass establishment and growth; however, establishment and growth vary in their response to shading, disturbance, and fertility. In a British Columbia field experiment, researchers found that common velvetgrass growth was greatest in undisturbed plots with low-nutrient levels. Monoculture and mixed stands were established from seed collected in pastures. Seedlings were grown for 11 months before applying treatments and evaluated after 5 months of nutrient additions and/or clipping treatments. Common velvetgrass cover was greatest in undisturbed monocultures with low-nutrient levels. Clipping to 0.4-inch (1 cm) heights each week was the highest level of disturbance tested and severely depressed common velvetgrass growth. Cover of common velvetgrass was lowest in high-disturbance, low-nutrient, mixed-species treatments [144].

Studies conducted in Derbyshire, United Kingdom, suggest that common velvetgrass establishment and abundance may increase with increased disturbance and fertility. Five years after common velvetgrass was seeded along fertility and disturbance gradients, researchers indicated that common velvetgrass "appeared to respond positively to both increased fertility and disturbance". Disturbances involved turf removal [137]. At the conclusion of this experiment, 3 years after 3 years of treatments, common velvetgrass cover differences were greatest between fertile, disturbed plots (30.3%) and infertile, undisturbed plots (9.0%) ($P=0.001$). Researchers reported that common velvetgrass went into "relatively steep" decline after treatments were discontinued [23].

Common velvetgrass appeared early after debris flows in the Coast Range of central Oregon and on Mount St Helens in Washington. On the more severe Mount St Helens debris flows, common velvetgrass increased consistently with time since flow [35]. On the less severe debris flow in Oregon, common velvetgrass increased until about the 4th year after the flow [102].

In alpine hairgrass grasslands and koa savannas in Hawaii Volcanoes National Park, common velvetgrass established soon after and was often abundant on recent pig digs and artificially created disturbances. Researchers concluded that pig digging could "greatly enlarge" the abundance of nonnative species in mostly native communities [129]. However, in the montane rainforest zone of Hawaii Volcanoes National Park, common velvetgrass was not associated with feral pig disturbances. Researchers suggested that common velvetgrass establishment and growth may have been so rapid that disturbances were not recognized as recent [4].

In coastal prairie vegetation in Sonoma County, California, common velvetgrass establishment and growth were greater in canopy gaps created in sweet vernalgrass patches than in common velvetgrass patches. Gaps in the canopy were created by killing individual bunchgrasses; standing dead vegetation remained. By the second year after gap creation in sweet vernalgrass, common velvetgrass cover was 100%. Common velvetgrass leaf area was 1,000 times greater in sweet vernalgrass than in common velvetgrass patches [109].

FIRE EFFECTS AND MANAGEMENT

SPECIES: Holcus lanatus

- FIRE EFFECTS
- FUELS AND FIRE REGIMES
- FIRE MANAGEMENT CONSIDERATIONS

Photo ©Forest and Kim Starr, photo taken in Maui, HI

FIRE EFFECTS:

Immediate fire effect on plant: Common velvetgrass is likely killed by fire, but some sources suggest that it may only be top-killed [51,127].

Postfire regeneration strategy [130]:
Tussock graminoid
Ground residual colonizer (on site, initial community)
Initial off-site colonizer (off site, initial community)
Secondary colonizer (on- or off-site seed sources)

Fire adaptations and plant response to fire: The majority of studies suggest that common velvetgrass establishes on burned sites by germination of soil-stored seed or from dispersed off-site seed [30,76,106,123]. However, some suggest that vegetative regeneration from surviving basal plant parts is possible [51,127]. In a review of nonnative species in Hawaii, Smith [127] reports that common velvetgrass "tolerates fire and regenerates rapidly from basal shoots". Researchers comparing burned and unburned grasslands in Argentina indicated that common velvetgrass can sprout following damage or top-kill. Reasons for this claim were not provided, and common velvetgrass was recorded on a nearly 2-year-old burned site but not on 5- or 10-month-old burned sites [51].

Soil-stored common velvetgrass seed may survive fire. In a laboratory study, germination of common velvetgrass was not affected by up to 10 minutes of exposure to temperatures of 180 to 230 °F (80-110 °C). Germination was inhibited after 10 minutes at 300 °F (150 °C), but seeds were not "destroyed". Smoke exposure did not affect common velvetgrass germination [120].

