APPENDIX 8:
TREE SPECIES PROFILES

Table A8-1. List of tree species profiles[1]

Species	Common name	Symbol	Page
Abies amabilis	Pacific silver fir	ABAM	A8-5
Abies concolor	White fir	ABCO	A8-8
Abies grandis	Grand fir	ABGR	A8-11
Abies lasiocarpa	Subalpine fir	ABLA	A8-14
Abies procera	Noble fir	ABPR	A8-17
Abies x *shastensis* [*magnifica* x *procera*]	Shasta red fir	ABSH	A8-20
Acer glabrum var. *douglasii*	Douglas maple / Rocky Mountain maple	ACGL, ACGLD4	A8-23
Acer macrophyllum	Bigleaf maple	ACMA3	A8-25
Alnus rhombifolia	White alder	ALRH2	A8-28
Alnus rubra	Red alder	ALRU2	A8-30
Arbutus menziesii	Pacific madrone	ARME	A8-33
Betula occidentalis	Water birch	BEOC2	A8-35
Betula papyrifera var. *papyrifera*	Paper birch	BEPA, BEPAP	A8-37
Calocedrus decurrens	Incense-cedar	CADE27	A8-40
Celtis laevigata var. *reticulata*	Netleaf hackberry	CELAR	A8-43
Chamaecyparis lawsoniana	Port-Orford-cedar	CHLA	A8-45
Chrysolepis chrysophylla	Golden chinquapin	CHCH7	A8-48
Cornus nuttallii	Pacific dogwood	CONU4	A8-51
Crataegus douglasii and *C. suksdorfii*	Black hawthorn, Suksdorf's hawthorn	CRDO2, CRSU16	A8-53
Cupressus bakeri	Baker cypress	CUBA	A8-55
Cupressus nootkatensis	Alaska yellow-cedar	CUNO	A8-57
Frangula purshiana	Cascara	FRPU7	A8-59
Fraxinus latifolia	Oregon ash	FRLA	A8-61
Juniperus occidentalis	Western juniper	JUOC	A8-63
Juniperus scopulorum	Rocky Mountain juniper	JUSC	A8-65
Larix lyallii	Subalpine larch	LALY	A8-67
Larix occidentalis	Western larch	LAOC	A8-69
Malus fusca	Oregon crab apple	MAFU	A8-72
Notholithocarpus densiflorus	Tanoak	LIDE3	A8-74
Picea breweriana	Brewer spruce	PIBR	A8-77
Picea engelmannii	Engelmann spruce	PIEN	A8-79
Picea sitchensis	Sitka spruce	PISI	A8-82
Pinus albicaulis	Whitebark pine	PIAL	A8-85
Pinus attenuata	Knobcone pine	PIAT	A8-88
Pinus contorta var. *contorta*	Shore pine	PICOC	A8-91
Pinus contorta var. *latifolia*	Lodgepole pine	PICOL	A8-94
Pinus contorta var. *murrayana*	Sierra lodgepole pine	PICOM	A8-97
Pinus flexilis	Limber pine	PIFL2	A8-100
Pinus jeffreyi	Jeffrey pine	PIJE	A8-103
Pinus lambertiana	Sugar pine	PILA	A8-106

Table A8-1, continued

Species	Common name	Symbol	Page
Pinus monticola	Western white pine	PIMO3	A8-109
Pinus ponderosa	Ponderosa pine	PIPO	A8-112
Populus balsamifera ssp. *trichocarpa*	Black cottonwood	POBAT	A8-115
Populus tremuloides	Quaking aspen	POTR5	A8-118
Prunus emarginata	Bitter cherry	PREM	A8-121
Pseudotsuga menziesii var. *glauca*	Douglas-fir	PSMEG	A8-123
Pseudotsuga menziesii var. *menziesii*	Douglas-fir	PSMEM	A8-126
Quercus chrysolepis	Canyon live oak	QUCH2	A8-129
Quercus garryana	Oregon white oak	QUGA4	A8-132
Quercus kelloggii	California black oak	QUKE	A8-135
Salix amygdaloides	Peachleaf willow	SAAM2	A8-138
Salix lucida ssp. *lasiandra*	Pacific willow	SALUL	A8-140
Salix scouleriana	Scouler's willow	SASC	A8-142
Sequoia sempervirens	Coast redwood	SESE3	A8-144
Taxus brevifolia	Pacific yew	TABR2	A8-147
Thuja plicata	Western redcedar	THPL	A8-149
Tsuga heterophylla	Western hemlock	TSHE	A8-152
Tsuga mertensiana	Mountain hemlock	TSME	A8-155
Umbellularia californica	Oregon myrtle	UMCA	A8-158

[1] *References begin on page A8-160.*

Table A8-2. NatureServe conservation status ranking and geographic scale definitions. The conservation status ranking and geographic scale of the ranking are listed in each tree species' profile (e.g., G5 indicates the species is secure at the global scale). Additional information on NatureServe rankings is available at: http://www.natureserve.org/explorer/ranking.htm

Variable	Level	Definition
NatureServe ranking	1	Critically imperiled
	2	Imperiled
	3	Vulnerable
	4	Apparently secure
	5	Secure
Geographic scale	G	Global
	N	National
	S	State

Table A8-3. Thresholds for genetic parameters appearing in tree species profiles

Parameter	Value	Description
Outcrossing rate	<0.8	Low
	0.8-0.9	Moderate
	>0.9	High
Genetic diversity (H_e)[1]	<0.08	Low
	0.08-0.20	Average
	>0.20	Above average
Population differentiation (F_{st}/Q_{st})	<0.10	Weak
	0.10-0.20	Moderate
	>0.20	Strong

[1] *Isozymes only; thresholds for other markers are marker-dependent.*

Pacific silver fir (*Abies amabilis*)

Ecology

Description		A medium-to-large, evergreen conifer typically reaching 150 to 200 ft (45 to 60 m) in height; a narrow, symmetrical, conical crown; straight, horizontal branches; smooth, light-gray bark
Distribution		From southeastern Alaska to around Crater Lake, Oregon, and infrequently in northwestern California; from 800 to 6,000 ft (240 to 1,830 m) elevation in the Cascade Range in Washington and from 2,000 to 6,000 ft (610 to 1830 m) in the Cascade Range in Oregon; occurs in the Olympics from sea level to 4,600 ft (1,400 m)
Successional stage		Occurs in all seral stages; most prevalent in late seral and climax stands; Pacific silver fir may establish soon after disturbance, but growth is too slow to compete with associated conifers; its high degree of shade tolerance allows it to persist and become an important overstory component of mid- to late-seral stands, sometimes several hundred years after a disturbance
Associated forest cover		Occurs most often with western hemlock, occurs with Douglas-fir on drier sites within its range; found to a lesser extent with a variety of other conifers including western redcedar, Alaska yellow-cedar, noble fir, and grand fir; sometimes occurs in pure stands
Habitat	**Sites**	Found most frequently on submontane to subalpine sites, but occasionally occurs to sea level in the Olympic Range
	Soils	Occurs on a wide range of soil types, from nutrient poor to nutrient rich
	Moisture	Requires an uninterrupted supply of water throughout the year; found predominantly on moderately moist to very moist sites; best growth occurs where moisture is highest, assuming the soil maintains aeration; range is limited by summer drought
	Temperature	Low tolerance of heat; may require protection on harsh sites; moderately frost tolerant; intolerant of frozen soil owing to its winter water requirement; benefits from heavy accumulations of snow that insulate the soil and its shallow roots
	Shade tolerance	Very shade tolerant; requires relatively little growing space for its crown; often overtopped by other species owing to its slower growth
Interspecific interactions	**Animal damage**	May incur damage from browsing by elk or bark-stripping by black bear; animal damage increases susceptibility to pathogens; high incidence of insect damage to seeds and cones
	Mycorrhizal fungi	Roots highly mycorrhizal, particularly at high elevations; *Cenococcum graniforme* frequently associated with Pacific silver fir

Reproduction and Growth

Mode of reproduction	Reproduction is sexual; monoecious
Reproductive phenology	Reproductive cycle begins in May when reproductive primordia are initiated and is completed when seeds reach maturity in late summer of the following year; development enters dormancy beginning in October or November of the first year; development of pollen- and seed-cone buds resumes in early April of the second year, and pollination occurs by late May (about 7 weeks after the end of dormancy), although fertilization does not take place until July; seeds reach maturity in late August or September; the period from pollination to seed maturity is 90 to 120 days; phenology varies by geographic location, elevation, local climate conditions, and snowpack
Pollination	Wind-pollinated

Seed	**Seed type**	Cones 3 to 4 in (8 to 10 cm) long and 1.5 to 2 in (3.5 to 5 cm) wide; seeds 0.4 to 0.5 in (10 to 12 mm) long and 0.2 in (4 mm) wide; seeds have a single wing approximately the same length as the seed body; seeds often fall in pairs
	Seed-bearing age	Cone production begins around age 20 to 30 years
	Seed size/ weight	Averages 11,000 seeds per lb (24,250 seeds per kg); ranges from 7,800 to 20,800 seeds per lb (17,200 to 45,860 seeds per kg); seeds heavier than those of most associated conifers
	Seed longevity/ survivability	Seed viability did not decline after 6 months for seeds stored at ambient temperatures; seed may be stored for 5 years or longer at 1 °F (-17 °C)
	Seed crop and frequency	Trees have low cone-bearing capacity; generally a poor seed producer, produces a low percentage of sound seed, probably a result of frequent years of low pollen production or the long period of time between pollination and fertilization; good seed crops occur approximately every 3 years
Seed dissemination	**Time of year**	Seed dissemination begins in mid-September, relatively early compared to associated species; timing of seedfall is not related to latitude or elevation; seedfall declines by late October, although some seed may continue to fall through April; typically, larger seeds with higher viability are shed first
	Method and dispersal agents	Seeds dispersed by gravity and wind; cones disintegrate as they mature; seeds occasionally dispersed by animals including Douglas squirrel
	Distance	Seeds not carried far by wind because they are relatively heavy; one third of dropped seed falls beyond 125 ft (38 m) of a stand edge; less than 10 percent falls beyond 375 ft (114 m)
Germination requirements		Germination averages 20 to 30 percent; lack of pollination and insect damage are main reasons for low viability; requires a minimum cold stratification period of 3 to 4 weeks; germination greatest in cool, moist locations; germination most likely on mineral soil, but also occurs on organic soil, rotten wood, and litter
Seedling survival		Seedling mortality most often caused by germination on snow, adverse climatic conditions, or competing vegetation; seedlings are sturdy and resistant to being flattened by wet snow or litter after snow melt
Vegetative phenology		At an elevation of 3,280 ft (1,000 m) on Vancouver Island, vegetative bud development began in early April; bud burst occurred in early June; shoot elongation continued until late July; about that time, vegetative buds initiated leaf primordia, which developed until entering dormancy in November; in British Columbia, budburst was delayed by 1 day for every 65-ft (20-m) increase in elevation

Genetics

Mating system	Predominantly outcrossing with a moderately high outcrossing rate
Outcrossing % (t_m)	0.875
Genetic diversity	Average levels of genetic diversity
Heterozygosity (H_e)	0.10
Geographic differentiation	Weak genetic differentiation based on molecular markers
F_{st} or G_{st}	0.05
Genetic analysis research results	Relatedness among individuals drops to near zero within distances 20 to 60 m; low levels of inbreeding depression in growth of 2 to 5 percent detected in natural stands

Threats and Management Considerations

Insects and disease	Moderate risk of insect damage; balsam woolly adelgid (*Adelges piceae*) is the most frequent cause of damage and mortality followed by silver fir beetle; Pacific silver fir is susceptible to root and butt rots including those caused by the fungi *Heterobasidion occidentale*, *Phellinus weirii*, and *Armillaria ostoyae*, although these are generally less frequent at high elevations; high incidence of insect damage to seed and cones
Fragmentation	Occurs to a relatively limited extent in the coastal ranges of Washington and Oregon
Fire	Extremely fire-sensitive owing to its thin bark, shallow roots, and highly flammable foliage; given the humidity and precipitation where it typically occurs, surface fires are rare and of low intensity
Other damaging agents	More susceptible to windthrow than associated species
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	An important species in watersheds and is prevalent in wilderness and multiple-use recreation areas; nursery seedlings planted in harvested areas have performed poorly

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Cope 1992a, Crawford and Oliver 1990, Davidson and El-Kassaby 1997, Edwards 2008, El-Kassaby et al. 2003, Klinka et al. 2000, Murray and Treat 1980, Owens and Molder 1977a, Owens and Molder 1977b, Ritland and Travis 2004, USDA NRCS 2010

White fir (*Abies concolor*)

Ecology

Taxonomy and nomenclature		There are two currently recognized varieties of *Abies concolor*: var. *concolor* (Rocky Mountain white fir) and var. *lowiana* (California white fir), although there is significant disagreement about the taxonomic nomenclature of this species; some sources treat these two varieties as subspecies and others treat them as separate species; the variety found in the Pacific Northwest, and the one described here, is var. *lowiana*; the varieties intergrade and hybridize in Oregon; the hybrid of white fir and grand fir is the predominant form in southern and eastern Oregon
Description		A large, evergreen conifer, commonly reaching 140 to 180 ft (43 to 55 m) in height; a narrow, cylindrical crown with stout horizontal and upward-curved branches; crown becomes rounded at the top; bark is smooth, gray, and blistered when young, becoming deeply furrowed with age
Distribution		Occurs from the central Oregon Cascades and the Blue Mountains southward through the Sierra Nevada Range to Mexico; occurs from approximately 2,000 to 6,600 ft (600 to 2,000 m) elevation in Oregon, although in the Cascade Range, the white fir zone occurs from approximately 4,500 to 6,500 ft (1,370 to 1,980 m) elevation
Successional stage		An aggressive pioneer species and a an important climax species on drier sites; on moister sites in Oregon, white fir succeeds to western hemlock and western redcedar; white fir is more tolerant of drought, cold, and fire than grand fir; the hybrid form, which is very common in Oregon, is intermediate in these tolerances
Associated forest cover		In mixed conifer forests, associated with grand fir, Pacific madrone, tanoak, incense-cedar, ponderosa pine, lodgepole pine, sugar pine, western white pine, Jeffrey pine, Douglas-fir, and California black oak; on the west side of the Klamath Mountains, occurs most often with Douglas-fir; on the east side occurs predominantly with pines (*Pinus* spp.) and California red fir; on higher elevation sites, may comprise 80 percent or more of the canopy; sometimes forms pure stands
Habitat	**Sites**	Occurs on a wide range of sites, from cold, high-elevation areas to warm, lower-elevation areas; occurs on drier sites than the closely related grand fir; found on steep, unstable slopes, but best growth occurs on gentle slopes and level ground
	Soils	Found on soils formed in a wide range of parent materials; found on numerous soil types and on soils varying widely in nutrient availability
	Moisture	In the southern Cascades, best growth occurs where precipitation ranges from 39 to 59 in (99 to 150 cm) or more; grows on sites with as little as 14 in (35 cm) annual precipitation; moderately sensitive to saturated soils
	Temperature	Occurs on high-elevation sites with long winters, heavy snowpacks, and short growing seasons; sensitive to spring and fall frosts
	Shade tolerance	Shade tolerant; shade tolerance is greater than that of Douglas-fir and most other associated conifers but less than that of western hemlock or western redcedar; seedlings establish best in partial shade but also establish in dense shade; young trees may persist in shade for many years and then respond rapidly to release
Interspecific interactions	**Animal damage**	Seedlings are relatively susceptible to browse
	Mycorrhizal fungi	Forms mycorrhizal associations

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		Completes reproductive cycle over two years; cones initiated in mid-May of first year, conelets become recognizable in early May of second year; flowers in late May or early June and fertilization occurs soon after that; cones attain their full size in August
Pollination		Wind-pollinated
Seed	**Seed type**	Winged seeds are borne in upright cones, 3 to 5 in (7 to 12 cm) long, near the top of the crown; cones average 185 to 295 seeds apiece
	Seed-bearing age	Trees bear cones as early as 40 years of age; cone production continues beyond 300 years of age
	Seed size/ weight	Averages 15,920 seeds per lb (35,070 seeds per kg)
	Seed longevity/ survivability	Seeds do not remain viable beyond the first year under natural conditions; seed may be stored for 5 or 6 years under controlled conditions
	Seed crop and frequency	Fair to good seed crops occur every 2 to 5 years; heavy seed crops occur every 3 to 9 years; where white fir is a major canopy component, seedfall may reach 600,000 seeds per acre (1,500,000 seeds per ha)
Seed dissemination	**Time of year**	Seed reaches maturity in September; seedfall begins less than 3 weeks later
	Method and dispersal agents	Cones disintegrate on the tree and seeds are dispersed by wind
	Distance	Most seed is transported by wind for only 1.5 to 2 times the tree's height; a small percentage of seed may be transported farther
Germination requirements		A relatively low percentage of seeds are viable (20 to 50 percent); germination averages 37 percent; seed overwinters in or beneath the snow, although seed beneath the snowpack is more likely to produce seedlings; cold, moist stratification is necessary for germination; germination occurs in the spring immediately after snowmelt; seed on bare mineral soil is most likely to establish, although seedlings also establish where litter is present
Seedling survival		Shade increases seedling survival because seedlings are sensitive to heat and dry soils; seedlings are relatively susceptible to spring frost and deer browse damage
Vegetative phenology		Radial growth precedes height growth in the spring and lasts longer; height growth begins later than that of associates species and lasts approximately 6 weeks; for low-elevation trees in particular, a second height growth flush may occur if sufficient moisture becomes available in late summer

Genetics

Mating system	Predominantly outcrossing
Outcrossing % (t_m)	Unknown
Genetic diversity	Above average genetic diversity
Heterozygosity (H_e)	0.2
Geographic differentiation	strong population differentiation based on molecular markers
F_{st} or G_{st}	0.229

Patterns of variation	Trees grown from a range-wide seed collection were highly variable in most growth, morphological, and wood structure characters, with variation significantly correlated to latitude of origin; there is also a relatively large amount of variation among families and within populations
Genetic analysis research results	Differences in seedling traits were ecotypic between low-elevation and high-elevation sources; within and among population differences exist in seedling growth and morphological traits, but variation was often not clinal

Threats and Management Considerations

Insects and disease	Highly susceptible to a variety of root diseases caused by the fungi *Heterobasidion occidentale*, *Armillaria ostoyae*, and *Phellinus weirii*, and stem decays caused by *Echinodontium tinctorium, Phellinus cancriformans,* and *Pholiota* spp.; of the many insect pests that damage white fir, the fir engraver (*Scolytus ventralis*) is the most important; white fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *concoloris*) may cause significant growth loss and mortality of trees in Southwest Oregon, particularly in association with Cytospora canker.
Harvest	Once considered undesirable for timber, white fir has become an important commercial species in California in recent decades
Fragmentation	Intergrades and hybridizes with grand fir in Oregon; hybrids are difficult to distinguish visually from white fir
Fire	Generally considered more fire-resistant than its associates at higher elevations and less fire-resistant that its associates at lower elevations; seedlings, saplings, and poles may be killed by fire; trees become increasingly fire-resistant with age and size; white fir is aggressively regenerating in California where wildfire has been suppressed
NatureServe conservation status ranking	G5T5 Secure—Common; widespread and abundant
Silvicultural considerations	Responds well to release after extended periods of suppression; shade tolerance facilitates management of white fir under a variety of silvicultural systems; capable of high productivity; capable of growth at high stand densities

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Dodd and Power 1994, Hamrick 1976, Hamrick and Libby 1972, Klinka et al. 2000, Laacke 1990a, USDA NRCS 2010, Westfall and Conkle 1992, Zhang et al. 2005, Zouhar 2001

Grand fir (*Abies grandis*)

