Holodiscus discolor

INTRODUCTORY

AUTHORSHIP AND CITATION:
Fryer, Janet L. 2010. Holodiscus discolor. 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, July 8].

FEIS ABBREVIATION:
HOLDIS

NRCS PLANT CODE [227]:
HODI

COMMON NAMES:
creambush oceanspray
creambush rockspirea
creambush rock spirea
hillside oceanspray
oceanspray

TAXONOMY:
The scientific name of creambush oceanspray is *Holodiscus discolor* (Pursh) Maxim (Rosaceae) [97,99,103,117,193].

The *Holodiscus* taxonomy is confused because creambush oceanspray, rockspirea (*H. dumosus*), and small-leaved rockspirea (*H. microphyllus*) are taxonomically and morphologically very similar [45,163]. Authorities separating these 3 closely related taxa do so based on different leaf morphologies [45,136] and distributions [136]. This review follows the taxonomy of Lis (in [97]), who is authoring the Flora of North America's [63] *Holodiscus* chapter. In Lis's treatment, creambush oceanspray, rockspirea, and small-leaved rockspirea are treated as separate and distinct species [97]. Some systematists lump either creambush oceanspray and rockspirea [104,236], creambush oceanspray and small-leaved rockspirea [103], or all 3 taxa [233] into single species.

SYNONYMS:
Holodiscus discolor (Pursh) Maxim. var. *dumosus* (Nutt. ex Hook.) Maxim. ex J.M. Coult.
Holodiscus dumosus (Pursh) Maxim. var. *glabrescens* (Greenm.) Jeps. [104]

LIFE FORM:
Shrub

DISTRIBUTION AND OCCURRENCE

SPECIES: Holodiscus discolor

GENERAL DISTRIBUTION:
Creambush oceanspray is native to the western United States and southwestern Canada. It occurs from southern British Columbia south to southern California and Arizona and east to western Montana [86,100,103]. A few collections have been made in Colorado [227]. Plants Database provides a distributional map of creambush oceanspray.

HABITAT TYPES AND PLANT COMMUNITIES:
Creambush oceanspray is important or dominant in many plant communities of the Pacific Northwest, California, and the Northern Rocky Mountains. These communities include seral and old-growth conifer, seral and old-growth hardwood, mixed-riparian, and mixed-shrubland types.

Conifer communities: Creambush oceanspray is called "the most widespread and possibly the most abundant flowering shrub" in coniferous forests of northeastern Washington and northern Idaho [225]. On the Umatilla National Forest, Washington, it is dominant in coast Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*), grand fir (*Abies grandis*), and western larch (*Larix occidentalis*) forests [90].

Creambush oceanspray in mixed-conifer forest of Oregon's Cascade Range. Photo permission of Craig Smith.

In Oregon, coast Douglas-fir/creambush oceanspray associations on the Willamette National Forest are primarily structurally diverse old-growth stands, containing long-lived canopy trees and a subcanopy of younger trees. Most of the stands are >150 years old [94]. Creambush oceanspray is common to dominant in dry white fir (*A. concolor*) forests in the Siskiyou Mountains of southwestern Oregon [238], and it is an important shrub in Port-Orford-cedar (*Chamaecyparis lawsoniana*) communities of southwestern Oregon and northwestern California [257]. It is important in many mixed-conifer forests of southern Oregon and California [33,34]. These communities are codominated by Pacific ponderosa pine (*P. ponderosa* var. *ponderosa*), coast Douglas-fir, Jeffrey pine (*P. jeffreyi*), California black oak (*Quercus kelloggii*), tanoak (*Lithocarpus densiflorus*), and/or canyon live oak (*Q. chrysolepis*) [34]. Creambush oceanspray is also important in knobcone pine (*P. attenuata*) communities of southern Oregon and California [39].

In California, creambush oceanspray is a characteristic to dominant species of redwood (*Sequoia sempervirens*) [202,254], Pacific ponderosa pine [116], shore pine (*P. contorta* var. *contorta*) [255], and Sierra Nevada lodgepole pine (*P. c.* var. *murrayana*) [77] forests. It is a minor species in pinyon-juniper (*Pinus-Juniperus* spp.) communities [24].

Creambush oceanspray is associated with Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) and Rocky Mountain lodgepole pine (*Pinus contorta* var. *latifolia*) in northern Idaho [217]; it is commonly dominant in Rocky Mountain Douglas-fir forests of northern Idaho and Montana [178,217,225]. It is infrequent to common in western redcedar-western hemlock (*Tsuga heterophylla-Thuja plicata*)) forests of the Interior Pacific Northwest and the Northern Rocky Mountains [148,186].

Hardwood communities: Creambush oceanspray occurs in the understories of Oregon white oak (*Q. garryana*) communities throughout Oregon white oak's range ([147,185,216], review by [122]). It also occurs or dominates in other montane oak (*Quercus* spp.) communities in California [142].

Riparian: Creambush oceanspray occurs in riparian communities throughout its range (review by [196]). Overstory dominants may be conifers, hardwoods or a mix [112,219]. Meriwether Lewis made the first scientific collection of creambush oceanspray on the banks of the Clearwater River in Idaho [48]. Creambush oceanspray is dominant in grand fir floodplain associations of eastern Washington [112]. In western hemlock stands in the central Cascade Range of Washington, it was more common on high floodplains than on low floodplains

[229]. On Myrtle Island Research Natural Area, Oregon, creambush oceanspray is occasional in red alder-Oregon ash (*Alnus rubra-Fraxinus latifolia*) and willow/field horsetail (*Salix* spp./*Equisetum arvense*) riparian communities [219].

Shrublands: Creambush oceanspray is common to dominant in mixed montane shrublands of the Pacific Northwest and the Northern Rocky Mountains [51,204]. These communities are common on harsh slopes and in coniferous forests in early succession [51]. In montane regions of Nevada and western Utah, creambush oceanspray occurs in mosaics of mountain meadow and mountain big sagebrush (*Artemisia tridentata* subsp. *vaseyana*) stands [65]. In Redwood National Park, California, it occurs in Lewis' mockorange/brittle bladderfern (*Philadelphus lewisii/Cystopteris fragilis*) and Sierra gooseberry/varileaf phacelia (*Ribes roezlii/Phacelia heterophylla)* bald-hill communities [211]. On the Jasper Ridge Biological Reserve in coastal northern California, creambush oceanspray is an associated species in chamise (*Adenostoma fasciculatum*) chaparral communities [1].

Publications describing plant communities where creambush oceanspray is a dominant or indicator species are listed below.

Pacific Northwest:

Washington:

- western hemlock/salal (*Gaultheria shallon*)-oceanspray forest association of the Olympic National Forest [95]
- western hemlock-coast Douglas-fir/creambush oceanspray association of the Gifford Pinchot National Forest [222]
- coast Douglas-fir-Pacific madrone (*Arbutus menziesii*)/hairy honeysuckle (*Lonicera hirsuta*)-creambush oceanspray and coast Douglas-fir-Pacific madrone/salal-creambush oceanspray associations across the Puget Trough of west-central Washington [32]
- Rocky Mountain lodgepole pine/Rocky Mountain maple-Saskatoon serviceberry (*Acer glabrum-Amelanchier alnifolia*)-creambush oceanspray woodlands and forests; occur on the east side of the Cascade Range, the Okanogan Highlands, and the Blue Mountains [43]
- Pacific ponderosa pine-coast Douglas-fir/Saskatoon serviceberry-creambush oceanspray communities of the Blue Mountains [84]
- creambush oceanspray and creambush oceanspray-mallow ninebark shrublands on north-facing slopes of the Blue Mountains [51]
- east-canyon mixed shrublands of the Columbia Basin and Blue Mountains [44]
- grand fir-creambush oceanspray floodplain association of eastern Washington; this type is a variant of the grand-fir-common snowberry (*Symphoricarpos albus*) floodplain association [112]
- Rocky Mountain Douglas-fir-Pacific ponderosa pine-Rocky Mountain lodgepole pine/mixed shrub forest zone in the Wallowa Mountains [38]
- Pacific ponderosa pine/mallow ninebark (*Physocarpus malvaceus*)-creambush oceanspray association of southeastern Washington [152]
- Rocky Mountain Douglas-fir-mallow ninebark-creambush oceanspray habitat type of eastern Washington

Oregon:

- coast Douglas-fir/creambush oceanspray forest communities in the west-central Cascade Range; characterized by open stands of old growth [57]
- coast Douglas-fir/creambush oceanspray/grass and coast Douglas-fir/creambush oceanspray/vine maple (*Acer circinatum*) community types of the western Cascade Range; the former is the most widely distributed of Oregon's dry-forest types [153]
- Rocky Mountain lodgepole pine/Rocky Mountain maple-Saskatoon serviceberry-creambush oceanspray woodlands and forests; occur on the east side of the Cascade Range and the Blue Mountains [43]
- creambush oceanspray and creambush oceanspray-mallow ninebark shrublands on north-facing slopes of the Blue Mountains [51]
- Pacific ponderosa pine-Rocky Mountain Douglas-fir/western snowberry-creambush oceanspray communities of the Blue Mountains [84]
- east-canyon mixed shrublands of the Columbia Basin and Blue Mountains [44]
- westside Oregon white oak/creambush oceanspray and dry coast Douglas-fir/creambush oceanspray woodlands and forests; mostly in Willamette Valley and the Klamath Mountains [33]
- coast Douglas-fir/creambush oceanspray-whipplevine (*Whipplea modesta*) series on the Coast Ranges; occurs on the Medford District of BLM and on the Siskiyou and Rogue River National Forests. Indicative of dry sites [19].
- coast Douglas-fir/creambush oceanspray/salal habitat type off the southern coast [20]

California:

- coast live oak (*Q. agrifolia*)/creambush oceanspray-common snowberry subseries of California's hardwood rangeland cover types; on upper-elevation (>1,250 feet (380 m)), mesic sites [9]
- redwood-coast Douglas-fir-hardwood/creambush oceanspray vegetation types of the North Coast Ranges [254]
- canyon live oak (*Q. chrysolepis*)-creambush oceanspray forest cover type of central California [142]

Northern Rocky Mountains:

Northern Idaho:

- Rocky Mountain Douglas-fir/mallow ninebark-creambush oceanspray habitat type [51,152]
- Pacific ponderosa pine/mallow ninebark-creambush oceanspray association

Montana:

- Rocky Mountain Douglas-fir/creambush oceanspray and Rocky Mountain Douglas-fir/mallow ninebark-creambush oceanspray forest habitat types [178]
- climax western redcedar-western hemlock, Rocky Mountain Douglas-fir, grand fir, and subalpine fir (*A. lasiocarpa*)-Rocky Mountain Douglas-fir-grand fir forests [186]
- indicator species of the Rocky Mountain Douglas-fir/mallow ninebark habitat type [125]

Western United States:

- indicator species of dry western redcedar-western hemlock/shrub, Pacific ponderosa pine/shrub, and Rocky Mountain Douglas-fir/shrub forests [148]

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Holodiscus discolor

GENERAL BOTANICAL CHARACTERISTICS:

Botanical description: This description covers characteristics that may be relevant to fire ecology and is not meant for identification. Keys for identification are available (for example, [97,99,117,193]). Morris and others [161] provide a key for identifying creambush oceanspray and other shrubs in winter. Creambush oceanspray and rockspirea are distinguished by their forms, leaf characteristics, and distributions [136]; intergradation of the 2 species is most pronounced in Nevada [104] and Utah [236].

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Morphology:

Form: Creambush oceanspray is a deciduous [1,41,198], spreading shrub with slender arching branches [75,136,223]. It can range from bushy forms about 2.5 feet (0.75 m) tall on poor or frequently disturbed sites to arborescent forms that may be 20 feet (6.1 m) tall in coastal areas. Plants are usually 3 to 10 feet (1-3 m) in height [52,99,198]. They typically have multiple branches [198]. Stem wood is hard and dense [73]; bark of mature plants is shreddy [41,174]. Stand structures of plant communities where creambush oceanspray is important are discussed in the Stand structure section of Fuels.

Leaves and flowers: The leaves are mostly 1.6 to 2.75 inches (4-7 cm) long and 0.8 to 2.75 inches (2-7 cm) wide [136,223]. Creambush oceanspray has a large leaf area relative to most associated shrubs. In the Siskiyou Mountains of southwestern Oregon, its leaves were more densely packed, larger, thinner, and more prone to wilt than leaves of associated shrub species [40].

Creambush oceanspray flowers are small, about 2 mm long [163]. They are borne on large, showy, terminal panicles that may reach 12 inches (30 cm) long [22]. The name "oceanspray" is derived from these masses of loose, creamy plumes [50]. The fruit is a 1-seeded [45]

achene [41,97,117], about 2 mm long [198].

Roots: Rooting depth is likely associated with depth to bedrock. In southwestern Oregon, creambush oceanspray extracted water from no deeper than 3 feet (1 m) below ground, indicating a shallow root system [40]. Dyrness and Franklin [57] had similar findings in the west-central portion of the Cascade Range in Oregon, where shallow soils confined roots to <3 feet below the soil surface. However, a planting guide for the Pacific Northwest reports creambush oceanspray roots as "deep and wide" [154], and researchers described creambush oceanspray as "relatively deep-rooted" in the Blue Mountains [249].

Descriptions of creambush oceanspray's root morphology were not found in the literature as of 2010.

Life span: This species rarely lives more than 30 years [10]. On the Jasper Ridge Biological Reserve, California, its mean life span was 4.5 years [1].

Physiology: Creambush oceanspray is highly drought tolerant [51]. It has adapted to dry sites and drought by shutting down or slowing its rate of transpiration. In droughty conditions, it apparently uses water less efficiently than associated sclerophyllous species. Its large leaf area, however, may partially compensate for low water transpiration rates in summer. It is likely that creambush oceanspray depletes water in upper soil layers rapidly in summer [40].

Antieau [13] suggested that creambush oceanspray may differ in water-use efficiency and cold tolerance across its distribution.

Raunkiaer [180] life form:
Phanerophyte

SEASONAL DEVELOPMENT:
Creambush oceanspray is among the first shrubs to initiate leaves in spring. Although floral buds swell in early [100] to late spring, creambush oceanspray is a late bloomer [12]. Full flowering does not occur until late June or July and may continue into August in some areas [12,100]. Fruits mature in late summer and may persist until fall (reviews by [196,198]). Panicles and panicle branches typically persist through winter after drying in fall [196].

Leaf phenology is closely regulated by weather. In the Siskiyou Mountains of Oregon, leaf water conductance peaked in July [40]. On the Jasper Ridge Biological Preserve, mean leaf age was 4.5 months; leaves were drought-deciduous and mostly absent by August [1]. A study in the western redcedar-western hemlock zone of northern Idaho found summer or fall drought initiated leaf color change and leaf drop [55].

Creambush oceanspray consistently shows a late and long period of flowering throughout its distribution:

Phenology of creambush oceanspray across its range	
Area	Event
southern California	flowers June-August [41]
northern Idaho	buds swell and burst late March-early April; leaf-out late March-mid-April [55]; stem elongation late March-late June [55,170]; flowers early May-late June; fruits late June-August [55,174]; leaves change color late June-late September [55,170]; leaves fall late July-late November; seeds disperse late August-late November [55]
Montana	flowers late June-July [117]
Nevada	flowers June-August [104]
southwestern Oregon	flower buds expand in July; flowers and fruits July-August [183]
Oregon and western Washington	flowers May-July; seeds disperse August-September (review by [237])
Pacific Northwest	flowers midsummer [113]
Puget Sound	flowers mid-June [12]
Northern Rocky Mountains	flowers mid- to late July; fruit ripens late August; seeds disperse late August-late November [170]

REGENERATION PROCESSES:
Creambush oceanspray regenerates by sprouting from the root crown [55,60,61,140,140,167,209,228,245] and establishing from seed [160]. Root crown sprouting is more prevalent than regeneration from seed [140,149,150,208,213]. Ackerly [1] characterizes creambush oceanspray's reproduction as "opportunistic regeneration following disturbance". Fire and other top-killing events favor creambush oceanspray regeneration.

Vegetative regeneration: Creambush oceanspray sprouts from the root crown after top-kill [55,60,61,140,140,150,167,209,228,245]. It may also reproduce by layering ([74], review by [196]).

Pollination and breeding system: Insects pollinate creambush oceanspray (review by [196]). The flowers are perfect [100].

Antieau [13] suggested that mountain ranges restrict creambush oceanspray breeding. A study across creambush oceanspray's distribution in Washington and Oregon showed phenotypic differences in creambush oceanspray (for example, in leaf area); these differences were related to geographic regions and climate [13].

Flower and seed production: Thinning, burning, or other canopy-opening events may increase creambush oceanspray's seed output. In the understories of coast Douglas-fir forests in western Oregon, creambush oceanspray showed a "large increase" in flower and/or fruit production after moderate thinnings (leaving 200 trees/ha) or heavy thinnings (leaving 100 trees/ha or 0.4-ha openings); production increases were "minimal" after light thinning (leaving 300 trees/ha) [213].

Seed dispersal: Creambush oceanspray seed is disseminated by wind ([213,237,248], review by [198]) or animals [213].

Seed banking: Creambush oceanspray has a soil seed bank [60,150]. In western hemlock forests of southwestern British Columbia, viable creambush oceanspray seed was more common in undisturbed soils ($\bar{x}$=15.5 germinants/0.04-m² soil sample) compared to clearcut rights-of-way in early-seral succession ($\bar{x}$=1-2.5 germinants/0.04-m² soil sample) [150].

Germination, seedling establishment, and plant growth: Fresh creambush oceanspray seed is dormant [74]. In the field, it likely requires overwintering to germinate. As of 2010, little research had been conducted on creambush oceanspray's germination requirements [197]. Stratification at around 41 °F (5 °C) [197] for 15 to 18 weeks breaks dormancy in the laboratory [12,113,197].

Creambush oceanspray seed may have low viability. According to a fact sheet, most seeds lack developed embryos, so only about 7% of a given seed lot may be sound [74].

Seedling establishment is uncommon [140,149,150,208,213] but has been documented a few times. Open stand structure [214], heat, and bare mineral soil may favor creambush oceanspray germination and establishment (review by [196]). In the Oregon Coast Range, creambush oceanspray seedlings emerged well (>70%) in both clearcuts and young, unthinned conifer stands; however, seedlings survived only in the young, unthinned stands [214]. Creambush oceanspray established from seed 3 growing seasons after a debris flow on the Central Coast Ranges of southwestern Oregon [173]. See Seedling establishment in the Plant Response to Fire section for studies on postfire seedling establishment.

A review states that creambush oceanspray seedlings grow slowly in their first 2 years of development [196]. Plants released by overstory removal may grow rapidly, however. Daubenmire and Daubenmire [51] found that in northern Idaho, creambush oceanspray grew up to 15 feet (4.6 m) tall following harvest of the Rocky Mountain Douglas-fir overstory; this was twice its stature in unharvested Rocky Mountain Douglas-fir forests.

SITE CHARACTERISTICS:
Soils: Creambush oceanspray tolerates soils with a pH range from approximately 5.0 to 7.5, fine to coarse textures, and low nutrient and moisture content [74]. In western redcedar-western hemlock forests of northern Idaho, it had significantly greater cover in soils with pH above 6.1 than in soils with lower pH values (6% vs. =1% cover, P=0.05) [165]. Soils supporting creambush oceanspray are often shallow

([87,94,100], review by [196]). In the Blue Mountains of Washington and Oregon, however, creambush oceanspray is dominant in Pacific ponderosa pine-Rocky Mountain Douglas-fir forests on deep, fertile soils similar to those of Palouse prairie [84].