Common velvetgrass is generally present soon after fire; it often occurs on sites in the first postfire growing season. On burned sites, persistence or increases in abundance are often short-lived. The recovery and type of associated vegetation may affect the persistence of common velvetgrass.

Native habitats: Studies do not indicate that common velvetgrass' response to fire is different in its native and nonnative ranges. In heathlands in France's Brittany region, common velvetgrass appeared after a "humus" fire but not after a less severe "flash" fire. The flash fire burned on 26 October 1985 and the humus fire on 7 March 1986. Vegetation recovery was more rapid on sites burned the flash fire due to abundant heath sprouting. The humus fire consumed the organic layer, eliminated heath sprouting, and likely removed most of the seed bank. Common velvetgrass was abundant in the first 2 postfire years, and cover reached 90% in the 3rd postfire year on heathland plots burned by the humus fire. Common velvetgrass began to decline after the 5th postfire year. Researchers suggested that common velvetgrass established from off-site seed [123]. In heathland vegetation in Hertfordshire, England, frequency of common velvetgrass was 10%, 19% and 9% on sites burned less than 4 years ago, 4 to 6 years ago, and a little more than 6 years ago, respectively [41].

Nonnative North American habitats: Fire studies reporting fire effects on common velvetgrass in North America are limited to northwestern areas, northeastern coastal areas, and the Hawaiian islands. Regardless of the location, vegetation type, fire severity, fire frequency, fire season, and associated disturbances, common velvetgrass is often present in early postfire succession. Abundance typically decreases with increasing time since fire.

Western United States: Common velvetgrass occurred on once-burned and repeatedly burned sites in Washington. Common velvetgrass occurred on severely burned microsites where logs had smoldered in an Oregon white oak savanna in western Washington. Time since fire was not provided [2]. In Roemer's fescue (*Festuca idahoensis* subsp. *roemeri*) dominated grasslands on Washington's Yellow Islands, common velvetgrass cover increased after prescribed fires. Fires occurred in late July or early August in 1987, 1996, and 1998 and resulted in nearly complete fine fuel combustion. The fire in 1987 was the first on the site in 50 years. Cover of common velvetgrass was generally greater on burned than unburned plots, and cover on burned plots was generally greater in the first few years after fire than in the year prior to the fire. Large increases in cover were short-lived [38]. In the Artillery Impact Area of Fort Lewis, Washington, fires associated with military training are allowed to burn. Almost annual summer fires have occurred for the last 50 years. Common velvetgrass cover and frequency in this area averaged 0.5% and 30%, respectively [145,146].

In the Willamette Valley of Oregon, common velvetgrass was either unaffected by fire or increased in the first postfire years. Common velvetgrass was common on nearly all wetland prairie plots regardless of burning that occurred 1 to 4 years earlier. Burned plots were not compared to unburned plots [126]. Common velvetgrass inflorescence production was reduced on control and burned sites in Willamette Valley wetland prairies. Sites were burned in October 1994 and again in late September 1996. Inflorescence production was evaluated before treatments in 1994 and in the year following each fire (1995 and 1997). On burned sites, common velvetgrass inflorescence production was 70% lower than prefire levels in 1995 and 1997. On unburned sites, however, inflorescence production was 38% lower than pretreatment levels in 1995 and 80% lower than pretreatment levels in 1997, suggesting that the reduced inflorescence production may have been due to factors other than fire [26].

In grassland and shrubland wetlands in the southern Willamette Valley, common velvetgrass generally increased in abundance in the 1st or 2nd year after fires. Sites in the study area are typically flooded for about 6 months of the year. Vegetation was measured in the summer prior to prescribed fires that burned on 11 October 1988 and 19 September 1990. Fires burned when temperatures were 61 to 75 °F (16-24 °C), relative humidities were 28% to 68%, and winds were 3.7 to 7.5 miles (6-12 km)/hour. Total biomass consumption ranged from 35% to 74% and was greatest after the 1st Fisher Butte fire and lowest after the 2nd Fisher Butte fire. Fireline intensity and heat released/unit area were about 4 times lower at Rose Prairie than at Fisher Butte. When compared to changes in abundance on unburned sites, common velvetgrass increases in abundance were generally greatest on burned sites. Consistent patterns in common velvetgrass abundance with vegetation type and total combustion were not apparent [111].