Ecology

Description		A medium-sized, evergreen conifer reaching a height of 150 to 200 ft (45 to 60 m); a long, conical crown that is rounded at the top; mature trees tend to lose apical dominance; branches are straight and horizontal; thick, furrowed bark similar to that of Douglas-fir
Distribution		Occurs in separate coastal and interior distributions in the Pacific Northwest; coastal distribution extends from southwestern British Columbia to northern California, from the coast east to the Cascade Range; interior distribution extends from southern British Columbia to central Idaho and eastern Oregon; grand fir occurs most often from below 1,500 ft (460 m) elevation in western Washington and below 3,000 ft (915 m) in western Oregon; in the eastern Cascades it occurs up to 5,000 ft (1,525 m) on moist sites; in Oregon's Blue Mountains, grand fir is occasionally found at elevations as high as 6,000 ft (1,830 m)
Successional stage		A seral or climax species; on moist, lowland sites its growth rate is sufficient for it to achieve overstory status; on dry sites, it grows more slowly and does not become part of the canopy until the stand nears climax conditions; grand fir establishes well on the bare mineral soil of disturbed sites
Associated forest cover		Typically occurs in mixed stands, often as a minor species; in western Washington and Oregon occurs most frequently with Douglas-fir, Sitka spruce, Pacific silver fir, western redcedar, western hemlock, bigleaf maple, red alder, and black cottonwood; east of the Cascade crest occurs most often with western white pine, western larch, Douglas-fir, western hemlock, western redcedar, lodgepole pine, and ponderosa pine
Habitat	**Sites**	Occurs most often in lowlands west of the Cascade crest, frequently in valleys and on floodplains; occurs on relatively moist sites east of the Cascade crest, where it is more common
	Soils	Found on a variety of soil types, but occurs most often on moderately to highly nutrient-rich soils
	Moisture	Tolerant of a greatly fluctuating water table; also tolerant of relatively dry soils at higher elevations, where it forms a deep taproot
	Temperature	Low frost tolerance; moderate heat tolerance
	Shade tolerance	Moderately shade-tolerant, less so than western hemlock, western redcedar, and other true firs; it generally outgrows these species but is outgrown by shade-intolerant species in full sunlight; grand fir is more shade tolerant in dry climates than in wet climates
Interspecific interactions	**Animal damage**	Grand fir is ranked intermediate in browse preference
	Mycorrhizal fungi	Grand fir forms associations with ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		Flowers between late March and mid-May, although early spring temperatures cause substantial variation in timing; cones mature in August or September and begin to disintegrate and drop seed approximately 1 month later
Pollination		Wind-pollinated
Seed	**Seed type**	Large, winged seeds; sometimes 200 or more seeds per cone

	Seed-bearing age	Begins to produce seed around age 20
	Seed size/ weight	Ranges from 11,900 to 28,700 seeds per lb (26,200 to 63,100 seeds per kg), with an average of 18,400 seeds per lb (40,500 seeds per kg)
	Seed longevity/ survivability	Seeds remain viable only through the first spring; seed may be stored for more than 5 years at 5 °F (-15 °C)
	Seed crop and frequency	Seed production is intermediate; produces a low percentage of sound seed; good seed crops occur every 2 to 3 years
Seed dissemination	**Time of year**	Seedfall begins about mid-September
	Method and dispersal agents	Cones disintegrate at maturity and seeds are dispersed by wind and rodents
	Distance	Average dispersal distance is about 150 to 200 ft (46 to 61 m), but adequate seed for regeneration is dispersed up to 400 ft (120 m)
Germination requirements		Germination is quite variable, averaging 50 percent or less; seeds stratify over winter under cool, moist conditions; germination is greatest on mineral soil or duff
Seedling survival		Seedling mortality is highest during the first 2 years after germination, when an average of 40 percent of seedlings die; early mortality is usually a result of fungal infection or summer drought; on exposed or dry sites, seedlings form deep taproots, which reduces their susceptibility to drought
Vegetative phenology		Vegetative buds become mitotically active in mid-March; bud burst occurs about mid-May; shoot elongation occurs through the end of June

Genetics

Genetic diversity	Average levels of genetic diversity
Heterozygosity (H_e)	0.10
Geographic differentiation	Weak differentiation based on molecular markers
F_{st} or G_{st}	0.057
Patterns of variation	Slower growth and higher frost resistance in inland (northern Idaho and eastern Oregon) populations; genetic differences exist among northern and southern provenances, but little difference within
Genetic analysis research results	Several provenance tests established in Europe show variation in growth, survival, and volume production among provenances, with lower elevation provenances usually performing best

Threats and Management Considerations

Insects and disease	Of the many insect pests that damage grand fir, the fir engraver (*Scolytus ventralis*) is the most important; Balsam woolly adelgid has caused serious losses to low elevation grand firs in the past; root disease fungi including *Heterobasidion occidentale, Armillaria ostoyae*, and *Phellinus weirii* as well as the stem decay fungus *Echinodontium tintorium* cause significant mortality, growth loss, and breakage in grand fir.
Harvest	Marketed with western hemlock and other true firs
Fragmentation	Hybridizes and intergrades with white fir in Oregon
Fire	At maturity, resistant to low- and moderate-severity fire; less resistant to fire damage than Douglas-fir but more resistant than Pacific silver fir; does not survive crown fire; susceptibility is greater on moist sites than on dry sites where roots are deeper and bark is thicker

Other damaging agents	Moderate tolerance to damage from snow and wind
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	As a moderately shade-tolerant species, grand fir may be suited to multi-aged silvicultural systems; sometimes responds well to release; a valued species for pulpwood

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Burton and Cumming 1995, Foiles et al. 1990, Franklin and Krueger 1968, Franklin and Ritchie 1970, Howard and Aleksoff 2000, Klinka et al. 2000, Konnert and Reutz 1997, Nielsen and Rasmussen 2009, Owens 1984, Owens and Blake 1985, USDA NRCS 2010

Subalpine fir (*Abies lasiocarpa*)

Ecology

Description		A medium-sized, evergreen conifer reaching a height of approximately 100 ft (30 m); a narrow, dense crown that extends to the ground; stiff, often downward-angled branches; gray-brown bark forming irregular scales on older trees
Distribution		From Yukon Territory, Canada, southward to New Mexico; a major component of high-elevation forests in the Olympic and Cascade ranges; typically occurs from about 4,000 to 6,500 ft elevation (1,200 to 2,000 m) in the Olympic and Cascade Ranges, although it is found as high as 8,000 ft (2,440 m) on sheltered slopes and as low as 2,000 ft (610 m) along cold stream bottoms
Successional stage		Occurs in all stages of secondary succession and as a climax dominant or codominant species; occurs as a pioneer on disturbed and severe sites
Associated forest cover		Occurs in pure and mixed-species stands; occurs frequently with mountain hemlock, whitebark pine, Pacific silver fir, Engelmann spruce, and lodgepole pine; occurs less frequently with western hemlock, western white pine, grand fir, noble fir, and Sitka spruce
Habitat	**Sites**	Found in cold, mid- to high-elevation forests, typically with very heavy snowpack and short growing seasons
	Soils	Grows on a wide range of soils, including shallow, coarse-textured, and nutrient-poor soils; grows in poorly aerated soils
	Moisture	Occurs on soils ranging from somewhat dry to wet; moderately tolerant of drought; tolerant of flooding and fluctuating water tables
	Temperature	Occupies sites where winters are cold and summers are cool; moderately tolerant of heat; tolerates frozen soil
	Shade tolerance	Shade tolerant; often grows as a seral species that is gradually replaced by trees such as Pacific silver fir, grand fir, and mountain hemlock; often grows in openings at high elevations
Interspecific interactions	**Animal damage**	Insects, small birds, and rodents may consume seeds; occasionally browsed by ungulates
	Mycorrhizal fungi	Subalpine fir is ectomycorrhizal

Reproduction and Growth

Mode of reproduction		Reproduces sexually and vegetatively; monoecious; vegetative reproduction occurs through layering
Reproductive phenology		Reproductive cycle spans two growing seasons; cones are initiated in the spring of the first year; buds differentiate in midsummer; conelets become apparent in early spring of the second year; in late spring or early summer, 8 to 9 weeks after the end of dormancy, pollination occurs; cones open in mid-August to mid-October; seeds ripen from mid-September to late-October
Pollination		Wind-pollinated
Seed	**Seed type**	Seeds are approximately 0.25 in (6 mm) long; seeds have a single, large, terminal wing
	Seed-bearing age	Seed production begins about age 20, but production is low in dense forest conditions

	Seed size/ weight	Averages 34,800 seeds per lb (76,700 seeds per kg)
	Seed longevity/ survivability	Seed remains viable for 1 year under natural conditions; seed may be stored for longer than 5 years at 1 °F (-17 °C)
	Seed crop and frequency	Heavy seed crops occur every 3 to 5 years; between heavy crops are light crops or crop failures; heavy crops may be predicted by good radial growth in the 2 years prior; produces a low percentage of sound seed
Seed dissemination	**Time of year**	Seedfall occurs in October and November, occasionally into December
	Method and dispersal agents	As cones disintegrate, seeds are dispersed by wind; occasionally squirrels disperse seed by caching cones
	Distance	Seeds usually fall within 260 ft (80 m) of the source tree, rarely more than 330 ft (100 m)
Germination requirements		Germination rates average approximately 31 to 38 percent; seeds require stratification under the moist, cold conditions of snow cover; germination occurs within the first few weeks after snow melt
Seedling survival		Seedling survival is highest on mineral soil, but seedlings also survive on duff, litter, and rotting wood; early root growth is rapid, while shoot growth is very slow; seedling mortality results from drought, heat-girdling, competing vegetation, frost heaving, animal damage, and pathogens
Vegetative phenology		Vegetative bud burst occurs about mid-May to mid-June; lateral shoot elongation is rapid for approximately 1 month and then slows and stops by the end of the second month; height and radial growth are very slow at high elevations

Genetics

Mating system	Predominantly outcrossing with moderately high outcrossing rate
Outcrossing % (t_m)	0.89
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.12
Geographic differentiation	Weak differentiation based on molecular markers
F_{st} or G_{st}	0.03
Genetic analysis research results	Seedlings from an elevation gradient of about 3,600 ft (1,100 m) showed strong clinal variation in timing of growth cessation, growth rate, and biomass partitioning related to elevation

Threats and Management Considerations

Insects and disease	Susceptible to the insects balsam woolly adelgid and western balsam bark beetle; and the fungi *Phellinus weirii, Heterobasidion occidentale*, and *Echinodontium tinctorium.*
Harvest	Harvest is limited by its accessibility
Fragmentation	Prevalent in high-elevation forests; discontinuities in distribution are associated with topography
Fire	Very sensitive to fire; highly susceptible to crown fire owing to highly flammable foliage and dense stands; may be slow to re-establish after fire owing to absence of seed source and competing herbaceous vegetation
Other damaging agents	Susceptible to windthrow where exposed by harvest; very tolerant of heavy snowpack

NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Well-suited to mixed-species stands and multi-aged management; natural regeneration usually preferred; planting usually ineffective; very susceptible to Indian paint fungus in pure, natural stands

References

Alexander et al. 1990, Arno and Hammerly 2007, Ettl and Peterson 2001, Franklin and Krueger 1968, Franklin and Ritchie 1970, Green 2005, Klinka et al. 2000, Kranabetter et al. 2009, Owens and Blake 1985, Owens and Singh 1982, Schmidt 1957, Shea 1987, 1990, Uchytil 1991a, USDA NRCS 2010, Woodward et al. 1994

Noble fir (*Abies procera*)

Ecology

Description		A medium-to-large, evergreen conifer; the largest of the true firs, sometimes reaching a height of more than 230 ft (70 m); self-prunes lower limbs resulting in a short, round-topped crown at maturity; gray-brown bark, increasingly reddish and deeply furrowed with age
Distribution		Occurs only in Washington and Oregon, in the Cascade Range and to a lesser extent in the Coast Range; occurs on the western slopes and near the crest of the Washington Cascades from Stevens Pass south to the central Cascades of Oregon; scattered populations occur in the peaks of the Willapa Hills in southwestern Washington and in Oregon's Coast Range; found primarily at elevations between 3,000 and 5,000 ft (910 and 1520 m)
Successional stage		A pioneer or early seral species that may be replaced over time by more tolerant species including Pacific silver fir and western hemlock
Associated forest cover		Associated with a wide variety of conifers including Douglas-fir, Pacific silver fir, grand fir, subalpine fir, western hemlock, mountain hemlock, western white pine, lodgepole pine, whitebark pine, western redcedar, Engelmann spruce, Sitka spruce, and Alaska yellow-cedar
Habitat	**Sites**	Occurs on a range of topography from gentle to steep slopes; grows best on warm, moist sites with southerly aspects
	Soils	Optimal soils include shallow to deep loams; moisture is more often a limiting factor than nutrients
	Moisture	Relatively low drought tolerance compared to its associates
	Temperature	Typically occurs where mean January temperature ranges from 24 to 30 °F (-4 to -1 °C) and mean July temperature ranges from 56 to 61 °F (13 to 16 °C); high frost tolerance
	Shade tolerance	Intermediate shade tolerance; the least shade-tolerant of all American true firs; cannot establish beneath a closed forest canopy
Interspecific interactions	**Animal damage**	Seedling browse damage less than for Douglas-fir; occasional black bear damage
	Mycorrhizal fungi	Known to be ectomycorrhizal

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		Male and female budburst from May to early June; pollination from June to early July; cones ripen in mid- to late-September; phenological events vary by 2 weeks or more depending on weather; spring and summer events are usually 1 to 2 days later for every 100 ft (30 m) increase in elevation
Pollination		Wind-pollinated
Seed	**Seed type**	Cones 4 to 6 in (10 to 15 cm); winged seeds; wing slightly longer than body
	Seed-bearing age	Seed production begins at age 20 to 30; large crops begin to occur approximately 20 years later
	Seed size/ weight	Averages 13,500 seeds per lb (29,750 seeds per kg); seeds 0.5 by 0.25 in (12 by 6 mm)
	Seed longevity/ survivability	Seed viable for one season under natural conditions; seed may be stored for 10 years or longer at -4 °C

	Seed crop and frequency	Good seed crops every 3 to 6 years; 10 or more cones per tree produced in 42 percent of years; older trees may produce large crops; seed crops poor in high Cascades and near the eastern edge of its range
Seed dissemination	**Time of year**	Seeds dispersal begins from late September to early October
	Method and dispersal agents	Seeds dispersed by wind
	Distance	Most seedfall within one or two tree heights of the source tree, although potential dispersal distance is more than 2,000 ft (610 m)
Germination requirements		Seed viability is generally low, averaging 10 percent in natural stands; viability closely related to magnitude of cone crop; cold stratification required; germination epigeal; germination in or on snowbank yields minimal survival; germination highest on mineral soil or moist humus
Seedling survival		Survival highest when germination occurs on a moist microsite; no dominant taproot; frosts and competing vegetation are major sources of mortality
Vegetative phenology		Vegetative budburst from late May to early July

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate (from planted stands in Norway)
Outcrossing % (t_m)	0.94
Genetic diversity	Above average genetic diversity
Heterozygosity (H_e)	0.22
Geographic differentiation	Weak differentiation based on molecular markers
F_{st} or G_{st}	0.05
Patterns of variation	Weak geographic differentiation on needle and cone traits

Threats and Management Considerations

Insects and disease	Insects, including noble fir bark beetle (*Pseudohylesinus nobilis*), are not regarded as a significant problem; a variety of fungal pathogens are found on noble fir, with the root disease fungus *Heterobasidion occidentale* causing the most damage.
Harvest	Boughs are prized for wreaths and decoration
Fragmentation	Contiguous distribution in the Cascades; disjunct populations in the Coast Ranges
Fire	Low resistance to fire when young; low to moderate resistance at maturity; foliage moderately to highly flammable; an early pioneer following stand-destroying fires
Other damaging agents	Very windfirm; tolerant of heavy snow
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Initial height growth is slow; often occurs in mixed stands where its low amount of taper results in a disproportionately large contribution to stand volume

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Cope 1993a, Franklin 1990, Franklin and Krueger 1968, Franklin and Ritchie 1970, Nielsen and Rasmussen 2009, Owens and Blake 1985, Siegismund and Kjaer 1997, USDA NRCS 2010, Xie and Ying 1994, Yeh and Hu 2005

Shasta red fir (*Abies* x *shastensis* [*magnifica* x *procera*])

Ecology

Taxonomy and nomenclature		Also known as *A. magnifica var. shastensis*; Shasta red fir resulted from California red fir (*A. magnifica*) and noble fir introgression; in Oregon, Shasta red fir intergrades and hybridizes with noble fir
Description		A large, evergreen conifer, growing up to 200 ft (60 m) in height; a narrow crown with relatively short branches; bark is thin when young, becoming deeply furrowed with age
Distribution		Occurs from the Klamath and Siskiyou Mountains southward through the Coast Range of northwest California to Lake County and through the Sierra Nevada Range to Kern County, California; occurs from approximately 4,500 to 5,900 ft (1,370 to 1,800 m) elevation in Oregon
Successional stage		A late-seral or climax species; in Oregon, Shasta red fir is less often a climax species than in California, possibly as a result of the influence of introgression with noble fir; in Oregon, Shasta red fir may succeed to white fir at lower elevations and to mountain hemlock at higher elevations; establishes in small to large openings created by disturbance; Shasta red fir stands are usually even-aged
Associated forest cover		Occurs with white fir, mountain hemlock, Douglas-fir, western white pine, and lodgepole pine; also found in pure, dense stands
Habitat	**Sites**	Found on sites with cold, wet winters and warm, dry summers; growing seasons are short; most precipitation occurs as snow; occurs at elevations above the white fir zone and below the mountain hemlock zone; most common on northern aspects; occurs on all slopes
	Soils	Occurs on well-drained, moist soils; soils are usually, but not always, nutrient-rich and relatively coarse; soils are typically poorly developed; best growth is on deep soils associated with glacial deposits
	Moisture	Low drought tolerance; grows poorly where soils are saturated during the growing season; grows where summer precipitation is negligible and most precipitation falls during the dormant season as snow; snowpack on Shasta red fir sites in Oregon may be deeper than 7 ft (2 m)
	Temperature	Frosts may occur during the growing season, but damage is minimal
	Shade tolerance	Moderately shade tolerant; may survive for decades in relatively dense shade; slightly less shade tolerant than white fir; establishes best in partial shade
Interspecific interactions	**Animal damage**	Pocket gophers and other rodents may cause substantial damage to seedlings; seedlings may be damaged by deer browse
	Mycorrhizal fungi	Forms mycorrhizal associations

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		Completes reproductive cycle over two years; cones are initiated in the first year; flowering occurs in June of the second year in southwestern Oregon; seeds reach maturity in mid-August and ripen until seedfall
Pollination		Wind-pollinated
Seed	**Seed type**	Winged seeds are borne in upright cones
	Seed-bearing age	Trees bear cones as early as 30 to 40 years of age; seed production is more erratic for immature trees

	Seed size/ weight	Averages 7,300 seeds per lb (16,100 seeds per kg)
	Seed longevity/ survivability	Seeds germinate the first spring and are not stored in the forest floor; seeds may be stored for at least 10 years at subfreezing temperatures
	Seed crop and frequency	Heavy seed crops are produced about every 2 to 3 years
Seed dissemination	**Time of year**	Late September to mid-October
	Method and dispersal agents	Cones disintegrate on the tree and seeds are dispersed by wind
	Distance	Most seed is transported distances of less than 2 to 2.5 times the tree's height; a small percentage of seed may be transported farther
Germination requirements		A relatively low percentage of seeds are viable (30 to 43 percent), although adequate regeneration can occur when field germination rates are below 5 percent; seeds germination immediately after snowmelt; germination epigeal; seeds germinating within the snowpack usually die; seedling establishment is best on bare mineral soil or in light litter
Seedling survival		Seedling survival may be increased by the presence of light litter and by shading; frost damage and competition from other vegetation reduce seedling survival
Vegetative phenology		Best growth occurs in years with low precipitation which are generally associated with a longer growing season

Genetics

Genetic analysis research results	Cholorplast DNA evidence indicates that Shasta red fir occurs in a broad zone of hybridization between *Abies procera* to the north and *A. magnifica* to the south; variation in seedling traits among sources of the noble fir-Shasta red fir complex strongly indicated a stepped north-to-south cline corresponding to the taxonomic differences