Creambush oceanspray is common in sands and clay loams (review by [196]) but may occur in all soil textures. In the Cascade Range of Oregon, coast Douglas-fir/creambush oceanspray communities occur on coarse soils and loams but not on fine soils [153]. A study in the Blue Mountains, however, found creambush oceanspray presence was positively correlated with fine-textured soils ($P<0.05$) [249]. In western redcedar-western hemlock forests of northern Idaho, creambush oceanspray cover, frequency, and importance value increased as soil organic matter increased; increases in importance values were significant ($P=0.05$) [165]. Soils supporting creambush oceanspray are often stony [67,87,94,97,98,100], and creambush oceanspray sometimes grows within rock crevices. It is common on talus slopes (review by [196]). In Nevada and western Utah, creambush oceanspray grew on talus slopes near mountain meadows and in granite boulder piles [65].

Creambush oceanspray occurs on a variety of parent materials. In the Cascade Range of Oregon, coast Douglas-fir/creambush oceanspray communities occur on poorly developed basalts, andesites, and other parent materials of volcanic origin [153]. At Oregon Caves National Monument, mixed-conifer forests with creambush oceanspray occur on soils of diorite origin [240]. Poison-oak (*Toxicodendron diversilobum*)-creambush oceanspray-Mexican elderberry (*Sambucus mexicana*) communities of San Luis Obispo County, California, are associated with andesite-derived soils [235].

Photo © Br. Alfred Brousseau, St Mary's College

Moisture regime: Creambush oceanspray is most common on dry sites. McDonald and others [148] list creambush oceanspray as an indicator species of dry montane/shrub forests of the Northern Rocky Mountains. Creambush oceanspray is also associated with dry montane forests in British Columbia [168,179] and elsewhere in the Pacific Northwest. It is an indicator species of very dry to moderately dry, nitrogen-medium soils in coastal British Columbia [110,111]; its occurrence decreases with increasing precipitation [111]. It also grows in dry to fresh soils in coniferous forests of interior British Columbia [168]. The western hemlock-coast Douglas-fir/creambush oceanspray association occurs on some of the hottest and driest sites in the Cascade Range of Washington [222]. In the west-central portion of the Cascade Range in Oregon, Dyrness and Franklin [57] found the coast Douglas-fir/creambush oceanspray association occurs on the dry end of coast Douglas-fir forest types. In an extreme case, creambush oceanspray is "widespread but not abundant" on the Indian Plateau of southwestern Oregon. The plateau is a severe site known for widely fluctuating and extreme temperatures in winter and summer and a record of poor artificial regeneration of conifers [156].

Creambush oceanspray is also reported from sites with moist to mesic soils. It is frequently associated with riparian communities (review by [196]). In southeastern Washington and northern Idaho, Pacific ponderosa pine/mallow ninebark-creambush oceanspray communities dry out later in the growing season than Pacific ponderosa pine/common snowberry communities [152]. Creambush oceanspray occurs on moist woodland edges in California [97] and in moist open woods in British Columbia [193]. In western redcedar-western hemlock forests of northern Idaho, creambush oceanspray frequency was significantly greater on sites with 21% to 25% soil moisture content than on sites with drier or wetter soils [165].

Aspect and topography: This species is most common on warm, dry, south-facing slopes [67,98,165]. A grand fir/creambush oceanspray association in southwestern Washington is common on exposed, south-facing slopes and on ridgetops. Sites having this association remain snow-free much of the year and experience extreme summer drought [221]. In Douglas-fir (*Pseudotsuga menziesii*) forests in the Columbia River Gorge of Washington, creambush oceanspray had greatest cover on south-facing slopes (13%) and least cover in mesic ravines (6%) [243]. The coast Douglas-fir/creambush oceanspray association in Oregon's Coast Ranges occurs most often on relatively steep, south- or west-facing slopes between 2,000 and 3,000 feet (600-900 m) elevation. The environment is hot and dry, and the growing season is long, with drought developing by midsummer. Snowpacks are not generally deep or persistent [94]. The western hemlock-Douglas-fir/creambush oceanspray association is found in some of the hottest and driest forests in the western Cascade Range. Sites are "always" upper slopes and fairly steep, and drainage and solar input are "excessive" [87]. Coast Douglas-fir/creambush oceanspray communities in the Cascade Range of Oregon are also most prevalent on dry, south-facing slopes [153]. In western redcedar-western hemlock forests of northern Idaho, creambush oceanspray cover, frequency, and importance values were significantly greater on south- than north-facing slopes ($P=0.05$) [165].

Creambush oceanspray grows on more mesic exposures as well. In montane zones on the Umatilla National Forest, it dominated the understory on north, northeast, northwest, and east aspects [90]; in western Oregon clearcuts it occurred only on north-facing slopes [246]. Creambush oceanspray mostly grows on moist slopes in southern California [41], where it reaches the southern end of its distribution.

Elevation: Creambush oceanspray occurs from sea level to about 7,000 feet (2,150 m) across its range. It mostly grows on low-elevation montane sites. In western redcedar-western hemlock forests of northern Idaho, creambush oceanspray cover, frequency, and importance values were significantly greater on 3,000- to 3,400-foot (910-1,000 m) elevations than on higher-elevation sites (*P*=0.05) [165]. Creambush oceanspray grows mostly on high peaks in the Great Basin (review by [196]).

Location	Elevation
eastern Washington and Oregon, Blue Mountains	1,700-4,800 feet [84]
Deschutes National Forest, Oregon, east slopes	>2,800 feet, from ponderosa pine to subalpine mixed-conifer zones [212]
California	<5,900 feet [97]
southern California	<4,500 feet [41]
Nevada	4,500-9,500 feet [104]
Pacific Northwest	sea level to 5,500 feet [135]

Climate: Creambush oceanspray occurs mostly in dry zones [135], although it is characterized as a "predominantly humid zone species" in western Washington [53]. Annual precipitation across its United States distribution [37,56,97,137,215,241] ranges from 9.3 inches (236 mm) in central Oregon [56] to 57 inches (1,140 mm) in western Washington [137].

SUCCESSIONAL STATUS:
Creambush oceanspray is most common in early succession but occurs in all stages of succession. In mesic coniferous forests of northwestern Montana, it is approximately 5 times as dense in stands =150 years old than in old growth [14].

Seral occurrence: Disturbance favors creambush oceanspray [111,113]. Kruckeberg [113] characterized creambush oceanspray as a "colorful reclaimer of open or disturbed lands" of the Pacific Northwest, where it commonly establishes on recently logged sites, in second growth, and on roadbanks. It is especially common in seral Douglas-fir forests [111]. Following the Sundance Fire in northern Idaho, creambush oceanspray was important or codominant in the first decade of postfire succession in Rocky Mountain Douglas-fir-western hemlock forests [206]. On another site in northern Idaho, creambush oceanspray grew rapidly and dominated early-seral sites after a Rocky Mountain Douglas-fir forest was clearcut. The shrub layer regained precutting cover about 60 to 80 years after tree harvest [51]. Creambush oceanspray seedlings established 3 growing seasons after a debris flow on the Central Coast Ranges of southwestern Oregon [173].

Creambush oceanspray prefers open sites [111,218]. It is described as a "light demanding, early successional" species [218]. Logging and fire promote creambush oceanspray by opening the canopy. A study at the Eastern Oregon Experiment Station showed shrub cover, including that of creambush oceanspray, decreased with increasing cover of the mixed-conifer overstory. At about 90% canopy closure, shrub cover dropped to about 5%. However, even under a nearly closed canopy, a few shrubs remained alive in the understory, and seedlings of these shrubs established in canopy breaks [247]. In coast Douglas-fir/salal stands on foothills of the Cascade Range, Washington, maximum creambush oceanspray cover occurred approximately 20 years after disturbance (clearcutting or wildfire); creambush oceanspray generally declined after that [137]:

Creambush oceanspray cover in different-aged Douglas-fir stands in Washington [137]					
Disturbance and stand age	Postclearcut year 5	Postfire year 22	Postfire year 30	Postfire year 42	Postfire year 73
Cover (%)	1.72	4.46	3.34	2.13	2.84

Defoliation and/or death of overstory trees due to insects may favor creambush oceanspray. In the Blue Mountains, creambush oceanspray showed 5% cover and 15% frequency 23 years after a record-breaking, 2-year attack by Douglas-fir tussock moths. About 1,250 miles² (3,240 km²) of a grand fir-Douglas-fir forest was affected by the outbreak [250].

Where it is a minor species, creambush oceanspray may not decline with canopy closure. In western redcedar-western hemlock forests of northern Idaho, its cover, frequency, and importance values were not significantly different in 5 canopy-cover classes ranging from 1% to 100% closure. Creambush oceanspray had =1% cover in all canopy-cover classes. Similarly, its cover, frequency, and importance values in these forests were not significantly different between logged, logged-and-burned, single-broadcast-burned, or multiple-broadcast-burned sites and sites with no history of logging or prescribed fire [165].

Logging: Lightly-shaded areas, such as those occurring a few decades after thinning, can promote creambush oceanspray growth [194]. In Douglas fir-western hemlock forests of coastal Oregon, creambush oceanspray was associated with intermediate tree densities (*P*<=0.01) [199]. In Douglas- fir stands in northern Idaho, its cover peaked about 20 years after logging [176].