Common velvetgrass frequency (%) (and cover %, if given) by community type and sampling year on burned and unburned plots on 2 sites in the Willamette Valley [111]					
Treatment	Sample date	Site/Plant community			
		Rose Prairie		Fisher Butte	
		Tufted hairgrass-California oatgrass (*Danthonia californica*)	Nootka rose (*Rosa nutkana*) /sweet vernalgrass	Tufted hairgrass-California oatgrass	Nootka rose /Sierra rush (*Juncus nevadensis*)
Unburned	1988	16	4 (0)	64 (0.8)	96
	1989	17	8 (0)	64 (1)	92
	1990	12	10 (0)	81 (1.2)	97
Burned once	1988 (prefire)	39a	12 (0.3)	67 (1.8)	72
	1989 (1 yr after fire)	28b	28 (0.6)	70a (1.5)	69
	1990 (2 yrs after fire)	41a	37 (0.1)	90b (3.6)	80
Burned twice	1988 (prefire)	18	13 (0)	78a (1.5)	38
	1989 (1 yr after 1st fire)	12	31 (0.4)	58a (1.6)	34
	1990 (1 yr after 2nd fire)	19	33 (0.2)	92b (2.9)	42
Different letters within the same column and burn sequence are significantly different (*P*=0.1). Statistical differences were available for only select comparisons.					

A later study of the southern Willamette Valley sites and vegetation types described above showed that common velvetgrass frequency decreased with increasing time since fire. In this study, sites were burned again in the spring of 1991, and the frequency of common velvetgrass was averaged for both sites and most of the above community types. By the 7th postfire year, the frequency of common velvetgrass was much lower on plots burned 2 and 3 times than on unburned or prefire plots. Common velvetgrass frequency also decreased on unburned plots throughout the study area, although decreases were more rapid on burned plots [133].

Average frequency of common velvetgrass on burned and unburned sites in the southern Willamette Valley [133]				
	1988 (prefire)	1989 (postfire year 1)	1990 (postfire year 2)	1998 (postfire year 7)
Unburned	44	44	48	14
Burned twice	44	43	55	9
Burned 3 times	41	29	40	9

In Oregon shrublands and forests, common velvetgrass often occurs in early postfire succession. Although not present in the 1st year after slash burning in Douglas-fir clearcuts in the Siuslaw National Forest, common velvetgrass frequency was 1% to 6% in the 2nd posttreatment year. Frequency of common velvetgrass did not depend on fire severity (evaluated by vegetation recovery). Frequency of common velvetgrass was 4% on a plot burned at the lowest severity and 3% on a plot burned at the highest severity [30]. Common velvetgrass was characterized as a subdominant species in a salal (*Gaultheria shallon*) and blackberry (*Rubus* spp.) shrubland before and 1 year after a prescribed fire in western Oregon. The "medium intensity" fire burned in mid-August. Sites were treated with a desiccant to dry fuels before the fire [71]. In the Coast Range, common velvetgrass typically dominates the understory by the 3rd postfire year on clearcut and slash-burned Douglas-fir sites. Common velvetgrass may dominate for several years after fire. On treated sites, the summer temperature at 1.5 inches (3.8 cm) above ground was up to 10 °F (5.6 °C) warmer on common velvetgrass-dominated than on unvegetated sites [122]. Common velvetgrass occurred within 1 year of logging and broadcast burning in a 60-year-old Douglas-fir stand near Springfield, Oregon. Abundance was not reported for treated or untreated sites [99].

Eastern United States: In oak woodlands and pitch pine forests of Manuel F. Correllus State Forest in Martha's Vineyard, Massachuesetts, common velvetgrass did not occur in pretreatment sampling but did occur after mowing, grazing, and fire treatments. Treatments in pitch pine stands included thinning and sheep grazing in 2002 and burning in May 2004. In oak woodlands, treatments included mowing in July 2002, sheep grazing in July 2003, and burning in April 2004. Common velvetgrass occurred on treated sites just months following fire [106].

Hawaii: Common velvetgrass cover was significantly greater on burned than adjacent unburned plots in a submontane \`ohi\`a woodland in Hawaii Volcanoes National Park ($P<0.05$). Common velvetgrass cover was 1.6% on unburned sites and 4.4% on 4-year-old burned sites. The low-severity fire burned in August [33].