Threats and Management Considerations

Insects and disease	Susceptible to fungal diseases, of which the most important are root diseases caused by *Heterobasidion occidentale* and *Armillaria ostoya*e, and stem decays caused by *Echinodontium tinctorium* and *Pholiota* spp; the fir engraver beetle (*Scolytus ventralis*) is the most important of a variety of insect pests; insect damage to seeds also may be severe in some years; red fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *magnificae*) may cause significant growth loss, breakage, and mortality especially in association with Cytospora canker.
Harvest	An important commercial species in California
Fragmentation	Intergrades and hybridizes with noble fir at the northern edge of its range in Oregon
Fire	Tolerates occasional low-severity fires; stand-replacing fires are rare; retention of lower branches increases the risk of crown fire; fire interval is 70 to 130 years for Shasta red fir
NatureServe conservation status ranking	GNA Not Applicable–A conservation status rank is not applicable because the species is not a suitable target for conservation activities

Silvicultural considerations	Grows in dense, highly productive stands; susceptible to windthrow after partial cutting; particularly susceptible to infection by fungal pathogens following mechanical injury to the lower bole

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Cope 1993c, Franklin 1990, Laacke 1990b, Oline 2008, Sorensen et al. 1990; USDA NRCS 2010

Douglas maple (*Acer glabrum* var. *douglasii*)

Ecology

Taxonomy and nomenclature		Rocky Mountain maple (*Acer glabrum*) has six varieties including Douglas maple
Description		A deciduous, broadleaf shrub or small tree growing 20 to 40 ft (6 to 12 m) in height; an irregular crown, often with multiple stems; smooth, reddish bark becoming rougher with age
Distribution		From Alaska south to California and east to Montana and Idaho; common at moderate elevations east of the Cascade crest; somewhat less common in western Washington and Oregon
Successional stage		Found in early seral, shrub-dominated vegetation; occurs in deciduous pioneer forests but also present in late successional and climax floodplain communities
Associated forest cover		An understory species in a variety of conifer forests; often associated with ponderosa pine forests; does not compete with conifers to the extent that vine maple does; grows above the shrub layer
Habitat	**Sites**	Low to middle elevations; moist and dry sites; floodplains, streambanks, and forest edges; dry, open, rocky areas, including avalanche tracks; occurs on drier, more exposed sites than vine maple
	Soils	Occurs on a wide variety of soils, from wetlands to rocky slopes; found on soils of many parent materials; reportedly an indicator of nitrogen-rich soils in British Columbia
	Moisture	Tolerates periodic flooding and moderately high water tables; moderately drought tolerant
	Temperature	Tolerant of heat and cold temperatures
	Shade tolerance	Moderately shade-tolerant
Interspecific interactions	**Animal damage**	An important browse species for deer and elk
	Mycorrhizal fungi	Known to be mycorrhizal

Reproduction and Growth

Mode of reproduction		Sexual and vegetative reproduction; may be monoecious or dioecious; sprouts from root crown after stem damage or top-kill
Reproductive phenology		Flowers from late April to late June, depending on elevation and latitude; fruit develops from June to August; fruit ripens from July to October
Pollination		Insect- and wind-pollinated
Seed	**Seed type**	Paired, winged samaras; 0.8 to 1.2 in (20 to 30 m) long
	Seed-bearing age	Seed production may begin as early as age 10
	Seed size/ weight	Seeds are 0.16 to 0.2 in (4 to 5 mm) long; 7,820 to 20,300 cleaned seeds per lb (17,240 to 44,750 seeds per kg) with an average of 13,430 seeds per lb (29,610 seeds per kg)
	Seed longevity/ survivability	Seeds sometimes remain dormant for one or two growing seasons before germination; seeds may remain viable in storage for up to 3 years

	Seed crop and frequency	Large seed crops occur every 1 to 3 years
Seed dissemination	**Time of year**	Seeds dispersed beginning in September; some seeds may not be dropped until February
	Method and dispersal agents	Seeds are dispersed by wind, whirling sideways
	Distance	Not reported
Germination requirements		Seeds require approximately 6 months of chilling before embryos break dormancy; germination occurs on mineral soil or shallow organic layers, often in partial shade
Seedling survival		Partial shade facilitates seedling establishment; after establishment, early growth is rapid in sunlight
Vegetative phenology		Bud swell in late March or April; budburst in early April to mid-May; leaf growth may continue through June; stem elongation begins in late April and may continue until late August

Threats and Management Considerations

Insects and disease	Little information available; significant damage from insects or disease has not been reported; dull red leaf spots attributed to unknown pathogen; *Eriophyid* mite colonies sometimes occur on the underside of leaves
Harvest	Not a commercial species
Fragmentation	Occurrence is sporadic west of the Cascade Range
Fire	Top-killed by fire; readily sprouts from root crown; a pioneer species in burned areas
Other damaging agents	Not reported
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Growth is stimulated when the forest overstory is thinned; rapidly sprouts after stem is cut

References

Anderson 2001a, Arno and Hammerly 2007, USDA NRCS 2010

Bigleaf maple (*Acer macrophyllum*)

Ecology

Description		A medium-sized, deciduous, broadleaf tree; the largest North American maple, reaching a height of more than 100 ft (30 m); a broad, outstretched crown with large leaves; light gray bark when young, becoming dark and ridged with age
Distribution		Coastal Pacific Northwest from British Columbia south to near San Francisco Bay in California; occurs primarily from the coast to the western slopes of the Cascade Range
Successional stage		Often occurs at intermediate or late seral stages in conifer forests; seedlings and sprouts grow rapidly after gap creation or canopy disturbance; follows willow or red alder in riparian succession
Associated forest cover		Frequently found with Douglas-fir, western redcedar, and western hemlock; occurs on moist sites with willow, black cottonwood, and red alder; occurs in the Olympic rain forest with old-growth Sitka spruce and western hemlock
Habitat	**Sites**	Often found where relatively open overstories occur, such as wet sites, and, to a lesser extent, dry sites; sites range from bottomlands to steep slopes; common on hardwood floodplain forests
	Soils	Occurs on a wide range of soil types; does not require high levels of nutrients; soils range from well-drained alluvium to steep talus slopes;
	Moisture	Very flood-tolerant; southern and interior distribution limited by moisture
	Temperature	Northern distribution limited by cold temperatures; moderately tolerant of heat; found on hot, dry sites in the Oregon Cascades
	Shade tolerance	Intermediate in shade tolerance; seedlings establish in conifer stands but usually survive fewer than 15 years unless the canopy is disturbed; mature bigleaf maple is found in conifer stands, where trees originated in canopy openings
Interspecific interactions	**Animal damage**	Seedlings are highly palatable to deer; high level of seed predation by a variety of small mammals and birds; buds and flowers also consumed
	Mycorrhizal fungi	Known to be ectomycorrhizal

Reproduction and Growth

Mode of reproduction		Sexual and vegetative reproduction; monoecious; primarily sexual reproduction on undisturbed sites; sprouts vigorously from stumps
Reproductive phenology		Flowers from March to June depending on elevation and latitude; pollination approximately 2 to 4 weeks after bud burst; seeds become ripe in September or October
Pollination		Insect-pollinated
Seed	**Seed type**	Fused double samaras; wings 1.4 to 2 in (3.5 to 5 cm) long; large triangular or oval seeds
	Seed-bearing age	Seed production begins about age 10
	Seed size/ weight	Seeds 0.2 to 0.5 in (4 to 12 mm) long and 0.2 to 0.4 in (4 to 9 mm) thick; averages 3,200 seeds per lb (7,050 seeds per kg); ranges from 2,400 to 3,600 seeds per lb (5,200 to 7,900 seeds per kg); seed coat is 60 to 70 percent of seed weight

	Seed longevity/ survivability	Seeds remain viable for only a few months under natural conditions; seeds have been stored for 1 year at 34 °F (1 °C)
	Seed crop and frequency	Although production varies among individuals, overall production is generally high every year, particularly in open areas
Seed dissemination	**Time of year**	Most seeds dispersed between October and January, some not dropped until March
	Method and dispersal agents	Primarily dispersed by wind; some seeds may be dispersed by small mammals and birds
	Distance	Not documented
Germination requirements		Seeds germinate beginning in winter, from late January through April or May; low temperature threshold for germination; germination epigeal; germination best on mineral soil or moist organic materials; with predation excluded, 30 to 40 percent of viable seed germinates under natural conditions
Seedling survival		Seedling mortality may result from competition, moisture stress, low light, and herbivory; understory seedlings are abundant in some Douglas-fir stands, although growth is very slow until overstory disturbance occurs; seedlings and sprouts have high growth potential, given sufficient sunlight
Vegetative phenology		Leaves appear in late March or April and are retained through October

Genetics

Mating system	High outcrossing rate
Outcrossing % (t_m)	0. 945
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.15
Geographic differentiation	Weak differentiation based on molecular markers
F_{st} or G_{st}	0.05

Threats and Management Considerations

Insects and disease	Overall risk of damage from insects and fungi is low, although over-mature or damaged trees are often infected by the root and butt rot fungi *Armillaria* spp. and *Ganoderma applanatum;* Several fungi cause substantial stem decay in older trees.
Harvest	Harvested with Douglas-fir in mixed stands; one of a few commercial hardwood species in the Pacific Northwest; used for veneer, furniture, and specialty products
Fragmentation	Widespread throughout its range
Fire	Well-adapted to fire owing to its ability to sprout and grow rapidly after top-kill; only severe fires damage the root crown
Other damaging agents	Boles or limbs may suffer breakage under heavy snow or high winds
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	A serious competitor in Douglas-fir stands, particularly after harvesting; sprouts and seedling grow faster than conifers and fallen leaves smother conifer seedlings

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Guries and Nordheim 1984, Hamann and Wang 2006, Iddrisu and Ritland 2004, Klinka et al. 2000, Minore and Zasada 1990, Uchytil 1989a, USDA NRCS 2010

White alder (*Alnus rhombifolia*)

Ecology

Description		A small, often multi-stemmed, deciduous broadleaf tree, typically reaching a height of 50 to 60 ft (15 to 18 m); a broadly rounded crown; dark green leaves, pale green beneath; bark is light gray and smooth on young trees, becoming reddish brown and plated on older trees
Distribution		From valleys of southeastern and south-central Washington southward through northeastern and north-central Oregon; from the Willamette Valley southward in the foothills of the Coast Ranges and in the low- to mid-elevation slopes of the Sierra Nevada; occurs as far south as southern California
Successional stage		A riparian pioneer species, colonizing moist sites disturbed by water
Associated forest cover		Grows in riparian communities with species including Oregon ash, willow (*Salix* spp.), black cottonwood, red alder, and Oregon white oak
Habitat	**Sites**	Occupies riparian areas in relatively warm, dry regions, including east of the Cascade Range in Oregon and Washington; occurs primarily in low-elevation riparian areas in western Oregon; found in non-forested areas near perennial streams; a good indicator of water
	Soils	Colonizes fresh alluvium; found on alluvial soils and soils with continuous moisture
	Moisture	Requires a constant water supply; restricted to locations with year-round water flow; low drought tolerance; occurs in areas that flood
	Temperature	Unknown; occurs on warm, interior sites
	Shade tolerance	Shade intolerant
Interspecific interactions	**Animal damage**	Not a preferred browse species
	Mycorrhizal fungi	Known to be mycorrhizal

Reproduction and Growth

Mode of reproduction		Sexual and vegetative reproduction; monoecious; vegetative reproduction is through stem and root sprouts; reproduction from seed is important in colonization of new sites; vegetative reproduction is important in established stands
Reproductive phenology		In Oregon: flowers in March; fruit ripens in late September to early October
Pollination		Wind-pollinated
Seed	**Seed type**	Woody cone-like catkins contain numerous, winged, nutlike seeds
	Seed-bearing age	Undocumented; although red alder, which is closely related, may produce seed as early as 3 to 4 years of age
	Seed size/ weight	Averages 650,000 seeds per lb (1,430,000 per kg)
	Seed longevity/ survivability	Undocumented under natural conditions; seed of closely related red alder may be stored for 10 to 20 years at temperatures of 10 °F (-12 °C) or lower
	Seed crop and frequency	Undocumented

Seed dissemination	**Time of year**	Seeds mature beginning in late September
	Method and dispersal agents	Seeds dispersed by wind and water
	Distance	Undocumented
Germination requirements		Germination is greatest in full sunlight, on wet mineral soils, such as those exposed after flooding; cold stratification not necessary
Seedling survival		Seedling establishment requires a continuously moist substrate

Threats and Management Considerations

Insects and disease	Leaf damage by the alder leaf beetle and several foliar pathogens is common but not usually debilitating; several fungal species cause stem decay in older trees; branch and stem dieback associated with woodboring insects are common.
Harvest	Not an important commercial species
Fragmentation	Scattered populations occur in eastern Washington and Oregon
Fire	Trees are not fire-resistant, although their streamside habitat burns less frequently than other areas; little information exists on their response to fire; high-intensity fire has been observed to kill trees and root systems, while root systems of associated species sprouted post-fire
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Planted to disturbed riparian areas to restore vegetation and stabilize soil

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, NatureServe 2010, Opperman and Merenlender 2001, Uchytil 1989b, USDA NRCS 2010

Red alder (*Alnus rubra*)

Ecology

Description		A medium-sized, short-lived, deciduous, broadleaf tree, often reaching 100 ft (30 m) in height; a narrow, rounded crown; smooth, light gray bark, often mottled due to lichen colonization
Distribution		From southeastern Alaska to southern California; rarely found east of the Cascade Range in the Pacific Northwest; several isolated populations in Idaho; primarily occurs at elevations below 2,400 ft (750 m)
Successional stage		Pioneer; aggressively establishes following natural and human-caused disturbances; on disturbed sites, outgrows its primary natural competitor, Douglas-fir, for approximately 25 years before Douglas-fir achieves equal height; considered a climax species where it occurs in swamps
Associated forest cover		Often found in pure or mixed stands within coniferous forests of Douglas-fir, western redcedar, western hemlock, grand fir, and Sitka spruce; mixed stands are relatively young and may contain other broadleafs and conifers; occurs in riparian communities, in pure stands or mixed with black cottonwood, bigleaf maple, and willow; occurs in swamps with western redcedar
Habitat	**Sites**	Occurs most often in riparian areas, moist bottomlands, and moist lower slopes; prevalent where soil drainage is poor; found on relatively moist upland sites where disturbance has occurred, rarely on dry, south-facing slopes
	Soils	Found on a wide range of soils, from well-drained to poorly drained; has relatively high nutrient requirements, although it fixes nitrogen through bacteria in root nodules
	Moisture	Infrequent on dry soils; low tolerance of drought; growth limited by moisture; tolerates wet sites, flooding, greatly fluctuating water tables
	Temperature	Infrequent on exposed, south-facing slopes; susceptible to frost damage; range limited by low temperatures
	Shade tolerance	Shade intolerant; will not survive if overtopped; must remain in upper canopy in mixed stands
Interspecific interactions	**Animal damage**	Occasional browse damage
	Mycorrhizal fungi and symbiotic bacteria	Roots are ectomycorrhizal, but with only a few fungal species; root nodules contain the nitrogen-fixing actinomycete *Frankia* spp.; annual increases in soil nitrogen in alder stands range from 40 to 300 lb per ac (45 to 355 kg per ha)

Reproduction and Growth

Mode of reproduction		Sexual and occasionally vegetative; monoecious; young trees sprout when stem is damaged
Reproductive phenology		Flowering begins as early as late February and lasts as late as May; fruits ripen from early August though October
Pollination		Wind-pollinated
Seed	**Seed type**	Woody cones, 0.5 to 1 in (1.2 to 2.5 cm) long, containing 50 to 100 seeds; seeds are nutlike, small, flattened, and winged
	Seed-bearing age	Seed production begins as early as age 3 or 4 when open-grown or age 6 to 8 in a stand; seed production peaks about age 25
	Seed size/ weight	Seeds are very light; 666,000 seeds per lb (1,465,000 seeds per kg)

	Seed longevity/ survivability	High rate of mortality for buried seed, but importance of seedbank uncertain; seed may be stored for 10 to 20 years at temperatures of 10 °F (-12 °C) or lower
	Seed crop and frequency	Moderate crops nearly every year; heavy crops every 3 to 5 years
Seed dissemination	**Time of year**	Dispersal begins around late September; most seeds dropped in fall or winter
	Method and dispersal agents	Seeds dispersed by wind and water
	Distance	Several hundred yards (m)
Germination requirements		Germinates in spring; germination highest on moist mineral soil, such as a disturbed seedbed, in full sunlight; germinates on other organic materials if moisture and light are available; germination increased by stratification; germination epigeal; germination ranges from 59 to 84 percent
Seedling survival		Shade tolerated for up to several years; full sunlight required for normal development; small seed makes germinants very susceptible to drought mortality
Vegetative phenology		Strongly influenced by climate and thus exhibits significant annual variation; radial growth lasts from approximately mid-April through mid-September; height growth begins slightly later than radial growth and continues until conditions become unfavorable

Genetics

Mating system	Moderately high outcrossing rate
Outcrossing % (t_m)	0.85
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.11
Geographic differentiation	Weak differentiation based on molecular markers
F_{st} or G_{st}	0.08
Genetic analysis research results	Strong geographic variation has been found in seedlings for top weight, bud flush and leaf abscission. Growth traits were correlated with temperature amplitude and length of the growing season, while phonological traits were related to spring thermal sums and fall frost dates. Provenances differ in physiological traits, but not families within provenances.