Creambush oceanspray cover in unlogged and logged Douglas-fir stands in northern Idaho [176]				
Treatment	Unlogged	Logged 13 years previous	Logged 20 years previous	Logged 40+ years previous
Cover (%)	0.6	21.4	26.8	8.0

On the Fort Lewis Military Reservation of Washington, a late 1990s study found creambush oceanspray cover was greater in a coast Douglas-fir/creambush oceanspray forest that had been clearcut in the 1920s and thinned twice afterwards (2.5% creambush oceanspray cover) than in a coast Douglas-fir/creambush oceanspray forest that had been partially cut only once, in the 1930s (1.5% creambush oceanspray cover) [220]. In Pacific ponderosa pine and Rocky Mountain Douglas-fir habitat types of the Swan Valley, Montana, creambush oceanspray cover was greater on clearcut (15%) and plantation (10%) plots than on untreated plots (8%) [69].

In the Klamath Mountains of Oregon and California, shrubfields of creambush oceanspray and other sprouting shrubs develop after logging or fire when conifers fail to regenerate in the early postfire community; conifers eventually replace the shrubs on most sites [149].

Logging does not favor creambush oceanspray on all sites. In northern Idaho logging reduced creambush oceanspray frequency slightly compared to its frequency in the understory of an adjacent unlogged site. The study site was in a western hemlock/pachistima forest. A tall-shrub (>3 feet (1 m)) community developed after logging; creambush oceanspray was a component of this early-seral, tall-shrub community. On cut sites, creambush oceanspray had 1.4% frequency 7 years after logging and 0.7% frequency 25 years after logging. It had 2.1% cover on the unlogged site 25 years after treatments [242].

See Plant response to fire for more information on creambush oceanspray occurrence in seral postfire communities.

Late-successional occurrence: Creambush oceanspray sometimes occurs in late succession. In Glacier Park's western redcedar-western hemlock forests, it is mostly restricted to late-seral or climax communities [81]. Creambush oceanspray also occurs in late succession in western redcedar-western hemlock and grand fir forests of Montana [186], and it is a late-successional or climax species in some western hemlock habitat types of Washington [95] and northern Idaho [251]. However, Henderson and others [95] point out that on the Olympic National Forest, climax western hemlock/salal-creambush oceanspray forests rarely develop due to recurrent fires. Coast Douglas-fir dominates the seral stands; creambush oceanspray often codominates the understory of these seral stands [95]. Creambush oceanspray also dominates the understories of late-successional Douglas-fir forests in Oregon [256] and Montana [186]. In mixed-conifer forests of western Oregon and California, creambush oceanspray and other deciduous shrubs are more likely to dominate in late succession on north-facing and other mesic slopes than on south-facing, dry slopes [240].

FIRE EFFECTS AND MANAGEMENT

SPECIES: Holodiscus discolor

FIRE EFFECTS:

Immediate fire effect on plant: Creambush oceanspray is usually top-killed by fire [25,35,60,140,167,167,203,207,207,253]. Many fire researchers describe it as "moderately resistant" to fire [60,61,207,248]. Stickney [208] classifies creambush oceanspray among the shrubs "least susceptible" to fire mortality, although fire may kill some individuals within a population [91].

Postfire regeneration strategy [207]:
Tall shrub, sprouting root crown
Small shrub, sprouting root crown
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:

Fire adaptations: Creambush oceanspray sprouts from the root crown after fire [55,60,61,140,167,208,209,228,232,245]. Stickney

[207,208] uses creambush oceanspray as a characteristic example of a root crown-sprouting, "postfire survivor species".

Creambush oceanspray may establish from soil-stored seed [25,60,160,167,207,232,248], although seedlign establishment is apparently rare [167,248] and to date (2010), has only been documented 3 times after fire [83,160,191]. Postfire seed dispersal onto burns by wind or animals is possible but has not been documented. Heat and bare mineral soil may favor creambush oceanspray germination and establishment (review by [196]); this has not been determined experimentally or in the field.

Plant response to fire: Creambush oceanspray sprouts from the root crown and establishes from seed after fire.

Sprouting from surviving root crowns is creambush oceanspray's most common method of postfire regeneration [25,25,35,42,54,58,108,126,134,167,167,206,207,208,208,232,245,248,248]. It usually takes 5 to 10 years for creambush oceanspray to recover its prefire abundance [55]. It is often important on early-seral shrubfields after fire; these shrubfields eventually succeed to coniferous forests [204]. Shatford and others [195] found creambush oceanspray "common and abundant" on 9- to 19-year-old burns in dry coast Douglas-fir forests of the Siskiyou and Klamath mountains of Oregon and California. Creambush oceanspray's cover generally increases after disturbances [25,35,167,248] that open the canopy in late-successional forests, so creambush oceanspray is likely to increase on sites that were in late succession before fire [42,60,61,167,248].

Sprouting allows creambush oceanspray to survive large, severe wildfires. In southeastern Oregon, creambush oceanspray was noted in montane postfire communities after the 2002 Biscuit Fire Complex, a series of mixed-severity (low- to high-severity surface and crown) wildfires that burned about 500,000 acres (200,000 ha), and after the Bear Butte and Booth Fire Complex, a series of mixed-severity wildfires that burned about 91,000 acres (37,000 ha) [85]. A survey of wildfire-burned sites in California chaparral and moist and dry, mixed-conifer forests of western Montana showed creambush oceanspray sprouted after fires of all severities in all vegetation types where it was present before fire. Its postfire sprouting response was stronger in moist and dry conifer forests than in chaparral [134]. Reburns generally favor creambush oceanspray (see Northern Idaho below).

Seedling establishment: Creambush oceanspray regenerates from soil-stored seed after fire [25] occasionally. Neuenschwander [167] noted that for creambush oceanspray, "reproduction from seed is rarely observed after a burn", and Stickney (1978 personal communication cited in [167]) noted that creambush oceanspray seedling growth is slow in burns compared to other species. However, in the western Cascade Range of Oregon, creambush oceanspray seedlings occurred 2 years after former western-hemlock/Douglas-fir old growth had been clearcut, broadcast burned, and planted to coast Douglas-fir. Creambush oceanspray was not present on study plots before treatments [191].

Although creambush oceanspray does not often establish from seed, its postfire seedling cover may be greatest where fire was severe. A northern Idaho study determined that creambush oceanspray regenerated from duff- and soil-stored seed 1 to 3 years after broadcast burning in western redcedar/queencup beadlily (*Clintonia uniflora*) habitat types. Greatest creambush oceanspray seedling cover was in areas that experienced severe fire [160]. Succession proceeded slowly after the severe 1960 Saddle Mountain Fire in the Saddle Mountain Wilderness, Arizona, where creambush oceanspray is near its southern distributional limit. Creambush oceanspray showed low cover (0.03%) and frequency (0.01 %) in a vegetation survey conducted in postfire year 48 [83].

Regional studies: Creambush oceanspray is most common in early postfire succession [41], with cover and frequency declining with advancing stand age. Studies from the following regions provide site- and habitat-specific examples of creambush oceanspray's postfire response, as well as information on combining spraying with prescribed burning for shrub control, reburning, and interactions between prescribed fire and browsing.

- Pacific Northwest
- Southern California
- Northern Rocky Mountains

Pacific Northwest:
Creambush oceanspray showed good recovery after prescribed-burning and thinning-and-burning treatments in the Pacific Northwest. Herbicides-and-burning treatments helped control creambush oceanspray.

Washington: In a short-term study, creambush oceanspray gained cover rapidly between postfire years 2 and 3 following a July 1970 wildfire in North Cascades National Park. The wildfire burned a coast Douglas-fir-western hemlock stand on a ridgetop [155].

Creambush oceanspray abundance after the 1970 Silver Creek Wildfire in North Cascades National Park [155]		
Year	Cover (%)	Frequency (%)
1971 (postfire year 1)	3.2	<0.05
1972 (postfire year 2)	3.2	<0.05
1973 (postfire year 3)	16.1	1.1

Near Wenatchee, creambush oceanspray was abundant a year after thinning and prescribed fire in a Pacific ponderosa pine/white spirea (*Spiraea betulifolia*) forest. Burning was conducted on 22 September 1997; the fire was of low severity, with flame lengths generally <4.9 feet (1.5 m). Seventy-eight percent of creambush oceanspray plants sprouted in postfire year 1. Ocean spray density was 15 plants/ha in postfire year 1; 337 plants/ha in postfire year 3; and 238 plants/ha in postfire year 9. The management objectives—to reduce fuels and conifer seedling density and to help restore approximate historical stand structure and composition—were considered met [91].

Creambush oceanspray had regained its "former size and luxuriance" 10 years after slash burning in a Pacific ponderosa pine/mallow ninebark habitat type in northeastern Washington [232].

Central Oregon:
Spraying and prescribed burning for shrub control: In the central Oregon coast, an herbicides-and-fire treatment helped control creambush oceanspray in the short term. A shrubfield on a heavily logged Sitka spruce (*Picea sitchensis*)-western hemlock habitat type was treated with either herbicides (picloram-phenoxy mix), herbicides followed by October prescribed fire, herbicides followed by tractor crushing, or bulldozer scarification without herbicides or fire. The objective was to reduced shrub interference with conifer seedlings. For sprayed plots, herbicide was applied in summer or early fall; any additional treatments were done in fall. Treatments employing mechanical disturbance were most effective, and spraying alone least effective, at controlling creambush oceanspray. The author attributed the only moderate control obtained from the herbicides-and-fire treatment to recent rains and poor combustion of fuels [107].

Mean creambush oceanspray frequency (%) a year after shrub-control treatments on an Oregon shrubfield [107]

	Pretreatment	Posttreatment
Herbicides	3	3
Herbicides + Rx fire	9	3
Herbicides + crushing	31	0
Scarification	13	0

Although herbicides and crushing best controlled creambush oceanspray in particular, scarification controlled shrubs in general better than other treatments [107].

Southern California: Prescribed burning had little or no effect on creambush oceanspray in a mixed-conifer Jeffrey pine-California black oak woodland with a chaparral understory in Cuyamaca Rancho State Park, San Diego County. In postfire year 2, creambush oceanspray was present in trace amounts (4 plants/ha) on unburned control plots but was not present on burned plots [143]. See the Research Project Summary of Martin and Lathrop's [124,143,144] study for details of the fire weather, fire prescription, and fire's effects on 38 other plants in the woodland.