Nonnative habitats of New Zealand: Researchers indicated that common velvetgrass established from seed after a fire in gorse (*Ulex europaeus*)-dominated scrub in the Awarua bog of Southland, New Zealand. Four months after the fire, common velvetgrass cover averaged 15%. Cover increased to 40% in the 10th postfire month and then decreased steadily with time since fire. Cover was 5% the 28th postfire month, and common velvetgrass was absent from the area 39 months after the fire. Descriptions of fire characteristics were generally lacking, although researchers noted that shrubs were killed but not consumed [76]. After an October fire in a New Zealand black beech (*Nothofagus solandri* var. *cliffortioides*) forest in Canterbury, New Zealand, common velvetgrass was more abundant in the 6th postfire year than in the 4th postfire year. Observations were not made in other postfire years [88].

FUELS AND FIRE REGIMES:
Fire regimes in the native range of common velvetgrass were not described in the reviewed literature. Given that common velvetgrass persists on sites in Washington that have burned almost annually for the last 50 years [145,146], frequent fire is likely tolerated. Lack of fire is more likely to reduce the abundance and/or persistence of common velvetgrass than frequent fire.

While common velvetgrass could potentially increase fine fuel loads in many of its nonnative US habitats, this is described only in Hawaii and California. Establishment of common velvetgrass may reduce the frequency and/or size of gaps in subalpine vegetation and increase fire potential through increased fuel continuity [128]. In coastal grasslands of Sonoma, California, litter accumulations are often greater in common velvetgrass communities than in annual grasslands [13], which may affect fire probability and/or behavior. This topic is also addressed in Litter accumulation. The Fire Regime Table provides fire regime information for many vegetation types and plant communities in which common velvetgrass may occur.

FIRE MANAGEMENT CONSIDERATIONS:
Potential for postfire establishment and spread: If common velvetgrass occurs in or around a burned area, it is possible in the postfire plant community. Studies described above suggest that common velvetgrass is often present and can be abundant in early postfire succession. This pattern does not appear to be affected by location, fire severity, fire frequency, fire season, or associated disturbances. Common velvetgrass abundance typically decreases with time since fire, although long-term studies are lacking. See Fire adaptations and plant response to fire for details.

Common velvetgrass establishes on burned sites from off-site or seed bank sources, and may sprout from surviving basal plant parts. Common velvetgrass seeds often occur in the soil even when mature plants are absent or occur in low abundance on the site. Seeds are readily dispersed by a number of vectors (see Seed dispersal). Germination from the seed bank on burned sites is possible, since germination was not affected by up to 10 minutes of exposure to temperatures of 180 to 230 °F (80-110 °C) [120]. Buried seed may also survive on severely burned sites. A review reports that viable common velvetgrass seed was collected from a maximum depth of 20 inches (50 cm) [136]. Anecdotal accounts from Hawaii [127] and Argentina [51] suggest that common velvetgrass may sprout following top-kill. Postfire sprouting was not reported in the majority of reviewed literature.

Minimizing soil disturbances and maintaining high cover of native plants may help prevent or minimize common velvetgrass establishment and spread after fire. For more detailed information on preventing postfire establishment and spread of invasive species, see the following publications: [6,22,55,147].

Use of prescribed fire as a control agent: Fire is not likely useful in the control of common velvetgrass because becaue it is likely to establish, persist, and/or spread after fire (see Fire adaptations and plant response to fire). Cover of common velvetgrass typically exceeds that of native Hawaiian grasses after fire, so prescribed fire is not recommended in common velvetgrass habitats in Hawaii [128]. Integrating mowing or grazing and prescribed fire treatments, however, may decrease common velvetgrass dominance [113].