Threats and Management Considerations

Insects and disease	Leaf damage by the alder leaf beetle and several foliar pathogens is common but not usually debilitating; several fungal species cause stem decay in older trees.
Harvest	Harvest has increased in recent decades, and the price of red alder timber is increasing; current supply does not meet demand and a long-term shortage is anticipated; harvested red alder comes primarily from southwestern British Columbia and western Washington and Oregon
Fragmentation	Red alder is widespread at lower elevations
Fire	Red alder stands generally are not prone to fire, and may serve as natural fire breaks; red alder tolerates light surface fires
Other damaging agents	Ice storms and unseasonable frosts may cause damage; windthrow is not a significant problem

NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Owing in part to its nitrogen-fixing properties, red alder is grown on sites including mine spoils, eroded banks, and other restoration projects; also may be grown in mixture or rotation with Douglas-fir

References

Ager et al. 1993; Arno and Hammerly 2007; Bonner and Karrfalt 2008; Dang et al. 1994; Harrington 1990, 2006; Hibbs et al. 1995; Klinka et al. 2000; Owens and Blake 1985; Uchytil 1989c; USDA NRCS 2010; WDNR 2010; Xie 2008; Xie et al. 2002

Pacific Madrone (*Arbutus menziesii*)

Ecology

Description		A small-to-medium, evergreen, broadleaf tree reaching a height of 50 to 80 ft (15 to 25 m); irregular, umbrella-shaped crown with thick, glossy leaves; stem crooked and often divided; recognizable, smooth, peeling, reddish-brown bark
Distribution		From the eastern coast of Vancouver Island, British Columbia, to San Diego County, California; in the Pacific Northwest, occurs primarily from the coast to the western slopes of the Cascades, becoming more common southward; maximum elevation is approximately 3,000 ft (915 m) in the Pacific Northwest, increasing to 4,700 ft (1,435 m) in the Klamath Mountains
Successional stage		An early successional to subclimax species; establishes after disturbance and is not found in the forest understory
Associated forest cover		Occurs individually or in groves, rarely in large stands; often interspersed among conifers including Douglas-fir, lodgepole pine, western hemlock, and ponderosa pine; also occurs with a wide variety of hardwoods including Oregon white oak, California black oak, tanoak, red alder, and bigleaf maple; occurs in southwestern Oregon with Douglas-fir and tanoak; often found in stands characterized by diverse structure and composition
Habitat	**Sites**	Found on a variety of terrain, from level to steeply sloping; found in canyons and on bluffs; most often found on south- and west-facing aspects
	Soils	Typically found on soils with poor to very poor nutrient availability; soils are typically dry in summer and often rapidly draining
	Moisture	Highly drought-tolerant; frequently occurs on sites with growing-season drought; intolerant of flooding
	Temperature	Very intolerant of frost; high tolerance of hot, exposed sites; in the Pacific Northwest, Pacific madrone occurs where winter temperatures are mild and diurnal temperature fluctuation is limited
	Shade tolerance	Low to intermediate tolerance of shade; shade-tolerant as a seedling; shade-intolerant at maturity
Interspecific interactions	**Animal damage**	Minor damage from deer browsing
	Mycorrhizal fungi	Wide-spreading root system is mycorrhizal

Reproduction and Growth

Mode of reproduction		Sexual and vegetative reproduction; monoecious; sprouts prolifically from dormant buds near the root collar
Reproductive phenology		Flowers in May and June; fruits mature in October
Pollination		Pollinated by bees and possibly hummingbirds
Seed	**Seed type**	Red five-celled berry 0.3 to 0.5 in (8 to 12 mm) in diameter; an average of 20 seeds per berry
	Seed-bearing age	Berries may be produced as early as age 3 to 5
	Seed size/ weight	Fresh berries average 630 to 1,130 per lb (1,390 to 2,490 per kg); seed averages 258,000 per lb (568,800 per kg); seed ranges from 197,000 to 320,000 per lb (434,300 to 705,500 per kg)

	Seed longevity/ survivability	Long-term seed dormancy and viability in the soil, possibly decades; dormancy broken by cool temperatures and moisture
	Seed crop and frequency	Abundant fruit in most years; for individual trees, crop is correlated with size of living crown
Seed dissemination	**Time of year**	Fruits mature in October
	Method and dispersal agents	Seeds dispersed by birds, deer, rodents, and gravity
	Distance	Potential for long dispersal distances; specific data not available
Germination requirements		Strong embryo dormancy; requires cold stratification for germination; epigeal; germination rates are fair to high, although mortality occurs rapidly without moisture of mineral soil
Seedling survival		Seedling mortality is high, particularly in the first year; mortality is caused by drought, fungi, litterfall, and invertebrates; survival is best in partial shade on bare mineral soil; seedlings are generally not abundant; early height growth is slow
Vegetative phenology		Leaf bud swell begins in late March; second-year leaves fall in June or July; bark exfoliates from June through September

Genetics

Mating system	High outcrossing rate
Outcrossing % (t_m)	0.97
Genetic diversity	Average genetic diversity based on AFLP
Heterozygosity (H_e)	0.094
Geographic differentiation	Moderate population differentiation
F_{st} or G_{st}	0.15

Threats and Management Considerations

Insects and disease	Fall webworm can cause significant defoliation; moderate risk of fungal damage; major causes of dieback and death are madrone cankers caused by *Neofusicoccum arbuti* and *Fusicoccum aesculi* and Phytophthora root rot caused by *P. cinnamomi and P. cactorum*; a variety of fungi cause significant damage to madrone leaves on moist sites, the sudden oak death pathogen (*Phytophthora ramorum*) has been reported on Pacific madrone in California but not in Oregon or Washington.
Harvest	Not a major commercial species; used for firewood or specialty products
Fragmentation	Relatively widespread within its range
Fire	Seedlings, sprouts, and mature trees are very susceptible to fire; top-killed trees sprout from the root collar or burl; fire favors establishment of Pacific madrone seedlings
Other damaging agents	Invasive species such as Scotch broom (*Cytisus scoparius*) impede regeneration; windfirm
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant

References

Arno and Hammerly 2007, Beland et al. 2005, Harrington and Kraft 2004, Klinka et al. 2000, McDonald and Tappeiner 1990, Reeves 2007, USDA NRCS 2010

Water birch (*Betula occidentalis*)

Ecology

Taxonomy and nomenclature		Hybridizes freely with paper birch, producing many intermediate forms
Description		A small, deciduous, broadleaf tree or shrub, growing from 15 to 45 ft (5 to 14 m) in height; often multi-stemmed, forming thickets; branches upswept; bark is thin, almost black when young and dark brownish when older; bark has horizontal lenticles, but does not peel like the bark of paper birch
Distribution		From the Yukon Territory east to Manitoba and south to northern Arizona and New Mexico; scattered populations occur throughout the western United States; occurs east of the Cascade crest in the Pacific Northwest
Successional stage		A pioneer in streamside habitat, where it often persists without succeeding to other species
Associated forest cover		Occurs with other riparian tree species, including black cottonwood, peachleaf willow, aspen, and alder (*Alnus* spp.)
Habitat	**Sites**	Found almost exclusively along water courses, including streams and springs; grows along mountains streams in conifer forests and along streams that extend into deserts; occasionally found on uplands; occurs at low to mid-elevations
	Soils	Soils vary widely in texture but are typically thin and formed over river cobbles; requires soils rich in nutrients including magnesium and calcium;
	Moisture	Very flood tolerant; low drought tolerance; occurs in very dry climates along streams where water supply is continuous
	Temperature	Very frost tolerant
	Shade tolerance	Shade tolerant
Interspecific interactions	**Animal damage**	Not a preferred browse species; catkins, buds, and seeds are consumed by many bird species
	Mycorrhizal fungi	Undocumented; other species of birch (*Betula*) are mycorrhizal

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; monoecious; vegetative reproduction is through basal sprouting
Reproductive phenology		Male flowers form in summer and shed pollen the following spring; female catkins appears with the leaves and, after fertilization, become conelike as they mature by late summer or fall; mature female catkins disintegrate during late fall and winter
Pollination		Wind-pollinated
Seed	**Seed type**	Seeds are winged nutlets borne in catkins
	Seed-bearing age	Undocumented; other birch species begin bearing seed from 8 to 40 years of age
	Seed size/ weight	Averages 402,000 seeds per lb (885,500 seeds per kg)
	Seed longevity/ survivability	Undocumented; seeds of other birch species have been stored up to 15 years under controlled conditions
	Seed crop and frequency	Large seed crops occur every 1 to 3 years

Seed dissemination	**Time of year**	Seed is dispersed in fall
	Method and dispersal agents	Seed is dispersed by wind and water; birds consume seed and thus may be an additional dispersal vector
	Distance	Undocumented
Germination requirements		Germination occurs in fall soon after seed dispersal or in the following spring; light apparently increases germination
Seedling survival		Delicate seedlings survive only under a narrow range of moisture, light, and seedbed conditions; seedling survival in the first year is apparently increased by shading in summer

Genetics

Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.187
Geographic differentiation	Weak population differentiation based on molecular markers
F_{st} or G_{st}	0.077

Threats and Management Considerations

Insects and disease	Undocumented
Fragmentation	Washington and Oregon populations are apparently fragmented
Harvest	Not a commercial timber species
Fire	Easily killed by fire, but fire is infrequent in its streamside habitat; trees sprout from basal buds after top-kill
NatureServe conservation status ranking	G4/G5: G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors/ G5 Secure—Common; widespread and abundant
Silvicultural considerations	Can be planted to reduce stream bank erosion

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Uchytil 1989d, USDA NRCS 2010, Wang and Qiu 2006

Paper birch (*Betula papyrifera* var. *papyrifera*)

Ecology

Taxonomy and nomenclature		Of the three varieties of *Betula papyrifera*; *Betula papyrifera* var. *papyrifera* is the only variety in the western portion of the contiguous 48 states; west of the continental divide, this variety is sometimes known as *Betula papyrifera* var. *commutata*
Description		A medium-sized, deciduous, broadleaf tree reaching 80 ft (24 m) in height; short-lived; ascending branches form an open crown; single or multiple slender stems with distinctive white, papery bark
Distribution		Occurs throughout the northern half of the United States, including Alaska, and across Canada; occurs in Washington sporadically from the Puget Sound region northward, from low elevations near Puget Sound to the North Cascade Range
Successional stage		An aggressive pioneer species that rapidly colonizes disturbed areas and openings; replaced by shade-tolerant species after one generation
Associated forest cover		Following disturbance, paper birch may dominate or be present as a component of a mixed-species stand; in Washington, it is most often associated with red alder, bigleaf maple, Douglas-fir, grand fir, and cascara; sometimes occurs with western hemlock and western redcedar
Habitat	**Sites**	Found on both upland and alluvial sites; occurs on mountain slopes, rock slides, open woodlands, pastures, river valleys, as well as edges of swamps and other wetlands
	Soils	Found on a wide range of soil types, from nutrient-poor to nutrient-rich; occurs on coarse- to fine-textured soils, as well as bog and peat soils
	Moisture	Tolerates flooding and a strongly fluctuating water table; only moderately tolerant of drought; responds to drought by shedding leaves
	Temperature	Tolerant of growing-season frost; moderately tolerant of high air temperatures
	Shade tolerance	Intolerant of shade
Interspecific interactions	**Animal damage**	A preferred browse species of deer; stems damaged by hares, porcupines, squirrels, and birds; birds and small mammals eat buds and seeds
	Mycorrhizal fungi	Associated with ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual (monoecious) and vegetative; sprouts vigorously from stumps or root collar following harvest or top-kill by fire
Reproductive phenology		Male catkins are partially formed in fall and are dormant during winter; male catkins expand prior to flowering, which begins in April; female catkins appear before leaves are fully expanded in spring; fruit ripens from early August until mid-September
Pollination		Wind-pollinated
Seed	**Seed type**	Fruits are small, double-winged nutlets, 0.06 in (1.5 mm) long by 0.03 in (0.8 mm) wide
	Seed-bearing age	Seed production begins around age 15 years; optimum production occurs from ages 40 to 70 years

	Seed size/ weight	Averages 1,380,000 cleaned seeds per lb (3,042,000 per kg)
	Seed longevity/ survivability	A small percentage of seed may remain viable in the forest floor for several years, particularly if seeds fall during a very dry year; dormant seed in the forest floor may be important in years of poor seed crops; seed has been stored for up to 15 years at 18 °F (-8 °C), although colder storage temperatures may improve viability
	Seed crop and frequency	A prolific seed producer; good seed crops occur every other year on average; some seed produced every year; good seed years vary by location; the following year's seed crop can be predicted by observing male catkins in fall; seed crop estimates range from 1 to 294 million seeds per ac (2.5 to 728 million seeds per ha) in light and heavy years, respectively, although seed crops vary substantially by stand density and location
Seed dissemination	**Time of year**	Seeds ripen from early August until mid-September; dispersal begins soon after ripening; most seed is dispersed by the end of November
	Method and dispersal agents	Seed is primarily disseminated by wind, occasionally by water
	Distance	Majority of seed falls 100 to 200 ft (30 to 61 m) from parent tree; seedfall 330 ft (100 m) from a stand edge is 10 percent of that within the stand
Germination requirements		Seed viability varies greatly by locality, parent tree, and year; seed viability highest during heavy crop years; germination best on disturbed mineral soil or on mineral-organic mixtures; stratification not necessary; small germinants sensitive to soil moisture and temperature; germination might be highest in shade where soil is moist and cool; higher seed viability and germinant survival in good seed years than in poor years; germination epigeal
Seedling survival		Dry soils and competing vegetation lead to early mortality; early growth best on humus seedbeds in partial or full sunlight; browse damage may significantly reduce the quantity and vigor of regeneration
Vegetative phenology		Vegetative bud activity may begin in spring when nighttime temperatures are still below freezing; shoot elongation begins after pollination, which occurs in April; stem expansion is correlated with air temperature in spring

Genetics

Patterns of variation	Populations differ significantly for germination, cold hardiness, and biomass allocation but not for gas exchange; population differences in germination and cold hardiness were related to winter temperature
Genetic analysis research results	Interior British Columbia population was the most frost hardy and seed transfer from warmer to colder environments might result in frost damage

Threats and Management Considerations

Insects and disease	Insects and fungal pathogens are not a major concern in the Pacific Northwest; bronze birch borer *(Agrilus anxius)* is the most serious insect pest, attacking older and weakened trees; a number of defoliators attack paper birch but seldom damage healthy trees
Fire	Fire usually kills or top-kills paper birch trees owing to their thin, flammable bark; fire kills seeds on the ground and immature seeds in catkins; quickly establishes after fire through sprouting and lightweight, abundant seed
Other damaging agents	Sensitive to air pollution

NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	A commercial species in boreal regions, either in pure stands or mixed with conifers; requires full sunlight for successful regeneration

References

Arno and Hammerly 2007; Benowicz et al. 2000, 2001a; Bonner and Karrfalt 2008; Klinka et al. 2000; Safford et al. 1990; Uchytil 1991b; USDA NRCS 2010; WDNR 2010

Incense-cedar (*Calocedrus decurrens*)

Ecology

Description		A medium-sized, evergreen conifer, reaching a height of more than 100 ft (30 m); a stout, tapered stem; forms a dense, uniform, pyramid-shaped crown when young, becoming more open at maturity; flat, scale-leaved sprays of foliage arranged vertically on branches; thick, orange-brown, fibrous, furrowed bark, becoming very thick with age
Distribution		Occurs occasionally on the southern slope of Mt. Hood and southward on the western slope of the Cascade Range; occasionally found in central Oregon; prevalent in southwestern Oregon and northern California; occurs east to western Nevada and south to Mexico; occurs at elevations from 150 to 6,600 ft (50 to 2,010 m) in the northern part of its range
Successional stage		Pioneer or mid- to late-successional species, depending on site; a pioneer species on high ridges and in meadow communities of central and southern Oregon; its shade-tolerance allows incense-cedar to persist in understory or midstory positions for many years until it is released when an opening is created in the canopy
Associated forest cover		Typically occurs as a minor component of mixed-conifer forests and woodlands where it is often in a subdominant canopy position; occurs with a wide variety of species including Douglas-fir, western hemlock, grand fir, ponderosa pine, white fir, sugar pine, western white pine, Jeffrey pine, oaks (*Quercus* spp.); incense-cedar is a stronger competitor and more likely to achieve a dominant crown position on harsh, dry sites than on cooler, moister sites
Habitat	**Sites**	Grows on a wide range of sites, from cool, moist areas to hot, dry, rocky slopes; found in canyons and ravines, on alluvial plains, and on a variety of xeric sites; common in foothills and mid-elevation forests within its range
	Soils	Occurs on soils formed from a wide variety of parent materials, including alluvium and soils derived from granitic rock, sandstone, and pumice; occurs on very infertile serpentine soils; soils are neutral to strongly acidic and range in texture from coarse sand to very fine clay
	Moisture	Very drought tolerant; dry summers are typical within its range; drought tolerance attributed, in part, to an extensive, well-developed root system; intolerant of flooding
	Temperature	Tolerant of heat; somewhat resistant to frost injury
	Shade tolerance	Shade-tolerant; may establish and persist in shade for many years; less shade-tolerant than grand fir; more shade-tolerant than Douglas-fir and associated pines
Interspecific interactions	**Animal damage**	Some browse damage by deer; rated medium to low in browse value
	Mycorrhizal fungi	Associated with arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction	Reproduces sexually; monoecious
Reproductive phenology	Flowering and pollination occur in late winter or early spring; female cones develop in one year, maturing in late summer or early fall
Pollination	Wind-pollinated

Seed	**Seed type**	Pendant female cones 0.8 to 1.5 in (20 to 40 mm) long at maturity, composed of opposing leathery scales, contain four or fewer large-winged seeds
	Seed size/ weight	Seeds 0.3 to 0.5 in (8 to 12 mm) long; 15,000 to 16,000 seeds per lb (33,100 to 35,300 seeds per kg)
	Seed longevity/ survivability	High viability is maintained in storage at 0 °F (-18 °C) for periods of at least 10 years; maximum storage duration is unknown
	Seed crop and frequency	Considered a prolific seed producer; abundant seed crops occur every 3 to 6 years; in some years no seed is produced; significant variability in seed crops among years, trees, and geographic locations; crops as great as 400,000 seeds per ac (988,000 seeds per ha) have been measured
Seed dissemination	**Time of year**	Seed dispersal begins in late August at low elevation sites and in October at higher elevations; seedfall may extend into winter; seed viability unrelated to time of seedfall
	Method and dispersal agents	Wind-dispersed
	Distance	Large-winged seeds are believed to be dispersed great distances by wind, although a study in California found that all seeds fell less than 200 ft (60 m) from the parent tree (McDonald 1980)
Germination requirements		Field germination rates are 20 to 40 percent; germination epigeal; germination best on bare mineral soil or light litter, although seedlings may establish on heavy litter and in heavy brush; germination improved by cold stratification
Seedling survival		Seedlings survive under a wide range of conditions; survival greatest under partial shade; seedlings may grow very slowly under shaded or dry conditions
Vegetative phenology		Shoot elongation does not exhibit a spring growth flush; internodes near the shoot tip continuously elongate at a variable rate except during winter months; does not form overwintering buds; in California, radial growth begins in early to mid-April

Genetics

Outcrossing % (t_m)	Unknown
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.18
Geographic differentiation	Weak population differentiation based on molecular markers
F_{st} or G_{st}	0.041
Patterns of variation	Genetic variation in growth traits is modest compared with other conifers; little genetic variation was found in the patterns of shoot elongation in seedlings
Genetic analysis research results	This species has a large degree of phenotypic plasticity that is largely under environmental control, although there is some genetic variation present

Threats and Management Considerations

Insects and disease	Although many different insects are found on trees and seedlings, serious damage is rare; incense-cedar mistletoe (*Phoradendron juniperinum* ssp. *libocedri*) occurs throughout its range; of the many fungal organisms affecting incense-cedar, pecky rot/pocket dry rot (caused by *Oligoprus amarus*) and incense-cedar rust (caused by *Gymnosporangiumlibocedri*) are most common.
Harvest	An important commercial species; wood is valued for its durability and decay resistance

Fragmentation	Distribution is relatively sparse near the northernmost extent of its range in Oregon
Fire	Young trees are usually killed by fire owing to flammable foliage, low branches, and thin bark; older trees have thick bark and may survive fire, depending on fire intensity; intense fires leave scars in older trees that are susceptible to fungal infection
NatureServe conservation status ranking	G5 **Secure**—Common; widespread and abundant
Silvicultural considerations	Responds well to release, although height growth is slower than that of associates; trees younger than 150 to 200 years of age have reduced susceptibility to pocket dry rot

References

Arno and Hammerly 2007; Bonner and Karrfalt 2008; Harry 1984, 1987; McDonald 1980; NatureServe 2010; Powers and Oliver 2010; Rogers et al. 1994; Tollefson 2008a; USDA NRCS 2010; Wang and Qiu 2006

Netleaf hackberry (*Celtis laevigata* var. *reticulata*)

Ecology

Taxonomy and nomenclature		Netleaf hackberry is also known as *C. douglasii*, *C. occidentalis* var. *reticulata*, *C. reticulata*, and *C. laevigata* var. *reticulata*; a highly variable, taxonomically confusing species
Description		A small, deciduous broadleaf tree, sometimes a large shrub, reaching a height of 20 ft (6 m) but occasionally growing to 50 ft (15 m); usually slow-growing; forms a spreading, often scraggly crown; a short, crooked trunk; bark is smooth and gray with corky ridges and warty projections
Distribution		Occurs in scattered locations in the interior Pacific Northwest, central Washington populations represent the northernmost extent of the species' range; disjunct populations occur throughout the western United States, from southern California eastward to southern Nebraska and Kansas and northward to southern Idaho; larger, contiguous distributions occur from Arizona eastward to Oklahoma and Texas and southward into Mexico
Successional stage		In the Pacific Northwest, netleaf hackberry usually occurs where no other trees exist; a pioneer on disturbed and harsh sites, as well as a climax species
Associated forest cover		Occurs alone or with white alder, water birch, or black cottonwood
Habitat	**Sites**	Tolerates a wide variety of sites; often found on rocky slopes and bluffs above rivers; also grows in bottomlands, washes, ravines, and rocky canyons, and along streams and rivers
	Soils	Occurs on well-drained soils of medium to coarse texture, including gravelly and rocky soils and shallow soils on rock outcrops; soils are often derived from limestone; best growth is on well-drained alluvial soils
	Moisture	Tolerates some periodic flooding, although its distribution may be limited by its degree of flood tolerance; tolerant of severe drought that limits the occurrence of most other tree species; occurs where annual precipitation averages as little as 7 in (18 cm)
	Temperature	Tolerant of very high temperatures; more heat-tolerant than its associates
	Shade tolerance	Intolerant of shade
Interspecific interactions	**Animal damage**	Browsed by mule deer and bighorn sheep; a preferred food of beavers
	Mycorrhizal fungi	Unknown