Northern Rocky Mountains:
In the Northern Rocky Mountains, prescribed fires had either no effect or a positive effect on creambush oceanspray. Creambush oceanspray had a strong postfire recovery after a wildfire. Prescribed and wildfire reburns promoted creambush oceanspray and other shrubs over conifers. Postfire ungulate browsing of creambush oceanspray was minimal.

Western Montana: Thinning and/or prescribed fire had little effect on creambush oceanspray in Pacific ponderosa pine and Rocky Mountain Douglas-fir forests on the Lubrecht Experimental Forest. Creambush oceanspray was scarce in these forests; it had <1% cover and frequency before treatments and in posttreatment year 2. The treatments successfully reduced fuel loads and helped restore historical stand structure in these forests. See Metlen and others' Research Project Summary for information on fire and thinning prescriptions used in this study, on fire behavior, and on the effects of thinning-alone and/or thinning-and-burning treatments on 7 tree, 24 shrub, 37 graminoid, 1 fern, and 540 forb species.

Northern Idaho: In Rocky Mountain Douglas-fir/mallow ninebark habitat types on the Coeur d'Alene Reservation, mean creambush oceanspray across 3 postfire years cover did not differ significantly on unburned control sites, sites burned at low intensity (127 Kcal/m-s), or sites burned at high intensity (781 Kcal/m-s). For information on the fire weather, fire prescription, and postfire responses of 14 other shrub, 9 perennial graminoid, 25 perennial forb, and 6 annual species, see the Research Project Summary of Armour and others' [15] study.

Creambush oceanspray showed mixed but mostly favorable responses after prescribed fires on the Clearwater National Forest [18]. Prefire abundance and season of burning were not given.

Creambush oceanspray abundance in the summer of 1969, after prescribed fires on the Clearwater National Forest, northern Idaho [18]

Site* (year of fire)	Frequency (%)	Density (plants/acre)
Lone Knob fire (1969)	56	219

Lone Knob control	12	53
Fish Creek fire (1968)	32	101
Fish Creek control	20	158
Bee Creek fire (1967)	4	28
Bee Creek control	44	101
Relay Station fire (1968)	8	24
Relay Station control	16	117
*Relay Station is near Avery; all other sites are on the Lochsa Watershed.		

Creambush oceanspray grew rapidly after prescribed fires in seral shrubfields in a grand fir/pachistima (*Pachistima myrsinites*) habitat type on the Coeur d'Alene National Forest. Its sprouts were approximately 24 inches (60 cm) tall by the end of the 1st postfire growing season. Spring-burned creambush oceanspray sprouted during postfire weeks 4 to 8; plants burned in fall did not sprout until the next spring. Unlike many associated shrubs that sprouted most prolifically following spring prescribed fire, creambush oceanspray showed greatest shoot production following fall prescribed fire [133].

Ten years after the mixed-severity Sundance Fire, Stickney [206] reported 5% to 11% cover of creambush oceanspray; it was one of the principal cover species on his plots. Study plots were in a western hemlock habitat type. Creambush oceanspray was a component of the initial "sprouting shrub stage" that formed a year after the fire and persisted through at least 10 years of postfire succession [206].

Reburning: Reburns generally promote creambush oceanspray and other sprouting shrubs over conifers. In conifer forests on the Coeur d'Alene National Forest, creambush oceanspray was a component of mixed-species shrubfields after wildfires 19, 21, and 9 years apart (initial fire in 1851, reburns in 1870, 1910, and 1919). The shrubs were dense and well developed 10 years after the 1919 wildfire [123].

Creambush oceanspray sprouted and grew rapidly after a March 1965 prescribed fire in a grand fir/Oregon boxwood (*Paxistima myrsinites*) habitat type in the Fish Creek area of the Nez Perce National Forest. Prior to the prescribed fire, the overstory had been killed by wildfires in 1934 and in 1954; a shrubfield developed after these fires. The fire management objective was to maintain the shrubfield as big game browse [131,132].

Creambush oceanspray response to spring prescribed fire in a grand fir/Oregon boxwood habitat type in northern Idaho [131,132]				
	Live crown diameter (feet)	Live crown height (feet)	Basal sprouts/plant	Sprout height (feet)
prefire (March 1965)	5.3	8.6	2.7	1.0
postfire month 5 (August 1965)	2.8	3.6	33.4	2.6

The fire successfully rejuvenated the shrubfield. See the 2nd Fire Case Study in Saskatoon serviceberry for details on the prescription and behavior of this prescribed fire.

Prescribed fire and postfire browsing: Since creambush oceanspray is relatively unpalatable, it is unlikely to be overbrowsed after fire. Ungulates browse new creambush oceanspray sprouts, but browsing pressure usually declines rapidly after postfire year 1. On the Sherman Creek Watershed in northern Idaho, elk browsed new creambush oceanspray sprouts but did not consume unburned plants or sprouts =3 years old. Prescribed burning was conducted in the spring or fall of 1966 to enhance winter browse for big game species, so fall-burned plants did not provide forage until the next growing season (1968). Creambush oceanspray was not utilized in postfire years 6 or 8 on either burned or unburned plots; overall, elk use of creambush oceanspray was the least of 8 browse species. Diameter of creambush oceanspray twigs that sprouted after fire was thicker than that of twigs of unburned plants for at least 2 postfire years [128]:

Percent of creambush oceanspray twigs that elk browsed and creambush oceanspray twig diameters on prescription-burned and unburned control plots on the Sherman Creek Watershed, northern Idaho. Data are means [128].						
	1967		1968		1970	
	Browsed (%)	Twig diameter (mm)	Browsed (%)	Twig diameter (mm)	Browsed (%)	Twig diameter (mm)
spring-burned, 1966	23.1	2.47*	6.9	2.1	2.1	2.95

fall-burned, 1966	no new growth	no new growth	12.1	2.4**	0	2.13
unburned	0.7	1.37	0	1.0	0	not available

*Different from control at *P*=0.01.
**Different from control at *P*=0.05.

Prescribed fire and cattle-grazing treatments had no significant effect on creambush oceanspray cover in a Rocky Mountain Douglas-fir/mallow ninebark habitat type on the Idaho Experimental Forest [253].

Creambush oceanspray density (and cover) 1 year after prescribed fire and grazing in a Douglas-fir/mallow ninebark habitat type in northern Idaho [253]

Treatments	Burned	Unburned
Grazed	1,267 plants/ha (1.1%)	500 plants/ha (0.6%)
Ungrazed	833 plants/ha (1.0%)	600 plants/ha (2.2%)

See Palatability for more information on ungulate use of creambush oceanspray after fire.

FUELS AND FIRE REGIMES:

- **Fuels**
- **Fire regimes**

Fuels: Creambush oceanspray is most frequent on south slopes of dry montane forests (see Site Characteristics); these sites typically burn earlier in the season or with higher severities than cooler, drier sites. In northern Idaho, Smith and Fischer [204] placed the Pacific ponderosa pine, Rocky Mountain Douglas-fir, and grand fir forests where creambush oceanspray is most typically dominant in Fire Group 2. These forests tend to have warm temperature regimes, dry to moderate soil moisture, and are generally more productive—with heavier loads of downed woody fuels—compared to cooler or drier forests. Creambush oceanspray also occurs in mesic to moist grand fir forests (Fire Group 7); these forests also have heavy fuel loads. See Smith and Fischer [204] for fuel load measurements representative of coniferous forest habitat types where creambush oceanspray is important in northern Idaho.

Photo by J. E. (Jed) and Bonnie McClellan © California Academy of Sciences

In Pacific ponderosa pine-grand fir forests of Washington and Oregon, growing-season moisture content of shrubs, including creambush oceanspray, averaged >125% over 2 years. Shrub moisture content peaked in June at ~175%. Moisture contents of dominant overstory trees are also described in this study [7].

In many forest types with creambush oceanspray, fire exclusion has resulted in higher loads of woody debris compared to woody fuel loads when historic fire regimes were still functioning. In white fir stands in the Siskiyou Mountains of southwestern Oregon, large woody-debris loads were positively correlated with time-since-fire (*P*=0.01). Snag density was positively correlated with low (30 snags/ha) and high (23 snags/ha) fire severities (*P*=0.05). The authors attributed the correlation to nonconsumption of preexisting snags at low fire severity and creation of new snags at high severity. In this study, creambush oceanspray dominated the shrub layer of white fir stands in dry, interior valleys [238].

Stand structure: Stand structure of communities where creambush oceanspray is an important component of the vegetation is variable, as is the amount of fuel creambush oceanspray contributes. On some sites, structure is open, with a sparse shrub component. In the west-central portion of the Cascade Range of Oregon, the coast Douglas-fir/creambush oceanspray association displayed a relatively open stand structure (30-60% crown closure) of old growth, with few shrubs and a "very poorly developed" herb layer. Creambush oceanspray cover averaged 5% [57]. Another study of coast Douglas-fir/creambush oceanspray communities in the Cascade Range found that except for

creambush oceanspray, the tall-shrub layer was depauperate; low-shrub and herbaceous cover was also low. Incense-cedar, however, was encroaching in the subcanopy. Tree densities averaged 53 stems/ha for coast Douglas-fir and 5/ha for incense-cedar [153]. Live shrubs, including creambush oceanspray as a dominant, comprised <5% of total stand biomass in mixed-conifer communities in the White Cap Wilderness Study Area of northern Idaho. Total shrub fuel loads ranged from 204 to 2,190 lbs/acre; shrubs were 0.6 inch to 27 inches (1.5-69 cm) tall, with 2% to 50% cover [26].