MANAGEMENT CONSIDERATIONS

SPECIES: Holcus lanatus

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

IMPORTANCE TO WILDLIFE AND LIVESTOCK:
In the western United States, common velvetgrass is consumed by game birds, deer, and elk. According to Blakely and others [18], common velvetgrass is a "key" food for California quail (*Callipepla californica*). Common velvetgrass occurred in more than 15% of 222 sampled crops. In a 20-year-old burned area in northwestern Oregon's Tillamook region, a researcher noted heavy grazing of common velvetgrass, although quantitative measurements were not made [32]. In the Mount St Helens Blast zone, common velvetgrass was predominant in fall elk diets. The average density of common velvetgrass in summer-collected elk feces ranged from 1.2% to 2% and ranged from 2.2% to 5.1% for fall-collected feces [95,96]. In coastal prairie and coastal scrub vegetation in California's Point Reyes Peninsula, common velvetgrass made up 15% to 41% of elk diets from August to December in the second year of a fecal analysis study. In the first year of study, common velvetgrass was less prevalent and made up a high of 9% in April diets. Common velvetgrass made up only a trace of deer diets in any year or season in the study area [54]. On California's Tomales Point Elk Reserve, elk grazing reduced the abundance of common velvetgrass in open grasslands [75].

Palatability/nutritional value: Although consumed by elk and deer, common velvetgrass is not considered very palatable [70]. Common velvetgrass has been described as "without forage value" [85] and "not well liked by stock" [131]. Watt [157] reports that common velvetgrass is considered palatable early in the growing season, but palatability decreases as plants reach the flowering stage.

Digestibility and nutrient content of common velvetgrass in western US habitats are provided in the following references: [96,118]. Digestibility and nitrogen were greatest in the vegetative stage in the Mount St Helens blast zone [96].

OTHER USES:
No information is available on this topic.

IMPACTS AND CONTROL:
In many of its nonnative habitats, common velvetgrass is not described as a serious weed; however, many studies indicate that common velvetgrass' allelopathic potential, rapid early development, litter accumulation, response to disturbances, and nutrient additions can negatively impact associated native vegetation.

Impacts: Common velvetgrass is referred to as a problematic species in Hawaii but is often considered a species of lesser concern in other parts of its nonnative North American range. In reviews from the Hawaiian Islands, common velvetgrass is considered "disruptive" and described as "forming dense stands that appear to inhibit recruitment of natives" [34]. Establishment on disturbed sites in Hawaii is often rapid [127]. Invasiveness ratings of common velvetgrass are likely relative; when associated with more invasive weed species, it is less likely to be described as a problem.

Throughout most of its nonnative range, common velvetgrass is either not listed on invasive plant lists [56,94] or is referred to as a "minor weed" [134], not a "major problem species" [113], moderately invasive [151], or "not readily invading natural areas" [82] as of this writing (2009). Although prevalent in Oregon and Washington, common velvetgrass is absent from many invasive species lists for the area [56]. Common velvetgrass is not listed in the Invasive Plant Atlas of New England [94], although it is well established in the area. Potentially problematic common velvetgrass growth characteristics are discussed below; these may result in impacts that affect a local scale in the nonnative range.

Allelopathy: In laboratory tests, common velvetgrass showed possible allelopathic properties. When common velvetgrass and garden sorrel (*Rumex acetosa*) seedlings were grown in sand that was collected beneath a common velvetgrass monoculture, growth of both species was "markedly depressed" as compared to controls, even when nutrients were added (Al-Mashhadani and Grime, personal communication, cited in [158]). Germination and radicle extension were significantly lower for bulbous canarygrass (*Phalaris aquatica*) and orchardgrass (*Dactylis glomerata*) seeds kept moist with water containing common velvetgrass leaf extracts than for those kept moist with deionized water (P=0.001) [154].

Rapid early growth: Rapid germination and seedling growth may allow common velvetgrass establishment and spread in a variety of habitats. In a greenhouse experiment, the maximum relative growth rate of common velvetgrass was 2.01/week. Soon after seedling establishment, 4 weekly harvests were made to calculate this growth rate, which was high compared to other species evaluated [59]. In another greenhouse experiment, growth rates of common velvetgrass were 42 mg and 65 mg/g/day in low- and high-nitrogen environments, respectively. Growth rates were calculated from 10 weekly harvests [20].