Reproduction and Growth

Mode of reproduction		Reproduces sexually and vegetatively; monoecious; vegetative reproduction occurs when the stumps, root crowns, or roots sprout
Reproductive phenology		Flowers in March or April, soon after initial leaf expansion; fruit matures in late summer or fall; seed dispersed in fall or winter
Pollination		Wind-pollinated
Seed	**Seed type**	A fleshy, pea-sized drupe, containing a single hard, thick-walled seed
	Seed-bearing age	*C. laevigata* (sugarberry) begins to bear seed at approximately 15 years of age
	Seed size/ weight	Averages 4,870 seeds per lb (10,500 per kg)
	Seed longevity/ survivability	Seed remains viable in storage for at least several years; seed longevity in the field is unknown

	Seed crop and frequency	Produces an abundance of seed nearly every year
Seed dissemination	**Time of year**	Fruit reaches maturity in September or November, and seed is dispersed through midwinter
	Method and dispersal agents	Seed is dispersed by birds, rodents, and other small mammals
	Distance	Unknown; seed may be carried long distances by birds
Germination requirements		Cold stratification significantly increases germination; germinates in late winter or spring under natural conditions; germination epigeal
Seedling survival		Although seedling survival is usually greater on moist soils, seedlings may be destroyed by flooding if they establish in flood-prone areas
Vegetative phenology		Leaves begin to expand between early April and late May; leaves mature in June

Threats and Management Considerations

Insects and disease	Susceptible to witch's broom as well as to various insects
Harvest	Not a commercial species
Fragmentation	Numerous disjunct populations occur throughout the western United States, including in Oregon and Washington
Fire	Although the aboveground portion of the tree is often killed by fire, the root crown usually sprouts; these sprouts grow relatively rapidly
NatureServe conservation status ranking	G5T5 Secure—Common; widespread and abundant
Silvicultural considerations	Can be propagated vegetatively or from seed; has been successfully transplanted to disturbed sites to stabilize soils; used for food and cover by a variety of wildlife species

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Krajicek and Williams 1990a, Tirmenstein 1990a

Port-Orford-cedar (*Chamaecyparis lawsoniana*)

Ecology

Description		A large, long-lived, evergreen conifer, reaching 200 ft (60 m) in height; young trees have a symmetrical, conical crown extending to the ground; trees self-prune with age; old trees have irregular crowns and top dieback; foliage is fine and lacy compared with similar species; bark is thick, deeply furrowed, silver-brown and fibrous
Distribution		Occurs in a small area in southwestern Oregon and northwestern California; northernmost extent is near Coos Bay, Oregon; most abundant within 40 mi (65 km) of the coast; distribution becomes scattered inland; occurs from sea level to 5,100 ft (1,550 m) in elevation (6,400 ft (1950 m) for the disjunct population near Mt. Shasta)
Successional stage		Both a pioneer species and a shade-tolerant climax species
Associated forest cover		Typically found in mixed-species stands in a wide range of vegetation types; occurs with numerous associates including Douglas-fir, grand fir, lodgepole pine, western redcedar, Pacific yew, sugar pine, western white pine, incense-cedar, tanoak, Pacific madrone, golden chinquapin, red alder, and canyon live oak
Habitat	**Sites**	Occurs on a variety of sites where sufficient moisture is present, including mid- and lower-slopes, benches, and drainages; usually on concave landforms; in drier inland areas Port-Orford-cedar is restricted to drainages and streamside locations; most prevalent on northern aspects
	Soils	Grows on many soil types and parent materials; found on sand dunes and in bogs; most dominant on wet soils; best sites are deep soils formed in sedimentary parent material; competes well on soils formed at least partially in ultramafic rock
	Moisture	Limited to mesic sites; low drought tolerance; infrequent at upper-slope positions; occurs inland only in riparian areas and seepages
	Temperature	Specific temperature requirements are met by the mild climate produced by maritime influences; susceptible to cold injury when planted outside of its natural range, although conflicting information exists on cold damage in the field
	Shade tolerance	Tolerant of shade and competition; usually more shade tolerant than its associates; responds to release from overtopping competitors, even when old
Interspecific interactions	**Animal damage**	Not an important food source for animals; browse damage is variable
	Mycorrhizal fungi	Associated with arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction	Primarily reproduces sexually; occasionally reproduces vegetatively by layering or forming stems from former branches; monoecious
Reproductive phenology	Cones are initiated in late spring or summer and develop throughout the summer; flowering occurs around mid-March of the second year; fertilization occurs at least one month later; seed matures from September to October of the second year and is dispersed from September until May of the third year
Pollination	Wind-pollinated

Seed	**Seed type**	Mature cones are spherical, 0.25 to 0.5 in (6 to 12 cm) in diameter, and contain 1 to 5 seeds with small, thin wings on both sides
	Seed-bearing age	Seed production begins when trees are as young as 5 to 9 years of age; cone production peaks around age 100 and continues throughout the tree's life
	Seed size/ weight	Seeds are approximately 0.11 to 0.16 in (3 to 4 mm) long; seeds are variable in weight and size; averages 210,000 seeds per lb (463,000 seeds per kg); ranges from 80,000 to 600,000 seeds per lb (176,000 to 1,323,000 seeds per kg)
	Seed longevity/ survivability	Under natural conditions, most seed germinates in the spring after dispersal, although a small number of seeds may remain dormant as long as 5 years; seed stored at 5 °F (-15 °C) maintained capacity for germination after 11 years
	Seed crop and frequency	Seed produced every year; heavy crops produced every 4 or 5 years; crops measured at 8,100 to 1,862,000 seeds per acre (20,000 to 4,600,000 seeds per hectare); no apparent synchrony in seed crops among regions; seed production not related to stand or site factors
Seed dissemination	**Time of year**	Seedfall peaks in late fall, although there is a smaller peak in spring; approximately 50 to 60 percent of seed falls by mid-January; 85 to 90 percent of seed falls by the beginning of May; a small amount of seed falls throughout the year
	Method and dispersal agents	Gravity and water; seeds may float and be dispersed by water in streamside habitats
	Distance	Seeds fall relatively rapidly; dispersal distances are typically small, one to three tree heights at the edge of a clearcut
Germination requirements		Germination occurs primarily from mid to late June; establishment of germinants greatest on a disturbed forest floor; cold stratification not necessary for germination; germination epigeal
Seedling survival		Seedlings are shade-tolerant, establishing in the understory; however, seedlings do not tolerate very dense shade or heavy competition; seedlings may establish in litter; one experiment reported that 5 percent of germinants survived after three years on the best microsites (Hayes 1958)
Vegetative phenology		Does not have preformed buds; growing-season shoot elongation proceeds at a slower rate than that of associated conifers; growing-season length, limited by frost, may influence the northern distribution of Port-Orford-cedar; shoot elongation begins and ends earlier on hot sites than on cooler sites

Genetics

Outcrossing % (t_m)	Unknown
Genetic diversity	Average genetic diversity based on molecular markers
Heterozygosity (H_e)	0.13
Geographic differentiation	Weak population differentiation based on molecular markers
F_{st} or G_{st}	0.05
Patterns of variation	Low levels of variation have been found in traits such as bud phenology and water relations
Genetic analysis research results	Considerable variation among families has been found in testing for resistance to *Phytophthora lateralis*

Threats and Management Considerations

Insects and disease	Highly susceptible to root rot caused by the non-native pathogen *Phytopthora. lateralis*, which was introduced into Coos County, Oregon around 1952
Fragmentation	Particularly on inland sites, Port-Orford-cedar occurs in small scattered populations; a disjunct group of small populations occurs southwest of Mt. Shasta in California
Harvest	Produces valuable, high-quality timber; extensively harvested for domestic use prior to World War II; harvested in recent decades primarily for export to Japan
Fire	Young trees are killed by fire; older trees with thick bark are fire-resistant
NatureServe conservation status ranking	G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors
Silvicultural considerations	Commercial outlook is limited by susceptibility to root rot; reproduces naturally from seed in small clearcuts; growth is generally slower than associated conifers; can be under-planted; may be grown in uneven-aged silvicultural systems; planted as an ornamental outside of its native range

References

Arno and Hammerly 2007; Bonner and Karrfalt 2008; Hayes 1958; Millar and Marshall 1991; Sniezko et al. 2009; Uchytil 1990; Zobel 1983, 1990; Zobel et al. 2001

Golden chinquapin (*Chrysolepis chrysophylla*)

Ecology

Taxonomy and nomenclature		Golden chinquapin is known as giant chinquapin in the USDA Plants Database; there are two varieties of *Chrysolepis chrysophylla*: *Chrysolepis chrysophylla* var. *chrysophylla* is the tree form described here, and *Chrysolepis chrysophylla* var. *minor* is the shrub form; the latter occurs in California and Oregon
Description		A small-to-medium, broadleaf, evergreen tree, occasionally reaching a height of 100 to 120 ft (30 to 35 m); stout, spreading branches; crown is conical where open-grown; narrow, leathery leaves; smooth, dark-gray bark when young, becoming furrowed and forming reddish-brown plates with age
Distribution		From Mason County, Washington, to Monterey County, California; occurs in the Pacific Northwest from the coast to the crest of the Cascade Range and occasionally east of the Cascade crest; several small populations in Mason County and an additional disjunct population in Skamania County are its only known occurrences in Washington; common in western Oregon; occurs from sea level to over 6,000 ft (1830 m) elevation in the Oregon Cascades
Successional stage		Generally an early successional species, although it may persist on sites where conifers do not form a dense overstory; sprouts after top-kill and is thus favored by fire
Associated forest cover		A minor component of a wide variety of forest types throughout its range; often occupies subcanopy in conifer stands; occurs most frequently in open areas and beneath sparse canopies of conifers; pure stands are rare; associates in the Cascades include Douglas-fir, incense-cedar, sugar pine, western hemlock, white fir, ponderosa pine, Pacific madrone, Shasta red fir; additional associates in southwestern Oregon include tanoak, California black oak, knobcone pine, Port-Orford-cedar, and canyon live oak
Habitat	**Sites**	Wide ecological amplitude; most competitive on infertile, droughty sites
	Soils	Occurs on a wide range of soils; growth is best on deep soils; often found on nutrient-poor soils
	Moisture	Very tolerant of droughty sites
	Temperature	Occurs on some of the hottest sites of the western Cascade slopes, as well as near the crest of the Oregon Cascade Range
	Shade tolerance	Intolerant to moderately tolerant of shade; seedlings are shade-tolerant; grows rapidly when released from shade of competition
Interspecific interactions	**Animal damage**	Some browse damage known to occur in California
	Mycorrhizal fungi	Possible mycorrhizal relationship with *Tricholoma magnivelare*

Reproduction and Growth

Mode of reproduction	Sexual and vegetative reproduction; monoecious; sprouts from stumps and basal burls following top-kill
Reproductive phenology	Varies widely across range; flowering occurs from April to June in Pacific Northwest; fruit ripens from August to October; reproductive cycle spans two growing seasons
Pollination	Wind-pollinated; sometimes bee-pollinated

Seed	**Seed type**	Spiny, chestnut-like burs 0.6 to 1 in (15 to 25 mm) in diameter contain one to three hard-shelled nuts
	Seed-bearing age	Stump sprouts may produce seed as early as age 6; trees of seed origin produce seed sometime before age 40
	Seed size/ weight	Averages 960 seeds per lb (2,120 seeds per kg); ranges from 830 to 1,100 seeds per lb (1,800 to 2,400 seeds per kg)
	Seed longevity/ survivability	Seed may be stored for 5 years or longer in a controlled environment
	Seed crop and frequency	Some seed produced every year; relatively heavy production every 2 to 5 years; seed viability may be low; in its shrub form, golden chinquapin flowers infrequently
Seed dissemination	**Time of year**	Seed dispersal peaks around late September and extends into early December
	Method and dispersal agents	Seeds dispersed by gravity, squirrels, and several species of birds; burs may be transported by larger mammals
	Distance	Some long-distance dispersal occurs via animals
Germination requirements		Germination relatively low; 14 to 53 percent viability reported; germination hypogeal, occurring after 16 to 24 days; stratification may not be required; germination observed beneath shallow litter layer in partial shade
Seedling survival		Seedlings often grow in partial shade; relatively cool, moist conditions required; seedling densities are typically low

Threats and Management Considerations

Insects and disease	In southwestern Oregon suffers moderate mortality due to infection by *Phytophthora cambivora*; also affected by *Phellinus ignarius* and Armillaria spp.
Harvest	Not a commercial timber species
Fragmentation	Small, disjunct populations occur in Washington's Mason and Skamania Counties; these represent the northernmost extent of the species' range; scattered occurrences in eastern Oregon
Fire	Well-adapted to frequent fire; sprouts vigorously after light or intense fire; aboveground portion highly susceptible to top-kill after fire; where fire is frequent and conditions are dry, sprouting is the primary form of regeneration
Other damaging agents	Windstorms damage trees, particularly those with heart-rot
NatureServe conservation status ranking and other listings	G5 Secure—Common; widespread and abundant S2 Imperiled (Washington)—Imperiled in the jurisdiction because of rarity due to very restricted range, very few populations, steep declines, or other factors making it very vulnerable to extirpation from jurisdiction; only two small disjunct populations of golden chinquapin occur in western Washington Golden chinquapin is designated a sensitive species under the USDA Region 6 Interagency Special Status/Sensitive Species Program (ISSSSP)
Silvicultural considerations	Historically most silvicultural efforts have been directed at suppressing golden chinquapin in conifer stands
Importance to wildlife	Only known host of Herr's hairstreak butterfly (*Habrodais grunus herri*), which has NatureServe conservation status ranking G4/G5/T2/T3, N2/N3, S1

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, McKee 1990, McMurray 1989, Ruchty 2008, Shoal 2009, USDA NRCS 2010

Pacific dogwood (*Cornus nuttallii*)

Ecology

Description		A small-to-medium, deciduous, broadleaf tree reaching a height of 30 to 50 ft (9 to 15 m); many spreading, horizontal branches; thin, light-gray bark
Distribution		Coastal regions from southern British Columbia to southern California; occurs in the Pacific Northwest from the coast to the Cascade Range; disjunct population in northern Idaho; occurs below 5,000 ft (1,520 m) elevation
Successional stage		Found in early to late seral stages; does not follow a distinct successional pattern; appears within 3 years of disturbance; often present in hardwood and second-growth conifer stands in British Columbia
Associated forest cover		Typically a subcanopy species in forests dominated by Douglas-fir, western hemlock, Pacific silver fir, grand fir, western redcedar, and bigleaf maple
Habitat	**Sites**	Often most prevalent in riparian areas and on gentle slopes in low-elevation conifer, hardwood, and mixed forests
	Soils	Moist, well-drained soils; tolerant of acidic, nutrient-poor soils; soil texture ranges from clay to sandy loam
	Moisture	Considered a mesic species but also very drought tolerant; high flood tolerance
	Temperature	Low frost tolerance; moderate heat tolerance; often occurs on exposed slopes
	Shade tolerance	Moderate shade tolerance; often present under partial canopies; maximum photosynthetic potential is reached in 33 percent of full sunlight
Interspecific interactions	**Animal damage**	Browse damage is greatest on sprouts and seedlings established after disturbance
	Mycorrhizal fungi	Other species of the genus *Cornus* are mycorrhizal

Reproduction and Growth

Mode of reproduction		Reproduces sexually and vegetatively; monoecious; readily sprouts after disturbance
Reproductive phenology		May flower twice per growing season; first flowering occurs from April to June; second flowering in late summer or fall may not produce fruit; fruit from first flowering ripens in September or October
Pollination		Primarily insect-pollinated
Seed	**Seed type**	Tight cluster of 20 to 40 slightly flattened red drupe
	Seed-bearing age	Minimum seed-bearing age is 10 to 15 years
	Seed size/ weight	Averages 4,700 seeds per lb (10,360 seeds per kg); drupes are approximately 0.4 to 0.6 in (10 to 15 mm) long
	Seed longevity/ survivability	Based on minimal evidence, seed may be part of the soil seed bank; seed of *Cornus florida* has been stored successfully for 7 years at 19 °F (-7 °C)
	Seed crop and frequency	Reports are inconsistent; heavy seed crops may occur every 1 or 2 years
Seed dissemination	**Time of year**	Fruit ripens in September or October

	Method and dispersal agents	Not formally studied, although seed probably dispersed by birds and small mammals
	Distance	Unknown
Germination requirements		Germination is relatively high; exposed mineral soil benefits germination
Seedling survival		Reports conflict; some indicate greater reproduction in shade and some indicate greater reproduction in sunlight

Genetics

Genetic diversity	Low genetic diversity based on microsatellites
Heterozygosity (H_e)	0.468
Geographic differentiation	Very high population differentiation based on microsatellites
F_{st} or G_{st}	0.9
Patterns of variation	Moderate geographic variation among populations was found in seedling growth and phenology with a weak relationship to temperature variables
Genetic analysis research results	Evidence of moderate local adaptation is present in quantitative traits, although the degree is less than most temperate or boreal tree species

Threats and Management Considerations

Insects and disease	Dogwood anthracnose, caused by the non-native fungus *Discula destructiva*, is the primary pathogen in the Pacific Northwest; spreads rapidly; causes leaf spot, trunk cankers, branch dieback, and sometimes death; fungal activity is greatest when conditions are moist during the growing season
Harvest	Not a commercial timber species
Fragmentation	Widespread in western Washington and Oregon
Fire	Sprouts from the root crown after fire
NatureServe Conservation Status Ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Frequently planted as an ornamental

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Gucker 2005, Kier and Aitken [n.d.], Keir et al. 2011, Klinka et al. 2000, USDA NRCS 2010

Black hawthorn and Suksdorf's hawthorn (*Crataegus douglasii* and *C. suksdorfii*)

Ecology

Taxonomy and nomenclature		Black hawthorn in Washington was formerly known as a single species (*Crataegus douglasii*) with two varieties: var. *suksdorfii* and var. *douglasii*; these varieties are now accepted as separate species, although inventories and some earlier publications treated these as a single species, called black hawthorn; here we refer to both species where information is available at that level
Description		A deciduous, broadleaf shrub or small tree reaching 20 ft (6 m) in height; often found in thickets; stems crooked; broad, brambly crowns of thorny branches
Distribution		*Crataegus douglasii* occurs in the coastal Pacific Northwest from southeastern Alaska to northern California; inland distribution occurs from Alberta and Saskatchewan south to Utah and Colorado; occurs both west and east of the Cascade Range in Washington; disjunct populations occur as far east as Minnesota, Michigan and Ontario, Canada; *Crataegus suksdorfii* occurs mainly in coastal regions from Alaska to northern California; in Washington it is primarily west of the Cascade crest
Successional stage		Occasionally an early seral species, but typically found in established forest stands
Associated forest cover		Occur in a wide variety of forest types owing to their broad distribution; most often occur as understory species; occasionally found in pure stands
Habitat	**Sites**	Both species occur on a range of sites including open woodlands, riparian areas, and steep slopes; found in moist areas but also on relatively dry southern aspects; occurs at low- to mid-elevations
	Soils	Most often found on deep, moist soils
	Moisture	Achieve best growth on moist sites; found in wetlands and on drier upland sites
	Temperature	Unknown, although the range suggests a degree of cold tolerance
	Shade tolerance	Intermediate shade tolerance; best growth in full sunlight; typically occurs in understory
Interspecific interactions	**Animal damage**	Leaves and twigs are browsed by deer
	Mycorrhizal fungi	Genus *Crataegus* is mycorrhizal

Reproduction and Growth

Mode of reproduction		Sexual and vegetative; both *C. douglasii* and *C. suksdorfii* exhibit polyploidy and are known to reproduce by apomixis; monoecious; sprouts from stumps and roots
Reproductive phenology		Flower around May in Washington; fruits ripen around August
Pollination		Insect-pollinated
Seed	**Seed type**	Cluster of black, fleshy pomes, approximately 0.4 in (11 cm) in diameter; as many as five seeds per fruit