Some communities with creambush oceanspray have denser overstories and/or understories. A coast Douglas-fir/creambush oceanspray stand on the west-central portion of the Cascade Range, Oregon, had 70% tree cover, 46% shrub cover, and 36% herb cover. Aspect of the forest was southwest; it was the hottest and driest of 18 stand types examined [256]. Bailey [20] found coast Douglas-fir/creambush oceanspray-salal habitat types off the southern coast of Oregon had relatively open canopies and "well-developed" shrub layers. Creambush oceanspray averaged 30% cover [20]. Western redcedar-western hemlock forests often have a dense overstory, but understory cover of creambush oceanspray and other shrubs may be sparse [204].

Mixed-conifer forests of southern Oregon and California are structurally and compositionally complex, with small conifers—often white fir and/or incense-cedar—often forming ladder fuels in a well-developed subcanopy. Snags and large, downed woody debris are common, but fuel loads are highly variable. Many of these mixed-conifer forests support a moderate to dense shrub understory, although some have few shrubs but a dominant herbaceous layer, and others have both depauperate understory and ground layers [34]. Stand structure in California's mixed-conifer forests was mostly open in the presettlement period [79].

Insect attacks increase snag densities in creambush oceanspray habitats, which eventually increase dead and downed woody fuel loads. Youngblood and Wickman [250] provide data on stand structure, live and dead tree abundance, and shrub and herb cover of a grand fir-Douglas-fir forest attacked by Douglas-fir tussock moths 23 years prior. Creambush oceanspray was an important component of the understory (5% cover); the site was in the Wenaha-Tucannon Wilderness in the Blue Mountains of Washington and Oregon [250].

Models: A few models were available for predicting creambush oceanspray's contribution to total fuel loads as of 2010. Smith and Brand [205] review equations for predicting creambush oceanspray biomass. Harris [90] presents models to predict creambush oceanspray aboveground biomass and cover; the models were developed from data collected in coast Douglas-fir, grand fir, and western larch forests on the Umatilla National Forest. Brown [27] provides a model for predicting total aboveground creambush oceanspray biomass and total leaf biomass based on basal stem diameter. Samples on which the model is based were collected in northern Idaho and western Montana [27].

Leaf area indices are used in some fuel models [49]. In the Siskiyou Mountains of southwestern Oregon, creambush oceanspray had a large mean leaf area compared to associated shrubs; about twice as large as the leaf areas of associated greenleaf manzanita (*Arctostaphylos patula*) and redstem ceanothus (*Ceanothus sanguineus*) [40]. Agee and Lolley [6] placed creambush oceanspray in fuel type 2: shrubs with thick stems but thin leaves.

Fire regimes: Plant communities with creambush oceanspray display a wide range of fire regimes. Creambush oceanspray is most often dominant in dry Douglas-fir forests but is also common in dry ponderosa pine (*Pinus ponderosa*) and mesic western redcedar-western hemlock forests. Historical fire regimes of these coniferous forests are a continuum from mostly frequent, low-severity surface fires for ponderosa pine; to mixed surface and crown fires for Douglas-fir; to mostly long return-interval, crown fires for western redcedar-western hemlock types. Creambush oceanspray also occurs in less widely distributed conifer and nonconifer types that historically experienced a similarly wide range of fire regimes. These types include Port-Orford-cedar, redwood, and knobcone pine coniferous communities and Oregon white oak and chaparral communities. See Habitat Types and Plant Communities for details on communities with creambush oceanspray.

Douglas-fir: Douglas-fir forests with creambush oceanspray experience low- to moderate-severity surface, stand-replacement surface, and crown fires (review by [204]). Because Douglas-fir forests with a large component of creambush oceanspray occur mainly at low elevations, human-ignited fires can be frequent [35]. A study in the Cascade Range of Oregon found the ages of coast Douglas-fir/creambush oceanspray stands that established after major fires (those killing =50% of the overstory) ranged from 75 to 450 years. Mean return intervals of major fires ranged from 72 years for the coast Douglas-fir/creambush oceanspray/Indian's-dream (*Aspidotis densa*) phase of the coast Douglas-fir/creambush oceanspray/grass type to 111 years for the coast Douglas-fir/creambush oceanspray/vine maple type. The coast Douglas-fir/creambush oceanspray/Indian's-dream phase is the driest phase of the coast Douglas-fir/creambush oceanspray/grass type; the coast Douglas-fir/creambush oceanspray/vine maple type occurs on ridges that may burn less frequently than other coast Douglas-fir/creambush oceanspray types [153].

Fire regime data for Douglas-fir/creambush oceanspray communities in the Cascade Range, Oregon [153]			
Plant community	Douglas-fir/creambush oceanspray/grass type, Indian's-dream phase	Douglas-fir/creambush oceanspray/grass type, manyleaf collomia (*Collomia heterophylla*) phase*	Douglas-fir/creambush oceanspray/vine maple type
Number of plots	4	19	12
Number of fire intervals	6	12	11
Mean stand age (SD); range	196 (104); 94-330	198 (84); 75-337	294 (151); 89-450
Mean time since last major fire (SD); range	128 (52); 82-197	133 (51); 63-266	162 (89); 89-420
Mean interval between stand-replacement fires (SD); range	72 (41); 26-131	107 (65); 34-217	111 (68); 41-232
Plots experiencing a major fire since initiation of last cohort (%)	50	47	48
Plots burned since initiation of oldest cohort (%)	75	58	61
*The most common phase of the Douglas-fir/creambush oceanspray/grass type.			

Chappell and Giglio [32] found fire was the major natural disturbance in coast Douglas-fir-Pacific madrone/creambush oceanspray associations near the Puget Trough of Washington. Their study of over 50 coast Douglas-fir-Pacific madrone sites across west-central Washington found all sites had experienced fire at least once in 130 years [32]. Agee [4] reported a fire regime of mostly mixed moderate-severity surface and crown fires—with some low-severity surface fires—for coast Douglas-fir-Pacific madrone forests in the area.

Weisburg [234] found coast Douglas-fir forests in the west-central portion of the Cascade Range of Oregon showed a mean fire-return interval of 97 years from 1475 to 1996; the mean interval was 197 years when low-severity fires were excluded. Low- to moderate-severity fires averaged 58% of all fires. Basal area of understory shrubs, which included creambush oceanspray, decreased with time since fire (R^2=0.51) [234].

Ponderosa pine: Ponderosa pine communities historically experienced mostly low-severity surface fires (for example, [16,82]). Pacific ponderosa pine forests of the Blue Mountains of Washington and Oregon had mostly low-severity surface fires averaging every 6 to 22 years (review by [244]). This fire regime favored creambush oceanspray; Wright [244] characterized creambush oceanspray and other shrubs in these communities as "vigorous sprouters and very tolerant of fire". Very frequent fire-return intervals (<5 years), however, resulted in greater cover of bluebunch wheatgrass and other bunchgrasses than cover of shrubs [244]. Pacific ponderosa pine forests of northern Idaho and western Montana historically experienced similar fire behavior and fire-return intervals. Rocky Mountain Douglas-fir generally becomes dominant in these forests with fire exclusion (review by [244]).

Western redcedar-western hemlock: Historical fire regimes in this type were variable; some stands experienced fire only rarely but others burned at moderate intervals. Stand-replacement fires are more common in this type than understory fires. Seral forests—where creambush oceanspray is most likely to occur—historically burned about every 50 to 100 years, usually with surface or mixed surface and crown fires. Surface fires in seral western redcedar-western hemlock forests may affect the composition of understory shrubs such as creambush oceanspray but typically have little effect on overstory composition. Western redcedar-western hemlock forests of northern Idaho, in which creambush oceanspray is prevalent, are typically cooler and damper than most conifer types, with a sparse understory, deep duff, and moist large woody fuels. The fire-return interval ranges from 25 to >500 years for these forests (review by [201]).

Port-Orford-cedar: Port-Orford-cedar forests experience mixed-severity and stand-replacement fires at short to long intervals. Port-Orford-cedar is somewhat unusual in that it persists from early-seral to climax stages of postfire succession [257]. Creambush oceanspray is unlikely to persist in closed-canopy, old-growth Port-Orford-cedar (see Successional Status), but may persist in seral Port-Orford-cedar communities.

Redwood: These forests historically experienced short to long fire-return intervals [76,119], with surface fires at short to moderate intervals (10-100 years) most common [119]. Creambush oceanspray is unlikely to persist in closed-canopy, old-growth redwood forests (see Successional Status) but may persist in seral communities.

Mixed-conifer forests of Oregon and California: These mixed-conifer forests historically had a regime of mostly low-severity surface fires on the hot, dry sites [34] where creambush oceanspray is most likely to occur (see Site Characteristics). Fire-return intervals varied from about 10 to 80 years (review by [34]). A study in the Klamath Mountains of California found that fires in mixed-conifer forests with creambush oceanspray were historically mostly small and of mixed severity. Fire activity declined in the 1950s, with the advent of fire exclusion [239]. Sierra Nevada lodgepole pine-white fir communities in Emigrant Basin Wilderness Area, California, historically had fire-return intervals averaging 57 years [77].

Oregon white oak: Oregon white oak communities historically had short- to moderate-interval surface fires. White and others [238] report that Oregon white oak in Oregon's Klamath Mountains experienced fire every 3 to 20 years. A fire history study of Oregon white oak-coast Douglas-fir mosaics of Vancouver Island, British Columbia, found that prior to European settlement, the island experienced mostly low-severity surface fires. Native Americans apparently burned these mosaics several times/decade, so fire-caused mortality of overstory trees was negligible. These intervals were much shorter [147] than the 50- to 100-year intervals Agee [4] estimated for coast Douglas-fir forests on the adjacent mainland.

Knobcone pine and chaparral: Some communities where creambush oceanspray is important experience frequent crown fires. Knobcone pine communities of southern Oregon and coastal California require frequent (<60-year intervals) [230], stand-replacement fires to maintain knobcone pine as the community dominant [39,230]. Likewise, chamise communities of southern Oregon and California require stand-replacement fires at <60-year intervals to maintain chamise as the community dominant [188].