Early germination and rapid seedling growth may allow for the development of stable common velvetgrass stands that limit the growth of associated species. Fifty days after seeding, common velvetgrass seedlings produced the greatest dry weights of 6 western Oregon pasture species grown in the greenhouse [64]. When seeds collected from coastal prairie in northern Marin County, California, were monitored in growth chambers, common velvetgrass germinated more rapidly than red fescue. However, the final germination rate of red fescue was 60% higher than common velvetgrass [117]. Common velvetgrass biomass was significantly greater than that of Hawaii's alpine hairgrass after 6 months of growth in low-light/low-nutrient, high-light/low-nutrient, and low-light/high-nutrient treatments ($P<0.05$). In high-light/high-nutrient conditions, alpine hairgrass biomass was greater than that of common velvetgrass, but not significantly. Common velvetgrass allocated more biomass to roots than did alpine hairgrass [50].

In greenhouse and field experiments, common velvetgrass was most abundant, had the highest growth rate, and, as a seedling, was the most resistant to invasion when compared to other British Columbia pasture species. In the greenhouse, common velvetgrass was most abundant in patches established from seed. Seedling patches resisted invasion most. Based on comparisons made with common velvetgrass tillers collected from older pastures, researchers characterized common velvetgrass as an "r-type" species that likely requires repeated colonization opportunities to maintain a viable population in pastures [143]. In patchy coastal prairie vegetation in California, patches of common velvetgrass inhibited establishment of other species when seed was introduced. Although some seedlings emerged in common velvetgrass patches, none of these produced seed within 2 years of establishment. In patches of nonnative annual grasses, common velvetgrass establishment was successful. An input of 12,442 common velvetgrass seeds/0.25 m^2 produced 39.2 common velvetgrass seedlings/0.25 m^2. Newly established individuals in annual grass patches produced up to 21 seeds/0.25 m^2 and 5.1 seedlings/0.25 m^2. Common velvetgrass also had some establishment in perennial grass patches, but none of these plants produced seed within 2 years [108].

A common velvetgrass monoculture established in the field near Bristol in the United Kingdom severely restricted the growth of European white birch (*Betula pendula*) seedlings. One year following planting, the diameter of European white birch seedlings averaged 2.8 mm when grown with common velvetgrass and 8.4 mm in the absence of common velvetgrass. Seedling heights averaged 8.7 inches (22.2 cm) with and 24.7 inches (62.7 cm) without common velvetgrass [168].

Litter accumulation: In California grasslands, high productivity and reduced litter decomposition in common velvetgrass grasslands may affect regeneration potential and species composition. On the Bodega Marine Reserve in Sonoma County, California, common velvetgrass stands (aboveground biomass 836 g/m^2) were more productive than annual grassland stands (aboveground biomass 534 g/m^2). Standing litter accumulations in common velvetgrass stands were 1,537 g/m^2 and in annual grasslands were 766 g/m^2. From exclusion experiments, researchers learned that the dominant detritivore in the area, *Porcellio scaber*, did not consume common velvetgrass litter. Increased litter in common velvetgrass stands could affect seedling recruitment as well as fuel loads, fire potential, and fire behavior [13]. In field studies in coastal prairie in northern Marin County, California, common velvetgrass litter decreased germination of native grasses more than that of common velvetgrass. Under 0.4 inch (1 cm) of litter, common velvetgrass germination was about 50% lower than germination on bare soil; however, germination of common velvetgrass was still significantly greater than that of Pacific hairgrass, red fescue, Pacific reedgrass (*Calamagrostis nutkaensis*), and purple needlegrass (*Nassella pulchra*) (*P*-value not reported). Under 1.2 inches (3 cm) of litter, common velvetgrass and native grass germination were not different [117].

Control: While several methods may be useful to control common velvetgrass, it is likely that severe defoliation and repeated treatments may provide the best control. Evaluation of associated vegetation and potential increases in these species may affect management decisions. In a greenhouse study using monocultures of 6 grasses and 4 legumes, researchers found that introduced thistle seed (*Carduus nutans* and *Cirsium vulgare*) emergence was lowest in common velvetgrass stands [155]. Management decisions in common velvetgrass' nonnative habitats may involve making value judgments between nonnative species.


Photo taken in Maui, HI,

Some researchers suggest that marking common velvetgrass treatment areas in the early morning when dew is trapped in its velvety hairs may help to focus control efforts and minimize nontarget effects [46].