	Seed-bearing age	Unknown
	Seed size/ weight	22,600 cleaned seeds per lb (49,800 seeds per kg)
	Seed longevity/ survivability	Unknown
	Seed crop and frequency	Produce many viable seeds; one British Columbia study found that trees averaged 550 fruits
Seed dissemination	**Time of year**	Beginning around August when fruits ripen and continuing into winter
	Method and dispersal agents	Fruits are an important food source for wildlife; fruits are consumed by deer, small mammals, and birds during fall and winter
	Distance	Unknown
Germination requirements		Cold stratification and acid scarification have been successfully used to break dormancy
Seedling survival		Little information available on natural regeneration; artificial regeneration difficult; seedling growth slow; seedlings develop long taproots

Genetics

Heterozygosity (H_e)	0.73 using chloroplast microsatellites
Geographic differentiation	Strong population differentiation
F_{st} or G_{st}	0.22 using nuclear microsatellites

Threats and Management Considerations

Insects and disease	Insects and diseases are not a major problem, reported diseases include fireblight, cedar-hawthorn rust, cedar-quince rust, leaf blight, fruit rot, and leaf spot
Harvest	Not a commercial species
Fragmentation	Widespread in western Washington
Fire	Top-killed by low- or high-severity fire; sprouts from root crown and roots following top-kill
NatureServe conservation status ranking	G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors

References

Arno and Hammerly 2007, Habeck 1991a, Jacobs et al. 2009, Lo et al. 2009, USDA NRCS 2010

Baker cypress (*Cupressus bakeri*)

Ecology

Taxonomy and nomenclature		Also known as Baker cypress
Description		A small or medium, slow-growing evergreen conifer, usually reaching 30 to 90 ft (10 to 27 m) in height; a narrow, pyramidal crown that is sparse on poor sites; foliage is in sparse sprays and ranges from gray-green to blue-green; bark is red and peeling when young, becoming gray and blocky with age
Distribution		Occurs in small, dispersed populations scattered through northern California and southwestern Oregon; occurs from approximately 3,800 to 7,000 ft (1,150 to 2,130 m) elevation
Successional stage		A pioneer species with serotinous cones that is adapted to, and dependent on, reproducing after fire
Associated forest cover		Occurs in an open, scrubby forest that is maintained by fire; rarely occurs in pure stands; occurs with sugar pine, knobcone pine, lodgepole pine, ponderosa pine, incense-cedar, red fir, white fir, Douglas-fir, California black oak, and Oregon white oak; also associated with chaparral
Habitat	**Sites**	Limited to scattered sites within its elevational range; often occurs on northern or northeastern aspects and on poor soils where competition from other tree species is limited
	Soils	Found on well-drained soils formed in a wide range of parent materials, including serpentine soils; tolerates shallow and rocky soils; occurs on basic volcanic rock
	Moisture	Tolerant of dry soils; requires well-drained soils
	Temperature	Tolerant of heat, but specific tolerances of extreme temperatures are unknown
	Shade tolerance	Intolerant of shade
Interspecific interactions	**Animal damage**	Susceptible to browse; rodents consume seeds of associated species
	Mycorrhizal fungi	Unknown

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		Completes reproductive cycle over two years; cones of *Cupressus* mature 15 to 18 months after pollination
Pollination		Wind-pollinated
Seed	**Seed type**	Cones are globose to oblong, 0.4 to 1 in (10 to 25 mm) long, with 6 or 8 scales; cones occur in clusters; cones average 50 to 85 seeds apiece; cones are closed at maturity and persist on trees until opened by hear or eventual desiccation
	Seed-bearing age	Cones produced by trees as young as 14 years of age
	Seed size/ weight	Averages 163,600 seeds per lb (359,900 per kg)
	Seed longevity/ survivability	Cones remain on the tree for years until they are exposed to extreme heat, after which they open over a period of a few months

	Seed crop and frequency	Cone production is abundant
Seed dissemination	**Time of year**	Dependent on the occurrence of fire; seed falls for a period of several months after cones are exposed to heat
	Method and dispersal agents	After cones open following exposure to extreme heat, seeds are dispersed by wind and runoff from rainfall
	Distance	Unknown
Germination requirements		Fire occurring in late summer or fall result in seedfall during moist winter conditions; germination requires bare mineral soil
Seedling survival		Seedlings exposed to abundant litter may be vulnerable to damping-off; seedlings are sensitive to excessive moisture; seedlings require full sunlight
Vegetative phenology		Unknown

Genetics

Genetic analysis research results	The species is morphometrically variable with more of the total species variation among populations than within populations (although it is not uncommon for morphological traits to have higher inter-population variation than genetic traits such as isozymes); similarities among populations on serpentine soils may indicate a serpentine race

Threats and Management Considerations

Insects and disease	Leaf damage caused by *Phytophthora ramorum*, the cause of sudden oak death, occurs in locations with high inoculum pressure in coastal southwestern Oregon; otherwise, little information available
Harvest	Not an important commercial species
Fragmentation	Populations are scattered; some populations are disjunct
Fire	Trees are easily killed by fire owing to thin bark; however, the species is dependent on fire for regeneration; suppression of fire may threaten populations
NatureServe conservation status ranking	G3 - Vulnerable
Silvicultural considerations	Tolerant of harsh sites, but slow-growing

References

Afzalrafii and Dodd 1994, Arno and Hammerly 2007, Bonner and Karrfalt 2008, Esser 1994, Merriam 2011, USDA NRCS 2010

Alaska yellow-cedar (*Cupressus nootkatensis*)

Ecology

Taxonomy and nomenclature		Also known as *Chamaecyparis nootkatensis*, *Xanthocyparis nootkatensis*, and *Callitropsis nootkatensis*
Description		A medium-sized, evergreen conifer, sometimes reaching a height of more than 130 ft (40 m); a slightly twisted stem with a drooping leader; forms a pyramidal crown at maturity; sparse branches and drooping scale-leaved foliage; thin, purplish bark becoming shaggy and gray at maturity
Distribution		In coastal mountain ranges from south-central Alaska to northern California; less common south of Mount Rainier; usually at elevations between 2,000 and 7,500 ft (600 to 2,300 m), but occasionally to near sea level in the Olympics
Successional stage		Present in all successional stages; a pioneer species on subalpine, colluvial, and wetland sites; found in climax stands owing in part to its longevity (>700 years)
Associated forest cover		Often occurs individually or in small groups in conifer stands including mountain hemlock, Pacific silver fir, subalpine fir, western hemlock, noble fir, whitebark pine, and western white pine; occasionally found in pure stands
Habitat	**Sites**	Maritime climates, from low elevation to treeline; sometimes found at high elevations where its associates cannot survive; often found on harsh sites, such as thin soils or wet soils where other species grow poorly
	Soils	Thin organic or rocky soils; talus; soils low in nutrients; wet, poorly drained soils; best growth is on deep, well-drained soils but it cannot compete with its faster-growing associates on such sites
	Moisture	Moderately drought tolerant; high tolerance of flooding and saturated soils
	Temperature	Occurs where snow insulates the soil during winter
	Shade tolerance	Shade-tolerant; similar to Pacific silver fir in its shade tolerance; photosynthetic saturation reached at 60 percent of full sunlight
Interspecific interactions	**Animal damage**	Browse damage is uncommon
	Mycorrhizal fungi	Mycorrhizal with vesicular arbuscular species

Reproduction and Growth

Mode of reproduction		Reproduces sexually and vegetatively; monoecious; vegetative reproduction through layering
Reproductive phenology		Reproductive cycle spans three growing seasons in the northern portion of its range, two growing seasons in the southern portion; for the 3-year cycle, cones are initiated in year 1, pollination occurs in year 2, and cones mature in year 3; for the 2-year cycle, cones mature in the second year; flowers from April to June, 1 week after breaking dormancy; flowers earlier with decreasing elevation and latitude; cones reach maturity in September or October
Pollination		Wind-pollinated
Seed	**Seed type**	Globe-shaped cones 0.3 to 0.5 in (8 to 12 mm) in diameter with four to six scales; 2 to 4 winged seeds per scale; a British Columbia study found an average of 7.2 seeds per cone
	Seed-bearing age	Unknown

	Seed size/ weight	Seeds 0.08 to 0.20 in (2 to 5 mm) long; 108,000 seeds per lb (240,000 seeds per kg)
	Seed longevity/ survivability	Seeds may be stored at 32 °F (0 °C) for 3 to 5 years
	Seed crop and frequency	Heavy seed crops occur irregularly, at intervals of 4 or more years; produces a low percentage of sound seed; seed viability is both low and extremely variable
Seed dissemination	**Time of year**	Seed dispersal begins in October and continues through spring; seeds shed during dry periods
	Method and dispersal agents	Wind-dispersed
	Distance	Dispersal distance is likely less than 400 ft (120 m)
Germination requirements		Germination percentage is low; germination epigeal; germination best on mineral soil and well-decomposed organic matter; germination significantly increased by cold stratification after warm stratification
Seedling survival		Seedlings relatively shade-tolerant; regeneration primarily vegetative on open sites and in closed-canopy forests south of Mount Rainier

Genetics

Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.15
Geographic differentiation	Moderate population differentiation
F_{st} or G_{st}	0.14
Genetic analysis research results	Seedlings from higher elevations generally had higher cold hardiness than seedlings from lower elevations

Threats and Management Considerations

Insects and disease	Insects and diseases are not a serious problem; wood is resistant to most fungal damage
Harvest	A valuable commercial species; harvested in the northern portion of its range
Fragmentation	Distribution is sparse south of Mount Rainier and in parts of the Olympic Range
Fire	Fire is infrequent in its cool, wet habitat; susceptible to fire damage owing to thin bark
Other damaging agents	Dieback has been occurring in southeastern Alaska for more than a century; cause may be a climate-related decrease in snowpack depth leading to root frost damage
NatureServe conservation status ranking	G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors
Silvicultural considerations	Vegetative reproduction of seedling stock is preferred method of regeneration owing to poor seed crops and germination

References

Arno and Hammerly 2007, Berube et al. 2003, Griffith 1992a, Harrington 2010, Harris 1990a, Hawkins et al. 1994, Klinka et al. 2000, Ritland et al. 2001, USDA NRCS 2010

Cascara (*Frangula purshiana*)

Ecology

Taxonomy and nomenclature		Also known as *Rhamnus purshiana*
Description		A deciduous, broadleaf, tall shrub or small tree, sometimes reaching 30 to 40 ft (9 to 12 m) in height; a broad, bushy crown composed of ascending branches; broad-leaved and deciduous; thin, grayish brown bark
Distribution		Southern British Columbia to northern California; primarily west of the Cascade Range but also occurs east to Idaho and western Montana
Successional stage		Occurs as an understory species in early to mid-seral stages of conifer or hardwood forests; sometimes occurs in late seral stages on wet sites
Associated forest cover		An understory species in a wide range of forest types in the coastal and interior Pacific Northwest; associates include Douglas-fir, western hemlock, western redcedar, Sitka spruce, red alder, Pacific silver fir, Pacific madrone, and Oregon white oak
Habitat	**Sites**	Moist, fertile coastal sites; lower mountain slopes; moist bottomlands; canyons east of the Cascade crest
	Soils	Prefers soils of moderate to high fertility, particularly nitrogen-rich soils
	Moisture	Tolerant of wet soils, flooding, and a highly fluctuating water table; tolerant of dry soils
	Temperature	Low frost tolerance; tolerant of heat
	Shade tolerance	Very shade-tolerant when young; moderately shade-tolerant at maturity
Interspecific interactions	**Animal damage**	Browsed by deer in winter despite low palatability; fruits consumed by a variety of bird species; bears may break branches to reach fruit
	Mycorrhizal fungi	Unpublished reports of mycorrhizal associates

Reproduction and Growth

Mode of reproduction		Reproduces sexually and vegetatively through layering and sprouting; monoecious; vegetative reproduction less common
Reproductive phenology		In Idaho, flowers from late May to early June, with fruit growth beginning in June; fruit mature by September; in California, flowers from April to July, with fruit maturing from July through September
Pollination		Insect pollination has been observed in some locations
Seed	**Seed type**	Purplish-black drupe about 0.3 in (8 mm) in diameter; drupe contains approximately three seeds
	Seed-bearing age	Unknown
	Seed size/ weight	Seed comprises approximate 20 percent of fruit by weight; cleaned averages 12,300 seeds per lb (27,100 seeds per kg) with a range of 5,000 to 19,000 seeds per lb (11,000 to 41,850 seeds per kg)
	Seed longevity/ survivability	Unknown
	Seed crop and frequency	A prolific seed producer, although seed production is lower when growing in an understory position

Seed dissemination	**Time of year**	Fruits mature by September
	Method and dispersal agents	Birds are the primary dispersal agent
	Distance	Unknown
Germination requirements		Germination is relatively low; cold stratification required; germination increased by exposed mineral soil; germination greater in sunlight than in the understory
Vegetative phenology		In Idaho, budswell occurred in late April, leafout occurred in May, and stem growth occurred from early May through July

Threats and Management Considerations

Insects and disease	Low risk of serious damage
Harvest	Some populations have been heavily harvested or extirpated for the medicinal value of cascara's bark; larger trees were preferentially harvested
Fragmentation	Widespread within its range
Fire	Usually top-killed by fire; sprouts from root crown
NatureServe conservation status ranking	G4/G5: G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors/G5 Secure—Common; widespread and abundant; range indicates some uncertainty about the exact status; concerns over rather intensive exploitation in considerable portions of the species' range
Silvicultural considerations	Usually regarded as a weed species in conifer plantations

References

Arno and Hammerly 2007, Habeck 1992c, USDA NRCS 2010

Oregon Ash (*Fraxinus latifolia*)

Ecology

Description		A medium-sized, deciduous, broadleaf tree typically reaching 60 to 80 ft (18 to 24 m) in height; a narrow crown in dense stands and a broad, spreading crown where open-grown; opposite branchlets; self prunes rapidly; dark gray-brown bark has deep, patterned fissures
Distribution		From the Puget Sound region of western Washington south through western Oregon to central California
Successional stage		A pioneer and early seral species that regenerates after floods, windstorms, fire, or other disturbances create open habitat; replaced by more shade-tolerant species such as bigleaf maple and conifers
Associated forest cover		Occurs with red alder, bigleaf maple, black cottonwood, Oregon white oak, and willows (*Salix* spp.); occasionally occurs in small, pure stands
Habitat	**Sites**	Found in lowlands and river valleys, most often in riparian habitats; occurs frequently in bottomlands, swamps, wet meadows and swales
	Soils	May occur on a wide range of soils, but most often found on deep, rich alluvial soils including those that are poorly drained or seasonally flooded
	Moisture	Tolerant of flooding and seasonally saturated soils; occurs in Oregon and California where annual precipitation is as low as 20 in (510 mm)
	Temperature	Temperatures are generally mild within its range; tolerates temperatures to -8 °F (-22 °C)
	Shade tolerance	Shade tolerance is low to intermediate
Interspecific interactions	**Animal damage**	Browsed by deer and elk; seeds consumed by birds and squirrels
	Mycorrhizal fungi	Other species in the same genus are associated with arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual (dioecious) and vegetative; stumps sprout vigorously
Reproductive phenology		Flowers appear at the same time as leaves in April or May
Pollination		Wind-pollinated
Seed	**Seed type**	Oblong to elliptical, single, winged samaras, 1 to 2 in (2.5 to 5 cm) long, including the wing; ripens in August or September, turning light brown
	Seed-bearing age	Seed production begins around age 30 years
	Seed size/ weight	Approximately 10,000 to 14,000 cleaned seeds per lb (22,000 to 31,000 per kg)
	Seed longevity/ survivability	Unknown; reported to have persistent viability
	Seed crop and frequency	An abundant annual seed producer where open-grown; produces heavy seed crops at 3- to 5-year intervals in forest stands
Seed dissemination	**Time of year**	Seed dispersed in September and October
	Method and dispersal	Winged samaras are dispersed by wind and are eaten by birds and squirrels

	agents	
	Distance	Unknown
Germination requirements		Cool, moist stratification required; germination medium to high; germination highest on moist or wet soils with significant organic matter; germination epigeal
Seedling survival		Seedlings tolerant of drought; seedling growth rapid on rich soils; seedlings moderately shade-tolerant
Vegetative phenology		Leaves appear in April or May

Threats and Management Considerations

Insects and disease	A variety of insects and fungal pathogens have been reported on Oregon ash, although the extent and severity of resulting damage is not well-documented; leaf anthracnose can be extensive in moist springs; the heart rot *Perenniporia fraxinophilus* is found in older trees; small weevils (*Thysanocnemis* spp.) may damage seed crops throughout the range of Oregon ash; bark beetles and woodborers commonly infest older trees and wounded stems
Fire	Typically occurs on wet sites where fire is less common; sprouts vigorously after trees are top-killed by fire
Other damaging agents	Very wind-firm; could be severely impacted if emerald ash borer were introduced
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Often planted as an ornamental

References

Arno and Hammerly 2007, Owston 1990, USDA NRCS 2010, Wallander 2008

Western Juniper (*Juniperus occidentalis*)

Ecology

Taxonomy and nomenclature		There are two varieties of western juniper: *J. occidentalis* var. *occidentalis* and *J. occidentalis* var. *australis*; only var. *occidentalis* occurs in Oregon and Washington and is therefore the variety described here; var. *australis* occurs in California and Nevada
Description		An evergreen, coniferous shrub or small tree, usually reaching heights of 15 to 30 ft (5 to 9 m), although some individuals reach 60 ft (18 m); stiff, scale-like leaves and a ragged, bushy crown; a tapered, often divided stem with long branches; thin, reddish brown or grayish, fibrous bark
Distribution		Occurs from southeastern Washington southward through the Cascade Range and Modoc Plateau in Oregon, Idaho, and northwestern Nevada; most prevalent in central Oregon; since the late 1800s, western juniper has substantially increased its range in Oregon as a result of grazing, fire suppression, and climatic patterns; occurs from 3,000 to 7,500 ft (910 to 2290 m) elevation in central Oregon and from 600 to 1,800 ft (180 to 550 m) elevation in eastern Washington
Successional stage		An aggressive pioneer species; also a potential climax species on very rocky soils and where there is insufficient fuels to carry intense fire
Associated forest cover		Forms a single-species woodland on sites too dry for ponderosa pine or Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*); occurs in conifer transitional zones with ponderosa pine and curlleaf mountain-mahogany (*Cercocarpus ledifolius*); occurs as individuals on rock outcrop and rimrock sites; occurs on inclusions of rock outcrops and shallow soils within ponderosa pine, Rocky Mountain Douglas-fir, white fir, lodgepole pine, and other forest types; also associated with big sagebrush (*Artemisia tridentate*)
Habitat	**Sites**	Found in the most xeric tree-dominated zone of the region; occurs in open, woodland stands on mountain slopes and high plateaus; found on canyon slopes, steep, rocky escarpments, along streams, on lower slopes, and in shifting sand dune communities
	Soils	Typically found on shallow, stony soils with low organic content; soils are derived from a wide variety of parent materials and vary widely in texture; soils often underlain by fractured bedrock
	Moisture	Tolerant of extremely dry sites; typical annual precipitation is between 10 and 13 in (25 and 33 cm), with most of that occurring as snow
	Temperature	Tolerant of heat and of long, dry summers; occurrence at high elevations may be limited by cold winter temperatures
	Shade tolerance	Tolerates shade when young; shade-intolerant at maturity
Interspecific interactions	**Animal damage**	Not a preferred browse species, damage may occur when other sources of browse are limited
	Mycorrhizal fungi	Known to be mycorrhizal

Reproduction and Growth

Mode of reproduction	Reproduction is sexual; dioecious or occasionally monoecious; individuals may shift their sex on an annual basis
Reproductive phenology	Cones develop from mid-April to mid-May; pollination occurs in May; seed cones ripen in mid-September of the second year; mature cones persist on trees for two to three years
Pollination	Wind-pollinated