Other shrublands: In Redwood National Park the bald-hill shrubland communities, of which creambush oceanspray is an important component, were historically maintained by very frequent fire. Native Americans may have burned the bald hills at least every other year. Fire scars on Oregon white oaks adjacent to the hills show fire-return intervals of about 2 years; 10 years was the maximum time between fires that left scars. Coast Douglas-fir seedlings are encroaching on the hills with fire exclusion; the former shrubby balds will likely succeed to redwood/Douglas-fir forests without the return of very frequent fire [211].

See the Fire Regime Table for further information on fire regimes of vegetation communities in which creambush oceanspray may occur.

FIRE MANAGEMENT CONSIDERATIONS:
Creambush oceanspray is well adapted to survive prescribed fires and wildfires, showing good recovery even after large, severe wildfires (see Plant response to fire). Prescribed fires at 10- to 15-year intervals may rejuvenate shrubfields with creambush oceanspray (review by [196]).

MANAGEMENT CONSIDERATIONS

SPECIES: Holodiscus discolor

FEDERAL LEGAL STATUS:
None

OTHER STATUS:
Creambush oceanspray had no special protection status as of 2010. Information on state- and province-level protection status of plants in the United States and Canada is available at NatureServe.

IMPORTANCE TO WILDLIFE AND LIVESTOCK:
Browse: Creambush oceanspray is a minor browse species [41,50,125,161,178,203,226]. Ungulates generally browse it only when more palatable forage is unavailable [84]. Many low-elevation, dry-site Douglas-fir forests with creambush oceanspray are important cattle rangelands, but the cattle generally seek forage other than creambush oceanspray [35]. Creambush oceanspray is considered poor forage in Idaho [203] and an undesirable "competitor" with redstem ceanothus, a more desirable browse species [139]. Among ungulates in British

Columbia, only Sitka black-tailed deer made much use of creambush oceanspray [23].

Importance of creambush oceanspray as browse for wild ungulates in British Columbian [23]	
Ungulate	Importance as Browse
Sitka black-tailed deer	moderate
white-tailed deer	low
mountain goat	low
bighorn sheep	low
Roosevelt elk	low
Rocky mountain elk	low
moose	low
caribou	low

However, because this species is common and readily available to wildlife and livestock on low-elevation rangelands, ungulates may make light but frequent use of creambush oceanspray in summer [161,226]. Cattle use it as summer forage in northern Idaho [35,217] and northeastern Oregon [115].

Wildlife [125,161] and livestock [125] sometimes browse creambush oceanspray more heavily [36,62,115], especially in late fall and winter when green forage is less available [125,197]. Snowshoe hares in the Flathead region of western Montana use the leaves and twigs for fall forage [3]. Studies on the Bitterroot National Forest and in the Rattlesnake Creek drainage of western Montana found elk, mule deer, and white-tailed deer preferred creambush oceanspray as winter forage [109,146]. Columbian black-tailed deer in western Oregon browse creambush oceanspray twigs in winter [47]; mule deer on the Los Padres National Forest of southern California also use creambush oceanspray [184]. Creambush oceanspray is heavily utilized by migrating mule deer and elk in central Washington [187].

Green clippings of creambush oceanspray were found in dusky-footed woodrat shelters in Oregon [29], and the shrub is apparently palatable to native slugs in western Washington [31].

Palatability and/or nutritional value: Creambush oceanspray is usually unpalatable to ungulates [157,158] and other browsing animals. A review rated its palatability as poor to fair for cattle and fair for domestic sheep [80]. A study on the Tillamook Burn of northwestern Oregon found mountain beavers browsed creambush oceanspray less than expected based on availability [46]. New postfire sprouts are most palatable ([18,166], review by [196]). On burned sites in northern Idaho, big game species in northern Idaho preferred browsing sprouts of creambush oceanspray and other shrubs to browsing current-year growth of shrubs on adjacent unburned sites, especially the first growing season after fire [18]. On one site, elk utilization of creambush oceanspray increased from 1.3% before fire to 36.3% a year after prescribed fire; elk use dropped to 6.9% in postfire year 2 [127]. Asherin [18] also noted that big game species browsed creambush oceanspray readily in postfire year 1, but use dropped after that. Browsing ungulates may pass over creambush oceanspray sprouts if more palatable shrubs are available. On a wildfire-burned Rocky Mountain Douglas-fir/mallow ninebark habitat type on upper Selway River, northern Idaho, mule deer browsed creambush oceanspray "minimally" in postfire years 2 and 3, while western serviceberry and Scouler willow were used heavily [105]. Following prescribed fires on the Lochsa Watershed in northern Idaho, elk preferred Scouler willow, western serviceberry, and Rocky Mountain maple sprouts to those of creambush oceanspray [126].

Habitat: Conifer/creambush oceanspray communities provide important habitat to a variety of wildlife species. Along the Umatilla River of Oregon, white-tailed deer used Pacific ponderosa pine-coast Douglas-fir/creambush oceanspray and Pacific ponderosa pine/creambush oceanspray communities more than expected based on availability ($P<0.0001$) [21]. On sky islands across Nevada and in western Utah, yellow-bellied marmot burrows were closely associated with creambush oceanspray, "almost without exception" [64,65]. In the central Oregon Coast Ranges, creambush oceanspray was found on streamside and upslope habitats where 18 of 22 small mammal species and 9 of 13 amphibian species known to the area were captured [145]. This shrub is also common in northern Idaho Pacific treefrog habitats [190].

Cover value: Creambush oceanspray provides cover for a variety of species. Blue grouse hide beneath creambush oceanspray and other shrubs [66]. Dense shrub understories in Rocky Mountain Douglas-fir/mallow ninebark habitat types—where creambush oceanspray is common to codominant—provide visual and thermal cover for deer and elk; in addition, these sites supply nesting habitat, cover, and food for a variety of nongame birds and mammals [36].

VALUE FOR REHABILITATION OF DISTURBED SITES:
Creambush oceanspray could potentially be used on Burned Area Recovery sites, although to date (2010), there was no documentation of its suvivorship after transplanting onto burns. It is used successfully for erosion control ([154], review by [196]), highway plantings, windbreaks, riparian plantings, and wildlife plantings (reviews by [196,197]). It establishes readily through natural regeneration on burned sites [35,246] (see Successional Status and Plant response to fire). In northern Idaho, for example, creambush oceanspray dominated (48%

of total understory cover) a Pacific ponderosa pine-Rocky Mountain Douglas-fir stand in early postfire succession; its size (10-15 feet (3-4.6 m)) and relative unpalatability allowed it to compete successfully with other shrubs for light, moisture, and space. Because it is a "poor forage species", researchers predicted it would dominate the burn until crowded out by conifers [203].

Creambush oceanspray is propagated from cuttings or seed [12,113], with cuttings the usual method. A 2004 review found creambush oceanspray seeds were "rare and costly" [196], and as of 2008, there were no published guidelines for growing this species from seed [197]. See these sources: ([74], reviews by [196,197]) for information on propagating creambush oceanspray. Plants are available commercially [74].

OTHER USES:
Creambush oceanspray is planted as an ornamental [197]. Leaf extracts show antifungal, antiviral, and cytotoxic properties ([102], review by [164]).

Traditional uses: Native Americans used creambush oceanspray for making implements, as medicine [255], and sometimes as food. The long, straight, hard branchwood was highly prized for making arrow shafts [50,224], as well as digging sticks, fishing hooks, and needles [73,224]. Native Americans used creambush oceanspray for treating viral and skin diseases ([73], review by [164]) and as a tonic [73]. The bark and leaves were dried and pulverized for application to burns or sores [86]. The Pima made tea from the leaves [118], and Native Americans in the Inland Northwest ate the seeds [55].

OTHER MANAGEMENT CONSIDERATIONS:
Creambush oceanspray may interfere with conifer seedlings on plantations [168]. Because its roots are often shallow, creambush oceanspray is likely to compete with conifer seedlings for water [40].

Grazing: Creambush oceanspray may decline with grazing despite its relative unpalatibility; its growth response in browsing and clipping studies has been mixed. In northern Idaho sites with elk, moose, mule deer, and white-tailed deer, creambush oceanspray was more common inside than outside exclosures [8]. Another northern Idaho study in a Douglas-fir habitat type found creambush oceanspray decreased in cattle-grazed stands [253]. Similarly, in the Bitterroot Mountains of northern Idaho, creambush oceanspray showed greater density, cover, and frequency on ungrazed plots than on plots grazed by cattle (989 vs. 522 plants/ha; 2.6% vs. 0.6%; 4.4% vs. 1.3%, respectively, for desnity, cover, and frequency) [252]. Garrison [71] recommends =50% to 60% utilization of creambush oceanspray to prevent the species' decline.

Daubenmire and Daubenmire [51] reported that in eastern Washington and northern Idaho, overgrazing of Pacific ponderosa pine/mallow ninebark stands, in which creambush oceanspray often codominates, may result in a disclimax ponderosa pine/bluegrass (*Poa* spp.) community.

Exclosure studies in eastern Washington and eastern Oregon found that creambush oceanspray production was significantly greater (P=0.04) for completely clipped plants (100% of new growth removed, $\bar{x}$=200 g/0.25 acre) compared with heavily (75%, $\bar{x}$=151 g), moderately (50%, $\bar{x}$=162 g), and slightly (25%, $\bar{x}$=64 g) clipped plants. Much of the new growth was long twig and branch sprouts. Moderate or heavier clipping suppressed flower production. Results were averaged over 4 to 5 consecutive years of clipping [70].