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Flooding/salinity: Common velvetgrass experienced high mortality when partial dike removal occurred in a 15-year-old pasture on the Salmon River Estuary in Lincoln County, Oregon. Cover of common velvetgrass was up to 70% in the pasture before dike removal. In the 1st growing season after dike breaching, common velvetgrass suffered high mortality and averaged less than 5% cover. By the 2nd growing season, common velvetgrass was essentially absent. Before dike removal, salinity in the pasture was 0 to 3 ppt and after breaching was 11 to 39 ppt [97].

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

Prevention: Methods that may limit the establishment of common velvetgrass in lawn or pasture plantings are discussed by Fitzsimmons and Burrill [46].

Physical and/or mechanical: Some suggest that hand-pulling and hoeing, while labor intensive, can decrease common velvetgrass abundance [113]. A review reports that intense grazing or mowing may limit common velvetgrass establishment and spread [161]. Mechanical methods to control common velvetgrass are described by Fitzsimmons and Burrill [46].

It is important to note that mowing equipment has the potential to disperse common velvetgrass seed. After mowing in a common velvetgrass-dominated grassland in the Netherlands, 86% of the seeds removed from the mower were common velvetgrass seeds [132].

During controlled studies conducted outdoors and in a greenhouse, short cutting heights and increased cutting frequencies decreased common velvetgrass yield. When plants were cut between mid-March and early May, regrowth produced panicles by July 8, but when cut in early June, no panicles were produced on regrowth [159].

In the Willamette Valley, mowing and cutting led to increased common velvetgrass inflorescence production. Plants were mowed short, cut to the base twice, or burned twice in the fall. Mowing and cutting increased the reproductive potential of common velvetgrass. Fire generally decreased inflorescence production; details are discussed in the Western United States section of Fire Ecology [26]:

Changes in the number of common velvetgrass inflorescences/plant between pretreatment and first growing season after 1st and 2nd treatments [26]				
Treatment	Mowed to 8-12 cm heights	Cut at base	Fall fire	Control
Difference between pretreatment and 1st year after single treatment	+4.45	+1.34	-0.7	-0.38
Difference between pretreatment and 1st year after 2 treatments	+11.50	+5.46	-0.7	-0.80

Biological: No information is available on this topic.

Chemical: Herbicides potentially useful in common velvetgrass control are discussed in the following reviews: [46,134,161]. McHenry (1985, cited in [113]) suggests herbicide treatments may be most effective in the spring or when the first seed head appears because translocation to the roots is likely at that time.

Integrated management: A review suggests that mowing or grazing combined with prescribed fire treatments may decrease common velvetgrass dominance [113].

APPENDIX: FIRE REGIME TABLE

SPECIES: Holcus lanatus

The following table provides fire regime information that may be relevant to common velvetgrass. Communities listed are those in which common velvetgrass has the greatest potential to persist. Since descriptions of common velvetgrass North American habitats were regionally limited, readers may want to view the complete FEIS Fire Regime Table for information on communities not listed below.

Fire regime information on vegetation communities in which common velvetgrass may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [87], 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 | Great Lakes | Northeast | South-central US | Southern Appalachians

Pacific Northwest

- Northwest Grassland
- Northwest Woodland
- 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		
Idaho fescue grasslands	Replacement	76%	40		
	Mixed	24%	125		
Northwest Woodland					
Oregon white oak-ponderosa pine	Replacement	16%	125	100	300
	Mixed	2%	900	50	
	Surface or low	81%	25	5	30
Oregon white oak	Replacement	3%	275		
	Mixed	19%	50		

	Surface or low	78%	12.5		
Northwest Forested					
Sitka spruce-western hemlock	Replacement	100%	700	300	>1,000
Douglas-fir (Willamette Valley foothills)	Replacement	18%	150	100	400
	Mixed	29%	90	40	150
	Surface or low	53%	50	20	80
Douglas-fir-western hemlock (wet mesic)	Replacement	71%	400		
	Mixed	29%	>1,000		
Mixed conifer (southwestern Oregon)	Replacement	4%	400		
	Mixed	29%	50		
	Surface or low	67%	22		
California mixed evergreen (northern California)	Replacement	6%	150	100	200
	Mixed	29%	33	15	50
	Surface or low	64%	15	5	30
Mixed conifer (eastside mesic)	Replacement	35%	200		
	Mixed	47%	150		
	Surface or low	18%	400		

California

- California Grassland
- California Shrubland
- California Woodland
- 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					
California grassland	Replacement	100%	2	1	3
Herbaceous wetland	Replacement	70%	15		
	Mixed	30%	35		
California Shrubland					