Seed	**Seed type**	Fleshy cones, often called berries, that contain two to three seeds
	Seed-bearing age	Seed production begins around 20 years of age; few seeds are produced until trees reach 50 to 70 years of age
	Seed size/ weight	Averages 12,300 seeds per lb (27,120 seeds per kg); ranges from 8,000 to 15,860 seeds per lb (17,640 to 34,970 seeds per kg)
	Seed longevity/ survivability	Seeds may remain dormant for several years or longer
	Seed crop and frequency	Produces abundant cone crops nearly every year after reaching maturity; heaviest crops are irregular
Seed dissemination	**Time of year**	Seed cones ripen around mid-September and may persist on trees for two to three years
	Method and dispersal agents	Seeds are dispersed by birds, mammals, water, and gravity; mammalian vectors include rabbits, squirrels, woodrats, mule deer, elk, coyotes, and domestic livestock; seed is dispersed by birds including the American robin, Steller's jay, scrub jay, and Townsend's solitaire
	Distance	Seed may be dispersed long distances by mammals and birds
Germination requirements		Germination is delayed by embryo dormancy, a cold stratification requirement, and an impermeable seedcoat; germination requires a specific sequence of environmental conditions; germination epigeal
Seedling survival		Disturbance and presence of mineral soil improves likelihood of establishment
Vegetative phenology		Leaf elongation begins in June in Oregon; annual foliar turnover is 15 to 20 percent

Threats and Management Considerations

Insects and disease	No serious insect or disease problems; the most common cause of damage is white trunk rot (*Pyrofomes demidoffii*); juniper bark beetle (*Phloeosinus serratus*) causes occasional damage
Harvest	Little commercial value
Fragmentation	The extent of western juniper is currently expanding in Oregon; occurrences in southeastern Washington represent the northern edge of the species' range
Fire	Young trees, seedlings, and saplings are highly vulnerable to fire; older trees are somewhat resistant to surface fires because they have thicker bark and their foliage is higher above the ground
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Stands have been managed in both even- and uneven-aged conditions; western juniper provides wildlife habitat, and its berries are a food source for a variety of animals

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Dealy 1990, Miller 2005, Tirmenstein 1999, USDA NRCS 2010

Rocky Mountain juniper (*Juniperus scopulorum*)

Ecology

Taxonomy and nomenclature		Based on recent genetic analysis (Adams 2007, Adams et al. 2010) identified the *Juniperus scopulorum* populations in the Puget Sound region and Olympic Range as a separate species, *Juniperus maritima,* found only in this area; because the descriptions presented here follow nomenclature of the USDA Plants Database, we treat *J. scopulorum* and *J. maritima* as a single species
Description		An evergreen, coniferous shrub or small tree, occasionally reaching a height of 35 ft (10 m) or more; scale-like leaves and a ragged, bushy crown; a tapered stem with long branches; thin, reddish brown or grayish, fibrous bark
Distribution		Throughout the mountains and foothills of interior British Columbia southward to Arizona and New Mexico; occurs from sea level to 9,000 ft (2,740 m); occurs on Vancouver Island and other Puget Sound islands and on the surrounding mainland
Successional stage		Typically part of long-term seral or near-climax communities
Associated forest cover		Often in isolated clumps or with Pacific madrone, Oregon white oak, red alder, western white pine, whitebark pine, trembling aspen, or Douglas-fir
Habitat	**Sites**	Wide ecological amplitude; occurs on a variety of sites and landforms including rocky bluffs and southern exposures, ravines, and valleys; in western Washington, Rocky Mountain juniper occurs close to the shore of Puget Sound on rocky sites characterized by granite and sand; in eastern Washington, it occurs on dry, rocky, mountainous sites
	Soils	Although it occurs on a wide range of soil types, it is often found on shallow, poorly developed, stony, alkaline soils; in the Puget Sound region it occurs on droughty soils derived from granite
	Moisture	Tolerant of extremely dry sites
	Temperature	Tolerant of growing-season frost; tolerant of heat
	Shade tolerance	Tolerates shade when young; shade-intolerant at maturity
Interspecific interactions	**Animal damage**	Although palatability is poor, damage occurs when other sources of browse are limited; animals use trees as “rubbing posts”
	Mycorrhizal fungi	No mycorrhizal associates have been reported for this species

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; dioecious; may be cultivated from cuttings
Reproductive phenology		Pistillate flowers appear in late summer; pollination occurs the following April; seed cones reach maturity by November or December of the second year after pollination and remain on the tree until approximately 24 months post-pollination; among Puget Sound populations of Rocky Mountain juniper, this period is only 14 to 16 months
Pollination		Wind-pollinated
Seed	**Seed type**	Globose to reniform berries 0.2 to 0.3 in (4 to 8 mm) in diameter; berries contain one to three seeds
	Seed-bearing age	Seed production begins as early as age 10 to 20; peak seed production occurs between ages 50 and 200

	Seed size/ weight	Averages 27,100 seeds per lb (59,700 seeds per kg); ranges from 18,000 to 42,000 seeds per lb (39,700 to 92,600 seeds per kg)
	Seed longevity/ survivability	Seeds may remain dormant for several years or longer
	Seed crop and frequency	Prolific seed producer; seed crops every year; heavy crops every 2 to 5 years; production greatest for open-grown trees
Seed dissemination	**Time of year**	Berries mature and fall from the tree in spring
	Method and dispersal agents	Seeds are dispersed primarily by birds and less frequently by mammals; some seeds dispersed by gravity and surface runoff
	Distance	Dispersal is primarily by birds and is therefore influenced by their daily and migratory movements
Germination requirements		Germination averages 22 to 45 percent; germination epigeal; seeds have both a seed-coat and a chemical dormancy; germination does not occur until 14 to 16 months after seeds reach maturity
Seedling survival		Seedling distribution is usually sparse; survival requires moisture often found in rock crevices or pockets; partial shade may assist establishment

Threats and Management Considerations

Insects and disease	Insects and fungal pathogens not a serious problem; blight caused by *Cercospora sequoiae* is the most serious disease
Harvest	Not a commercial timber species
Fragmentation	Puget Sound populations are small and scattered; because populations apparently originate from seed dispersed by birds, Rocky Mountain juniper has a scattered distribution
Fire	Vulnerable to damage from fire; seedlings, saplings, and small trees easily killed; larger trees survive surface fires
Other damaging agents	Very resistant to windthrow
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Difficult to grow from seed owing to prolonged dormancy; may be propagated from cuttings; often planted for restoration and reclamation purposes, windbreaks, and as an ornamental

References

Adams 2007, Adams et al. 2010, Arno and Hammerly 2007, Klinka et al. 2000, Noble 1990, Scher 2002a, USDA NRCS 2010

Subalpine larch (*Larix lyallii*)

Ecology

Description		A small- to medium-sized, long-lived, deciduous conifer, usually 40 to 50 ft (12 to 15 m) in height; forms a long, open crown that spreads and eventually becomes irregular with age; clusters of soft, light blue-green needles; a sturdy, tapered stem; bark is yellowish gray with irregular, scaly plates
Distribution		Occurs in the northern Cascades in southern British Columbia and north-central Washington; also occurs in a separate distribution in the northern Rocky Mountains, in British Columbia, Alberta, western Montana, and northern Idaho; occurs between approximately 5,800 and 9,900 ft (1,770 and 3,020 m) elevation
Successional stage		A pioneer species that establishes on rocky surfaces and after fire, avalanches, or other disturbances; a climax species at its highest elevations where other tree species cannot grow
Associated forest cover		A dominant species near timberline; found in pure stands or with subalpine fir, whitebark pine, and Engelmann spruce
Habitat	**Sites**	Found in very cold, moist, high-elevation sites, where average temperatures are below freezing for six months per year; precipitation occurs primarily in the form of snow and sleet
	Soils	Occurs on soils that are rocky, poorly developed, and shallow; often the first vascular plant species to occupy slopes covered with talus; growth is somewhat better on calcium-rich substrates
	Moisture	High resistance to winter desiccation; moderately drought tolerant, although drought is uncommon in its generally moist habitat
	Temperature	Highly frost tolerant; occurs on sites where growing seasons are short and cool and winters are long and very cold
	Shade tolerance	Intolerant of shade
Interspecific interactions	**Animal damage**	Not frequently browsed
	Mycorrhizal fungi	Associated with ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		Initiates flowers in late May or early June; flowers in June; cones mature in August or September
Pollination		Wind-pollinated
Seed	**Seed type**	Winged seeds are borne in cones 1.5 to 2.0 in (3.8 to 5.1 cm) long
	Seed-bearing age	On a typical site, cone production begins at about 100 years of age; large cone crops occur after trees reach 200 years of age
	Seed size/ weight	Averages 142,000 seeds per lb (313,000 seeds per kg)
	Seed longevity/ survivability	Undocumented; seed of other larch species remains viable for 10 to 23 years under controlled conditions
	Seed crop and frequency	Large cone crops occur at intervals of approximately 10 years

Seed dissemination	**Time of year**	September
	Method and dispersal agents	Wind; occasionally snowslides
	Distance	Unknown
Germination requirements		Germination occurs in July, soon after snowmelt; germination is most common on moist mineral soil; germination is poor without seed scarification
Seedling survival		Successful seedling establishment likely occurs only under ideal conditions; aboveground growth of seedlings is very slow, as root systems establish first
Vegetative phenology		The growing season lasts approximately 90 days in subalpine larch's habitat; annual development usually begins by the end of May and is triggered by increasing air temperature; annual shoot growth is rapid and occurs primarily in July; leaf fall and dormancy are controlled by photoperiod, with some influence of drought

Genetics

Mating system	Predominantly outcrossing with moderate outcrossing rate
Outcrossing % (t_m)	0.861
Genetic diversity	0.094 (from only 1 population)
Heterozygosity (H_e)	Average genetic diversity
Geographic differentiation	0.07
F_{st} or G_{st}	Weak population differentiation based on molecular markers

Threats and Management Considerations

Insects and disease	Insects and fungal pathogens are not a major concern in subalpine larch; trees are long-lived and mortality often results when older trees with significant heart rot suffer wind damage
Harvest	Not a commercial timber species
Fragmentation	Overall distribution is in two separate mountain ranges; distribution is discontinuous within each range
Fire	Low resistance to fire; fire is infrequent on the rocky isolated sites where subalpine larch typically occurs
NatureServe conservation status ranking	G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors
Silvicultural considerations	Important for stabilizing snow loads on steep slopes; often the only tree in its habitat and therefore an important species for wildlife

References

Arno 1990, Bonner and Karrfalt 2008, Habeck 1991b, Klinka et al. 2000

Western larch (*Larix occidentalis*)

Ecology

Description		A medium- to large-sized, deciduous conifer, reaching a height of over 180 ft (55 m); forms a high, narrow, open crown with horizontal branches; a significant portion of the stem is free of branches at maturity; soft, yellow-green needles generally appear in tufts; bark is orange or reddish brown, flaky, very thick, and deeply furrowed
Distribution		Occurs from southeastern British Columbia southward to central and eastern Oregon, west-central Idaho, and western Montana; occurs in eastern Washington, including the east slopes of the Cascade Range; also occurs in the Blue and Wallowa Mountains of Oregon and southeastern Washington; occurs at elevations from 1,500 ft (460 m) to 5,500 ft in the northern part of its range and up to 7,000 ft (2,100 m) in the southern part of its range; occurs from 2,000 to 5,500 ft (600 to 1,680 m) in Washington and from 3,500 to 6,500 ft (1,070 to 1,980 m) in Oregon
Successional stage		An aggressive pioneer, usually establishing after fire; a long-lived early successional species that may persist for several hundred years
Associated forest cover		Often associated with lodgepole pine following disturbance; over time, more shade-tolerant species become common associates; found on lower-elevation, dry sites with ponderosa pine and on lower-elevation moist sites with grand fir, western hemlock, western redcedar, and western white pine; associated with Engelmann spruce, subalpine fir, lodgepole pine, and mountain hemlock at high elevations
Habitat	**Sites**	Found on valley bottoms, benches, and on mountain slopes; on dry slopes, found on northern and eastern aspects; southern and western aspects are often too severe where moisture is limiting
	Soils	Occurs on a wide variety of soils; deep, medium- to coarse-textured soils are most productive
	Moisture	Moderately drought tolerant; drought stress is greatest for seedlings, especially when growing in association with other vegetation that is competing for water; lower-elevational range is limited by insufficient precipitation; low tolerance of flooding
	Temperature	Moderately tolerant of heat, although seedlings are vulnerable to high soil temperatures; moderately tolerant of frost
	Shade tolerance	Highly intolerant of shade at maturity; tolerates partial shade as a seedling
Interspecific interactions	**Animal damage**	Unpalatable to most big game species
	Mycorrhizal fungi	Associated with ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction	Reproduces sexually; monoecious
Reproductive phenology	Buds appear in early fall and enter dormancy during winter; pollen and seed conelets appear from mid-April to mid-May the following year; pollination occurs from late April to early June; fertilization occurs in June or July, 6 to 8 weeks after pollination; cones mature in mid- to late-August and open in late August and early September
Pollination	Wind-pollinated

Seed	**Seed type**	Small, lightweight seeds with large wings are formed in cones that reach 1.0 to 1.8 in (2.5 to 4.5 cm) in length; averages approximately 40 seeds per cone
	Seed-bearing age	Capable of producing cones as early as age 8, but cone production becomes more common after age 25; begins to produce abundant cone crops around age 40 to 50 and may continue this production for hundreds of years
	Seed size/ weight	Averages 137,000 seeds per lb (302,000 seeds per kg)
	Seed longevity/ survivability	Seed viability ranges from less than 10 percent to 70 to 80 percent, and is correlated with the size of the cone crop; seeds remain viable only for the first year after fertilization; *Larix* spp. seed stored at 34 to 37 °F (1 to 3 °C) for 25 years has maintained viability
	Seed crop and frequency	A good seed producer; bears cones throughout the crown, and thus trees with large crowns produce the most cones; cone crops vary greatly by year and location; in Montana, the ratio of good or fair seed years to poor seed years was approximately 1 to 1; heavy seed crops in mature stands may exceed 500,000 seeds per acre (1.2 million seeds per ha)
Seed dissemination	**Time of year**	Seed dispersal begins in late August or early September and 80 percent of seeds are usually dispersed by mid-October
	Method and dispersal agents	Wind-dispersed
	Distance	Seed may be dispersed 800 ft (240 m) from a stand edge under normal conditions; density of seedfall at this distance may be up to 40,000 seeds per ac (100,000 seeds per ha)
Germination requirements		Seeds germinate well on a variety of seedbeds and aspects; germination is greatest on mineral soil, followed by burned seedbeds; germination is lowest on organic seedbeds; cold stratification substantially increases germination; germination epigeal
Seedling survival		Survival of germinants is greatest on mineral soil with full sunlight, although young seedlings tolerate partial shade; the majority of seedling mortality occurs in the first year and mortality is minimal after age 3; seedling mortality is primarily caused by high soil temperatures and mid- to late-season drought; other, minor causes of mortality are fungi, rodents, birds, and insects
Vegetative phenology		Buds swell and open in late March and April, before those of associated conifer species; diameter growth begins in mid-May and peaks in mid- to late-June; height growth begins in mid- to late-June, peaks in mid-July, and is complete by mid-August

Genetics

Mating system	Predominantly outcrossing with moderate outcrossing rate
Outcrossing % (t_m)	0.813
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.140
Geographic differentiation	Weak population differentiation based on molecular markers
F_{st} or G_{st}	0.086
Patterns of variation	Low levels of differentiation have been found among populations in quantitative traits, typical of a “generalist” species

Genetic analysis research results	Patterns of genetic variation were dominated by the effects of latitude and elevation, with populations from the north and from high elevations having the lowest growth potential, the lowest tolerance to needle cast, and the lowest survival; however, the slope of the geographic clines was relatively flat; populations in the same geographic area, for instance, need to be separated by about 500 m in elevation before genetic differentiation can be expected

Threats and Management Considerations

Insects and disease	Although many different insects and diseases affect western larch, damage is typically less severe than in associated species; two major insect pests are larch casebearer (*Coleophora laricella*) and western spruce budworm (*Choristoneura occidentalis*); fungal diseases are not a major concern; the most damaging fungi are brown trunk rot (*Fomitopsis officinalis*) and red ring rot (*Phellinus pini*); dwarf mistletoe *(Arceuthobium laricis)* is the most damaging parasite
Harvest	A fast-growing, productive species, used for lumber, veneer, poles, and pulp
Fire	Young trees are somewhat susceptible to fire damage, but older trees are fire-resistant owing to thick bark, self-pruning of lower limbs, and low flammability of foliage; fire is an important component of western larch's ecology, as it is highly adapted to surviving fire and regenerating after fire
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Fire is important for maintaining naturally regenerated stands of western larch; even-aged silvicultural systems are best-suited to the requirements of western larch; partial cuttings in mixed stands favor species other than western larch; diameter growth is very sensitive to stand density; thinning before age 20 increases height and diameter growth of residual trees

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Fins and Seeb 1986, Jaquich and El-Kassaby 1998, Khasa et al. 2006, Klinka et al. 2000, NatureServe 2010, Rehfeldt 1995, Scher 2002b, Schmidt and Shearer 1990, Semerikov and Lascoux 1999, USDA NRCS 2010

Western crab apple (*Malus fusca*)

Ecology

Taxonomy and nomenclature		Also known as *Pyrus fusca* and *Malus diversifolia*
Description		A small, scraggly, deciduous, broadleaf tree, sometimes reaching 40 ft (12 m) in height; spreading branches with a rounded crown
Distribution		Coastal Pacific Northwest from Alaska to northern California; elevations from sea level to 1,000 ft (300 m)
Successional stage		An early seral species
Associated forest cover		Occurs with a variety of species; commonly found on sites also occupied by red alder, bigleaf maple, cascara, Oregon ash (*Fraxinus latifolia*), and Sitka willow (*Salix sitchensis*)
Habitat	**Sites**	Moist woods, swamps, edges of rivers, streams, estuaries, and lakes; brackish-water marshes; sites affected by ocean spray
	Soils	Moist soils; sandy to clayey in texture; prefers nutrient-rich wetland soils
	Moisture	Tolerant of prolonged soil saturation; intolerant of drought
	Temperature	Intolerant of extremely cold temperatures
	Shade tolerance	Moderately shade tolerant; best growth occurs in full sunlight
Interspecific interactions	**Animal damage**	Attracts wildlife, providing food and cover; wildlife damage not reported
	Mycorrhizal fungi	Other species in the genus *Malus* are associated with arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduces sexually and vegetatively; monoecious
Reproductive phenology		Flowers in late spring, around May
Pollination		Insect-pollinated
Seed	**Seed type**	Egg-shaped, yellow-green to red pomes about 0.4 to 0.6 in (10 to 15 mm) in diameter, formed in dense clusters
	Seed-bearing age	Unknown
	Seed size/ weight	24,500 cleaned seeds per lb (54,000 seeds per kg)
	Seed longevity/ survivability	Unknown
	Seed crop and frequency	Abundant seed producer
Seed dissemination	**Time of year**	Fruit ripens in October to November and is disseminated through the winter

	Method and dispersal agents	Fruits consumed by birds, deer, elk, and bears
	Distance	Dependent upon animal vectors
Germination requirements		Usually germinates in late winter; requires cold stratification

Genetics

Genetic diversity	Above-average genetic diversity
Heterozygosity (H_e)	0.27

Threats and Management Considerations

Insects and disease	Unknown
Harvest	Not a commercial species
Fragmentation	Widespread in western Washington
Fire	Unknown
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Planted for restoration and wildlife purposes; tolerates wet and saline soils better than many associated species

References

Arno and Hammerly 2007, Dickson et al. 1991, Lyons 1999, USDA NRCS 2010

Tanoak (*Notholithocarpus densiflorus*)