APPENDIX: FIRE REGIME TABLE

SPECIES: Holodiscus discolor

The following table provides fire regime information that may be relevant to creambush oceanspray 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 creambush oceanspray may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [121], 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

Pacific Northwest

- Northwest Shrubland
- 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 Shrubland					
Mountain big sagebrush (cool sagebrush)	Replacement	100%	20	10	40
Northwest Woodland					
Western juniper (pumice)	Replacement	33%	>1,000		
	Mixed	67%	500		
Oregon white oak-ponderosa pine	Replacement	16%	125	100	300
	Mixed	2%	900	50	
	Surface or low	81%	25	5	30
Ponderosa pine	Replacement	5%	200		
	Mixed	17%	60		
	Surface or low	78%	13		
Oregon white oak	Replacement	3%	275		
	Mixed	19%	50		
	Surface or low	78%	12.5		
Subalpine woodland	Replacement	21%	300	200	400
	Mixed	79%	80	35	120
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
Oregon coastal tanoak	Replacement	10%	250		
	Mixed	90%	28	15	40
Ponderosa pine (xeric)	Replacement	37%	130		
	Mixed	48%	100		
	Surface or low	16%	300		
Dry ponderosa pine (mesic)	Replacement	5%	125		
	Mixed	13%	50		
	Surface or low	82%	8		
Douglas-fir-western hemlock (dry mesic)	Replacement	25%	300	250	500
	Mixed	75%	100	50	150
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
Lodgepole pine (pumice soils)	Replacement	78%	125	65	200
	Mixed	22%	450	45	85
Pacific silver fir (low elevation)	Replacement	46%	350	100	800
	Mixed	54%	300	100	400
Subalpine fir	Replacement	81%	185	150	300
	Mixed	19%	800	500	>1,000
Mixed conifer (eastside dry)	Replacement	14%	115	70	200
	Mixed	21%	75	70	175
	Surface or low	64%	25	20	25
Mixed conifer (eastside mesic)	Replacement	35%	200		
	Mixed	47%	150		
	Surface or low	18%	400		
Spruce-fir	Replacement	84%	135	80	270
	Mixed	16%	700	285	>1,000

California

- 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 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
Chaparral	Replacement	100%	50	30	125
Montane chaparral	Replacement	34%	95		
	Mixed	66%	50		
California Woodland					

California oak woodlands	Replacement	8%	120		
	Mixed	2%	500		
	Surface or low	91%	10		
Ponderosa pine	Replacement	5%	200		
	Mixed	17%	60		
	Surface or low	78%	13		
California Forested					
California mixed evergreen	Replacement	10%	140	65	700
	Mixed	58%	25	10	33
	Surface or low	32%	45	7	
Coast redwood	Replacement	2%	=1,000		
	Surface or low	98%	20		
Mixed conifer (North Slopes)	Replacement	5%	250		
	Mixed	7%	200		
	Surface or low	88%	15	10	40
Mixed conifer (South Slopes)	Replacement	4%	200		
	Mixed	16%	50		
	Surface or low	80%	10		
Aspen with conifer	Replacement	24%	155	50	300
	Mixed	15%	240		
	Surface or low	61%	60		
Jeffrey pine	Replacement	9%	250		
	Mixed	17%	130		
	Surface or low	74%	30		
Mixed evergreen-bigcone Douglas-fir (southern coastal)	Replacement	29%	250		
	Mixed	71%	100		
Interior white fir (northeastern California)	Replacement	47%	145		
	Mixed	32%	210		
	Surface or low	21%	325		
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 Grassland
- 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 Grassland					
Montane and subalpine grasslands with shrubs or trees	Replacement	30%	70	10	100
	Surface or low	70%	30		
Southwest Shrubland					
Interior Arizona chaparral	Replacement	100%	125	60	150
Mountain sagebrush (cool sage)	Replacement	75%	100		
	Mixed	25%	300		
Gambel oak	Replacement	75%	50		
	Mixed	25%	150		
Mountain-mahogany shrubland	Replacement	73%	75		
	Mixed	27%	200		
Southwest Woodland					
Madrean oak-conifer woodland	Replacement	16%	65	25	
	Mixed	8%	140	5	
	Surface or low	76%	14	1	20
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 forest with conifers	Replacement	100%	435	300	550
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		
Southwest mixed conifer (warm, dry with aspen)	Replacement	7%	300		
	Mixed	13%	150	80	200
	Surface or low	80%	25	2	70

Southwest mixed conifer (cool, moist with aspen)	Replacement	29%	200	80	200
	Mixed	35%	165	35	
	Surface or low	36%	160	10	
Aspen with spruce-fir	Replacement	38%	75	40	90
	Mixed	38%	75	40	
	Surface or low	23%	125	30	250
Lodgepole pine (Central Rocky Mountains, infrequent fire)	Replacement	82%	300	250	500
	Surface or low	18%	>1,000	>1,000	>1,000
Spruce-fir	Replacement	96%	210	150	
	Mixed	4%	>1,000	35	>1,000

Great Basin

- Great Basin Grassland
- Great Basin Shrubland
- 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 Grassland					
Mountain meadow (mesic to dry)	Replacement	66%	31	15	45
	Mixed	34%	59	30	90
Great Basin Shrubland					
Wyoming big sagebrush semidesert with trees	Replacement	84%	137	30	200
	Mixed	11%	≥1,000	20	>1,000
	Surface or low	5%	>1,000	20	>1,000
Wyoming sagebrush steppe	Replacement	89%	92	30	120
	Mixed	11%	714	120	
Interior Arizona chaparral	Replacement	88%	46	25	100
	Mixed	12%	350		
Mountain big sagebrush	Replacement	100%	48	15	100
Mountain big sagebrush with conifers	Replacement	100%	49	15	100
Mountain sagebrush (cool sage)	Replacement	75%	100		
	Mixed	25%	300		

Montane chaparral	Replacement	37%	93		
	Mixed	63%	54		
Gambel oak	Replacement	75%	50		
	Mixed	25%	150		
Mountain shrubland with trees	Replacement	22%	105	100	200
	Mixed	78%	29	25	100
Black and low sagebrushes	Replacement	33%	243	100	
	Mixed	67%	119	75	140
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	
Ponderosa pine	Replacement	5%	200		
	Mixed	17%	60		
	Surface or low	78%	13		
Great Basin Forested					
Interior ponderosa pine	Replacement	5%	161		800
	Mixed	10%	80	50	80
	Surface or low	86%	9	8	10
Ponderosa pine-Douglas-fir	Replacement	10%	250		≥1,000
	Mixed	51%	50	50	130
	Surface or low	39%	65	15	
Great Basin Douglas-fir (dry)	Replacement	12%	90		600
	Mixed	14%	76	45	
	Surface or low	75%	14	10	50
Aspen with conifer (low to midelevation)	Replacement	53%	61	20	
	Mixed	24%	137	10	
	Surface or low	23%	143	10	
Douglas-fir (warm mesic interior)	Replacement	28%	170	80	400
	Mixed	72%	65	50	250
Aspen with conifer (high elevation)	Replacement	47%	76	40	
	Mixed	18%	196	10	
	Surface or low	35%	100	10	
Stable aspen-cottonwood, no conifers	Replacement	31%	96	50	300
	Surface or low	69%	44	20	60
Spruce-fir-pine (subalpine)	Replacement	98%	217	75	300
	Mixed	2%	>1,000		

Aspen with spruce-fir	Replacement	38%	75	40	90
	Mixed	38%	75	40	
	Surface or low	23%	125	30	250
Stable aspen without conifers	Replacement	81%	150	50	300
	Surface or low	19%	650	600	>1,000

Northern and Central Rockies

- Northern and Central Rockies Shrubland
- Northern and Central Rockies Woodland
- 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 Shrubland					
Mountain shrub, nonsagebrush	Replacement	80%	100	20	150
	Mixed	20%	400		
Mountain big sagebrush steppe and shrubland	Replacement	100%	70	30	200
Northern and Central Rockies Woodland					
Ancient juniper	Replacement	100%	750	200	≥1,000
Northern and Central Rockies Forested					
Ponderosa pine (Northern Great Plains)	Replacement	5%	300		
	Mixed	20%	75		
	Surface or low	75%	20	10	40
Ponderosa pine (Northern and Central Rockies)	Replacement	4%	300	100	≥1,000
	Mixed	19%	60	50	200
	Surface or low	77%	15	3	30
Ponderosa pine (Black Hills, low elevation)	Replacement	7%	300	200	400
	Mixed	21%	100	50	400
	Surface or low	71%	30	5	50
Ponderosa pine (Black Hills, high elevation)	Replacement	12%	300		
	Mixed	18%	200		
	Surface or low	71%	50		
Ponderosa pine-Douglas-fir	Replacement	10%	250		≥1,000
	Mixed	51%	50	50	130
	Surface or low	39%	65	15	

Western redcedar	Replacement	87%	385	75	≥1,000
	Mixed	13%	>1,000	25	
Douglas-fir (xeric interior)	Replacement	12%	165	100	300
	Mixed	19%	100	30	100
	Surface or low	69%	28	15	40
Douglas-fir (warm mesic interior)	Replacement	28%	170	80	400
	Mixed	72%	65	50	250
Douglas-fir (cold)	Replacement	31%	145	75	250
	Mixed	69%	65	35	150
Grand fir-Douglas-fir-western larch mix	Replacement	29%	150	100	200
	Mixed	71%	60	3	75
Mixed conifer-upland western redcedar-western hemlock	Replacement	67%	225	150	300
	Mixed	33%	450	35	500
Western larch-lodgepole pine-Douglas-fir	Replacement	33%	200	50	250
	Mixed	67%	100	20	140
Grand fir-lodgepole pine-larch-Douglas-fir	Replacement	31%	220	50	250
	Mixed	69%	100	35	150
Persistent lodgepole pine	Replacement	89%	450	300	600
	Mixed	11%	>1,000		
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

*Fire Severitiesâ€"
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 [88,120].

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FEIS Home Page