Coastal sage scrub	Replacement	100%	50	20	150
Coastal sage scrub-coastal prairie	Replacement	8%	40	8	900
	Mixed	31%	10	1	900
	Surface or low	62%	5	1	6
California Woodland					
California oak woodlands	Replacement	8%	120		
	Mixed	2%	500		
	Surface or low	91%	10		
California Forested					
California mixed evergreen	Replacement	10%	140	65	700
	Mixed	58%	25	10	33
	Surface or low	32%	45	7	
Mixed evergreen-bigcone Douglas-fir (southern coastal)	Replacement	29%	250		
	Mixed	71%	100		

Great Lakes

- Great Lakes Grassland
- Great Lakes Shrubland
- Great Lakes Woodland
- 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 Grassland					
Mosaic of bluestem prairie and oak-hickory	Replacement	79%	5	1	8
	Mixed	2%	260		
	Surface or low	20%	2		33
Great Lakes Woodland					
Northern oak savanna	Replacement	4%	110	50	500
	Mixed	9%	50	15	150
	Surface or low	87%	5	1	20

Great Lakes Forested					
Great Lakes pine forest, jack pine	Replacement	67%	50		
	Mixed	23%	143		
	Surface or low	10%	333		
Pine-oak	Replacement	19%	357		
	Surface or low	81%	85		

Northeast

- Northeast Grassland
- Northeast Woodland
- 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 Grassland					
Northern coastal marsh	Replacement	97%	7	2	50
	Mixed	3%	265	20	
Northeast Woodland					
Eastern woodland mosaic	Replacement	2%	200	100	300
	Mixed	9%	40	20	60
	Surface or low	89%	4	1	7
Pine barrens	Replacement	10%	78		
	Mixed	25%	32		
	Surface or low	65%	12		
Oak-pine (eastern dry-xeric)	Replacement	4%	185		
	Mixed	7%	110		
	Surface or low	90%	8		
Northeast Forested					
Northern hardwoods (Northeast)	Replacement	39%	≥1,000		
	Mixed	61%	650		
Appalachian oak forest (dry-mesic)	Replacement	2%	625	500	≥1,000
	Mixed	6%	250	200	500

	Fire severity*	Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
	Surface or low	92%	15	7	26

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					
Bluestem-sacahuista	Replacement	70%	3.6	1	
	Mixed	30%	7.7	2	
Southern shortgrass or mixed-grass prairie	Replacement	100%	8	1	10
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		
Oak woodland-shrubland-grassland mosaic	Replacement	11%	50		
	Mixed	56%	10		
	Surface or low	33%	17		
South-central US Forested					
West Gulf Coastal plain pine (uplands and flatwoods)	Replacement	4%	100	50	200
	Mixed	4%	100	50	
	Surface or low	93%	4	4	10
West Gulf Coastal Plain pine-hardwood woodland or forest upland	Replacement	3%	100	20	200
	Mixed	3%	100	25	
	Surface or low	94%	3	3	5

Southern Appalachians

- Southern Appalachians Grassland
- 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 Grassland					
Bluestem-oak barrens	Replacement	46%	15		
	Mixed	10%	69		
	Surface or low	44%	16		
Eastern prairie-woodland mosaic	Replacement	50%	10		
	Mixed	1%	900		
	Surface or low	50%	10		
Southern Appalachians Woodland					
Appalachian shortleaf pine	Replacement	4%	125		
	Mixed	4%	155		
	Surface or low	92%	6		
Table Mountain-pitch pine	Replacement	5%	100		
	Mixed	3%	160		
	Surface or low	92%	5		
Oak-ash woodland	Replacement	23%	119		
	Mixed	28%	95		
	Surface or low	49%	55		
Southern Appalachians Forested					
Mixed mesophytic hardwood	Replacement	11%	665		
	Mixed	10%	715		
	Surface or low	79%	90		
Appalachian oak-hickory-pine	Replacement	3%	180	30	500
	Mixed	8%	65	15	150
	Surface or low	89%	6	3	10
	Replacement	6%	220		

Appalachian oak forest (dry-mesic)	Mixed	15%	90		
	Surface or low	79%	17		

*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 [60,86].

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