Ecology

Taxonomy and nomenclature		Also known as *Lithocarpus densiflorus*; sometimes two varieties of *Notholithocarpus densiflorus* are recognized: var. *densiflorus* (typical variety) and var. *echinoides* (dwarf tanoak)
Description		A medium-size, evergreen broadleaf tree, typically reaching 65 to 80 ft (20 to 24 m) in height, but capable of reaching 120 ft (35 m) in height when growing in stands with taller conifers; forms a broad, dense crown when open-grown, with a stout stem and spreading branches; growing with taller conifers, tanoak has a narrow crown and upswept limbs; shaded stems self-prune; foliage is thick and leathery, with a pale green, shiny upper surface; at maturity, bark is dark gray to brown and deeply fissured
Distribution		Occurs near the Pacific Coast from near the Umpqua River in Oregon south to near Santa Barbara, California; occurs in the Siskiyou and Klamath Ranges and in scattered populations south through the Cascade and Sierra Nevada Ranges; occurs from sea level to 4,000 ft (1,200 m) elevation in Oregon
Successional stage		Found in all successional stages, from post-disturbance to climax communities; regenerates rapidly from sprouts and seed after harvest or fire; also capable of regenerating and growing in the shade of conifers
Associated forest cover		Part of the tanoak-mixed evergreen forest of southwestern Oregon; often associated with a Douglas-fir overstory; found in a variety of forest types with Douglas-fir, Port-Orford-cedar, white fir, Oregon white oak, and knobcone pine; occurs in mixed forests with other evergreen broadleaf trees including Pacific madrone, canyon live oak, golden chinquapin, and Oregon myrtle; also found on harsh sites that do not support Douglas-fir or other conifers
Habitat	**Sites**	Occurs where moisture availability is relatively high and temperatures are mild; in Oregon, tanoak is an indicator of productive sites; on less-productive sites, it is found only in riparian areas and sheltered habitats; on low-elevation coastal sites, tanoak is not restricted by aspect; on drier inland sites, tanoak is most prevalent on north aspects
	Soils	Found on a wide variety of soils, but typically limited to medium and coarse-textured soil; in Oregon, typically occurs on relatively deep, well-drained soils
	Moisture	Requires relatively high levels of soil moisture; best-adapted to sites with a cool, moist maritime climate; requires moister soils than associated broadleaf trees; intolerant of saturated soils and flooding
	Temperature	Requires mild temperatures; range is limited inland by cold, dry winters
	Shade tolerance	Shade-tolerant
Interspecific interactions	**Animal damage**	Acorn predation is usually heavy; palatability of foliage is low
	Mycorrhizal fungi	Known to form mycorrhizal associations

Reproduction and Growth

Mode of reproduction	Reproduces sexually and vegetatively; monoecious; vegetative reproduction is common and occurs through vigorous and frequent sprouting
Reproductive phenology	Flowers for an extended period, from April through August and sometimes in fall; heaviest flowering is from June through August; coastal and low-elevation trees flower earlier; flowers usually borne on new shoots; produces acorns that mature near the end of the second year
Pollination	Wind-pollinated

Seed	**Seed type**	Acorns, from 0.8 to 1.3 in (2 to 3 cm) long, similar to those of oak (*Quercus*); usually borne singly, sometimes in clusters of 2 to 4
	Seed-bearing age	Sprouts may produce seed as early as age 5 years; maximum seed production begins around age 30 to 40 years
	Seed size/ weight	Averages 110 acorns per lb (242 acorns per kg)
	Seed longevity/ survivability	Acorns that fall in an exposed environment may be killed within a few days by high temperatures or freezing; predation levels are often very high; viability of acorns immediately after seedfall ranges from 49 to 79 percent; storage in controlled environments is not recommended because acorns rapidly die or germinate; recommended storage is by burial in wire containers at the future planting site
	Seed crop and frequency	Tanoak produces acorn crops more reliably than western oak species; annual production by individual trees has been estimated at 3,900 to 110,000 acorns; in a heavy seed year, the number of sound acorns produced was estimated at 89,000 to 170,000 per acre (220,000 to 420,000 per hectare); acorn production is heavy almost every alternate year; poor crops are usually caused by frost or by a dry year; crop failure is rare
Seed dissemination	**Time of year**	Mature acorns drop between 20 September and 15 November; the first acorns to fall are likely those damaged by insects
	Method and dispersal agents	Acorns are dispersed by rodents and birds; the most important dispersers are those that bury acorns in shallow caches: western gray squirrels, western scrub-jays, and Steller's jays
	Distance	Not documented; dispersal distance depends on movement of animals
Germination requirements		No seed dormancy; litter or duff provides best seedbed; acorns buried by animals in shallow caches are likely to establish; germination not hindered by shade; germination hypogeal; nearly all seedlings emerge from the ground in spring
Seedling survival		The ratio of sound acorns to established seedling was determined to be 156: 1; seedlings are not rare, but are less common than sprouts; seedling survival is high in the understory of conifer stands; vegetative reproduction is prolific in clear-cuts; dieback of sprouts and young trees is common, and is followed by resprouting from the burl; seedlings that are top-killed may sprout
Vegetative phenology		Leaves persist for 3 to 4 years; leaf fall coincides with seedfall; below 2,000 ft (610 m) elevation in California, vegetative buds opened in mid-April; from 2,000 to 3,500 ft elevation (610 to 1,065 m) buds opened in mid-May; from 3,500 to 4,400 ft (1,065 to 1,340 m) buds opened in late May; at 4,500 ft (1,370 m) buds opened in early June

Genetics

Genetic diversity	Relatively high genetic diversity in southwestern Oregon based on DNA markers
Geographic differentiation	Weak to moderate geographic differentiation based on DNA markers
F_{st} or G_{st}	0.1

Threats and Management Considerations

Insects and disease	The most important disease affecting tanoak is sudden oak death (caused by *Phytophthora ramorum*); tanoak is more susceptible to this disease than any other regional tree species; infection by the sudden oak death pathogen is nearly always fatal; all sizes and ages of trees are affected; root disease caused by *Armillaria* spp. is common mortality associated with *Phytophthora nemorosa* also occurs; a significant portions of acorns are destroyed by

	insects including the filbert weevil (*Curculio uniformis*) and the filbertworm (*Melissopus latiferreanus*); fire scars often lead to stem damage from fungi or insects
Fragmentation	Disjunct populations occur in Oregon and California
Harvest	Wood is of high quality, but supply is limited and defects are common in the lower stem
Fire	Seedlings and saplings are easily killed by fire; large trees can survive moderate severity fires, but often incur bole scars; burls of large trees usually survive even severe fires
NatureServe conservation status ranking	G4/G5T4/T5: G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors/ G5 Secure—Common; widespread and abundant
Silvicultural considerations	Regenerates at high densities followed by rapid self-thinning; thinning is not recommended because of its propensity to sprout; growth in tanoak stands is rapid, particularly in stands of sprout origin; in conifer plantations, tanoak sprouts compete strongly with young planted trees

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Fryer 2008, Nettel et al. 2009, Tappeiner et al. 1990

Brewer spruce (*Picea breweriana*)

Ecology

Description		A small or medium, long-lived, evergreen conifer, typically reaching 80 to 100 ft (24 to 30 m) in height; crown characterized by drooping, rope-like branches hanging from limbs; bark is broken into long, thin scales
Distribution		Occurs only in the Siskiyou and Klamath Mountains of Oregon and California in widely scattered, disjunct populations from 4,000 to 8,000 ft (1,200 to 2,400 m) elevation
Successional stage		Occurs most often in late-successional or climax forests; sometimes also occurs in earlier successional stages
Associated forest cover		Occurs as a minor component of a variety of communities; occurs with California red fir, white fir, mountain hemlock, Engelmann spruce, subalpine fir, western white pine, and numerous other species
Habitat	**Sites**	Limited to scattered sites within its elevational range, but occurs on a variety of topographic locations; often an indicator of cold and wet sites, but it does not tolerate saturated soils; occurs at all aspects, but most frequently on north-facing slopes
	Soils	Found on soils formed in a wide range of parent materials, including serpentine soils; typically found on shallow, rocky soils; tolerates low fertility
	Moisture	Tolerant of soil moisture stress; does not tolerate a shallow water table
	Temperature	Tolerant of cold temperatures
	Shade tolerance	Very shade tolerant
Interspecific interactions	**Animal damage**	Seeds do not appear to be a preferred rodent food
	Mycorrhizal fungi	Unknown

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		Pollen is shed in early summer; cones mature by September or October; seed is dispersed immediately
Pollination		Wind-pollinated
Seed	**Seed type**	Seed occurs in cones 3 to 6 in (8 to 15 cm) long; seeds are 0.1 to 0.2 in (3 to 5 mm) in length, with a wing four times as long as the seed
	Seed-bearing age	Seed production may begin between 20 and 30 years of age
	Seed size/ weight	Averages 61,000 seeds per lb (134,500 per kg)
	Seed longevity/ survivability	Seeds may be stored for 5 to 17 years under controlled conditions
	Seed crop and frequency	Good crops occur every 2 years; some trees produce good crops every year
Seed dissemination	**Time of year**	Seedfall occurs in September or October
	Method and dispersal agents	Wind

	Distance	Unknown
Germination requirements		Germinates on a wide variety of seedbeds; germination epigeal; germination occurs beneath a forest canopy
Seedling survival		Seedlings cannot survive under direct sunlight because they are sensitive to heat and moisture stress; seedlings are typically absent from clearcuts
Vegetative phenology		Unknown

Genetics

Mating system	Strongly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.92-1.0
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.121
Geographic differentiation	Moderate population differentiation based on molecular markers
F_{st} or G_{st}	0.157

Threats and Management Considerations

Insects and disease	Tip damage caused by the Cooley spruce gall adelgid is frequently observed; parasitism by dwarf mistletoe (*Arceuthobium abietinum* subsp. *weinsii*) and high incidences of root rot (*Heterobasision occidentale*) have been observed in some populations
Harvest	Not an important timber species
Fragmentation	Populations are scattered; many populations are disjunct
Fire	Trees are easily killed by fire owing to thin bark, drooping branches, and shallow roots; the range of the species is limited to sites where fire is infrequent
NatureServe conservation status ranking	G4 - Apparently secure
Silvicultural considerations	Growth is best on mesic sites and in mixed, uneven-aged stands; does not regenerate well in openings

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Cope 1992b, Ledig et al. 2005, Thornburgh 1990a, USDA NRCS 2010

Engelmann spruce (*Picea engelmannii*)

Ecology

Description		A large, evergreen conifer sometimes reaching 130 ft (40 m) in height; a narrow, conical crown that extends to the ground; dense limbs with hanging branchlets; thin, purplish or reddish bark with flaking scales
Distribution		From British Columbia and Alberta south to Arizona and New Mexico, including all states from the Pacific Coast to the Rocky Mountains; occurs in Washington and Oregon near the crest and eastern slope of the Cascade Range and in mountain ranges in eastern parts of the states; most commonly found at elevations from 4,000 to 6,000 ft (1,220 to 1,830 m); small population occurs in the northeastern Olympic Range
Successional stage		A long-lived seral species found at all successional stages; sometimes occurs as a climax species
Associated forest cover		Common associates at high elevations are subalpine fir, Pacific silver fir, mountain hemlock, and whitebark pine; common associates at low to mid-elevations are western white pine, Douglas-fir, grand fir, and lodgepole pine; sometimes occurs in pure stands
Habitat	**Sites**	Occurs on moist and cool sites, at all aspects at higher elevations and at northern and eastern aspects at lower elevations within its range
	Soils	Occurs on a variety of soils formed in residuum, glacial and lacustrine deposits, and volcanic materials; water availability is more important than soil physical properties
	Moisture	Tolerant of wet soils; shallow root system; low drought tolerance; requires a relatively large amount of soil water; transpiration rate is much higher than that of subalpine fir or lodgepole pine
	Temperature	High tolerance of growing-season frost; relatively intolerant of heat
	Shade tolerance	Moderately shade-tolerant; less shade-tolerant than its true fir (*Abies*) associates or mountain hemlock
Interspecific interactions	**Animal damage**	Occasionally browsed; not a preferred species
	Mycorrhizal fungi	Associated with both ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; monoecious, with ovulate cones in the upper crown and staminate cones in the lower crown; vegetative reproduction occurs through layering
Reproductive phenology		Strobili formed in late April to early May; pollination occurs from late May at lower elevations to early July at higher elevations; cones mature in one season, ripening from August to early September
Pollination		Wind-pollinated
Seed	**Seed type**	Cones 1 to 1.25 in (2.5 to 6.3 cm) long; small, winged seeds
	Seed-bearing age	May begin seed production by age 15 to 40; production peaks between ages 150 and 250
	Seed size/ weight	135,000 seeds per lb (297,000 seeds per kg)

	Seed longevity/ survivability	Seed viability is persistent
	Seed crop and frequency	A moderate to good seed producer; large inter-annual and geographic variations in crop size; large seed crops occur every 2 to 5 years; some seed produced nearly every year
Seed dissemination	**Time of year**	Most seedfall occurs during September and October; some seed continues to fall through winter
	Method and dispersal agents	Seed primarily dispersed by wind
	Distance	Seed typically dispersed to 300 ft (90 m) or to 600 ft (180 m) when heavy seed crops occur
Germination requirements		Seed viability relatively high compared to associated species; seeds germinate after snowmelt when seedbeds are moist and air temperature warms above 45 °F (7 °C); seeds germinate on many types of mineral and organic substrates; germination occurs at all light intensities although 40 to 60 percent of full sunlight is optimal at high elevations
Seedling survival		Seedlings germinating on exposed mineral soil or humus seedbeds are most likely to become established; seedlings are very vulnerable to drought and heat girdling in their first year owing in part to slow initial root penetration and heat sensitivity; drought mortality often remains significant through the first 5 years

Genetics

Mating system	High outcrossing rate
Outcrossing % (t_m)	0.93
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.16
Geographic differentiation	Weak differentiation based on molecular markers
F_{st} or G_{st}	0.02
Patterns of variation	Engelmann spruce is considered intermediate with regard to adaptive strategy; both individuals and populations are suited to a broad range of environments, but populations still show habitat specificity
Genetic analysis research results	Intermountain west populations are differentiated for seedling characters with clines related to elevation and latitude; however, the clines are gentle, indicating low levels of genetic differentiation

Threats and Management Considerations

Insects and disease	Moderately susceptible to damage from insects and disease; in southwestern Oregon vulnerable to spruce beetle (*Dendroctonus rufipennis*); the Cooley spruce gall adelgid is frequently observed causing tip damage; susceptible to fungal stem and butt decays including those caused by *Phaeolus schweinitzii*, *Inonotus tomentosus*, *Phellinus pini* and *Heterobasidion occidentale*
Harvest	A commercial timber species with wood qualities yielding quality pulp; a minor timber species
Fragmentation	Widespread in the Cascade Range; small, disjunct populations in the northeastern Olympic Range
Fire	Very susceptible to damage from surface and crown fires
Other damaging agents	Relatively susceptible to windthrow

NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Planting of nursery stock preferred over direct seedling for regeneration

References

Alexander and Shepperd 1990; Arno and Hammerly 2007; Klinka et al. 2000; Rajora and Dancik 2000; Rehfeldt 1994; Shea 1987, 1990; Uchytil 1991c; USDA NRCS 2010

Sitka spruce (*Picea sitchensis*)

Ecology

Description		A very large, evergreen conifer; the largest spruce species in the world, reaching 300 ft (90 m) in height on some sites; a wide, dense crown with hanging branchlets; thin, reddish-brown bark with large, loose scales
Distribution		Occupies a narrow coastal zone from south-central Alaska to northern California; this zone also includes the shores of Puget Sound and the lower portions of major rivers; occurs sporadically to near the Cascade crest in Washington; occurs predominantly at elevations from sea level to 2,000 ft (600 m)
Successional stage		Both a pioneer and a climax species; a pioneer following disturbances on coastal sites; its presence is maintained in these forests owing to its longevity, its size, and its ability to regenerate in gaps
Associated forest cover		Occurs with western hemlock and western redcedar, also with bigleaf maple, red alder, and black cottonwood; less frequently found in pure stands
Habitat	**Sites**	Moist, well-drained coastal sites with a heavy maritime influence; riparian zones; does not grow well in swampy areas; high tolerance of ocean spray and brackish water compared to associated species
	Soils	Deep, well-aerated soils; often found on alluvial soils of medium to coarse texture; best growth occurs on soils high in calcium, magnesium, and phosphorus
	Moisture	Restricted to a zone of high annual precipitation, fog, and cool, moist summers; drought-intolerant; requires abundant moisture year-round
	Temperature	Low heat and frost tolerances; occurs in a mild, maritime climate
	Shade tolerance	Shade-tolerant; less shade-tolerant than hemlock but more shade-tolerant than Douglas-fir
Interspecific interactions	**Animal damage**	Incurs less animal damage than associated species; beaver dam flooding may cause mortality
	Mycorrhizal fungi	Ectomycorrhizal inoculation increased seedling growth

Reproduction and Growth

Mode of reproduction		Sexual and vegetative reproduction; monoecious; vegetative reproduction occurs through layering
Reproductive phenology		Reproductive cycle spans two growing seasons; reproductive buds appear in early summer of first year; pollination occurs around May of the second year, 7 to 8 weeks after dormancy is broken; timing depends on temperature; fruit ripens around August
Pollination		Wind-pollinated
Seed	**Seed type**	Cones 2.5 to 4 in (6 to 10 cm) long contain small, winged seeds; a British Columbia study found an average of 7.2 seeds per cone; only 29 percent were viable
	Seed-bearing age	Seed production begins between ages 20 and 40
	Seed size/ weight	210,000 seeds per lb (463,000 seeds per kg)

	Seed longevity/ survivability	Seed viability was maintained in a trial in which cones were stored for 5 months
	Seed crop and frequency	Good seed crops occur every 3 to 5 years; growing-season moisture may affect seed crop in subsequent year
Seed dissemination	**Time of year**	Seed dispersal begins around October and continues through spring; majority of seed released within first 6 weeks
	Method and dispersal agents	Wind-dispersed
	Distance	Wind carries seed 100 ft (30 m) to 0.5 mi (0.8 km) depending on topography and other factors
Germination requirements		Germination occurs on mineral and organic soils and on rotting logs; germination greatest in sunlight resulting from canopy gaps or disturbances such as windstorms
Seedling survival		Survival greatest in open areas, on mineral soil seedbeds where soil drainage is adequate; survival often greater on rotting logs than on the forest floor

Genetics

Mating system	High outcrossing rate
Outcrossing % (t_m)	0.98
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.165
Geographic differentiation	Weak differentiation based on molecular markers
F_{st} or G_{st}	0.08
Patterns of variation	Strong patterns of differentiation for height, growth period, bud set, and cold injury (Q_{ST} = 0.80), but not for growth rate and budburst (Q_{ST} = 0.29)
Genetic analysis research results	Southern populations (California) have higher growth and frost damage than northern (British Columbia) populations; clinal patterns related to climate, especially temperature variables; families within a single watershed in Alaska differed significantly in growth and phenology traits, genetic gradients were related to elevation, slope and aspect

Threats and Management Considerations

Insects and disease	Highly susceptible to insect damage when young, particularly white pine weevil (*Pissodes strobe*); successive years of heavy defoliation by the spruce aphid (*Elatobium abietinum*), usually when winters are mild, may cause branch dieback and tree mortality; low susceptibility to fungal pathogens
Harvest	Historically heavily logged, particularly during World Wars I and II
Fragmentation	Widespread within its range
Fire	Fires are infrequent in its hypermaritime habitat; stem is damaged by low- or high-intensity surface fires
Other damaging agents	Windthrow
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Planted in the northwestern United States and in British Columbia

References

Arno and Hammerly 2007; Campbell et al. 1989; Chaisurisri and El-Kassaby 1994; Chaisurisri et al. 1994; Gapare and Aitken 2005; Gapare et al. 2005; Griffith 1992b; Harris 1990b; Klinka et al. 2000; Mimura and Aitken 2007a, 2007b; USDA NRCS 2010; Yeh and El-Kassaby 1980

Whitebark pine (*Pinus albicaulis*)

Ecology

Description		A small or medium-sized evergreen conifer reaching 80 ft (25 m) or more in height on some sites; slow-growing and long-lived; often multi-stemmed; long branches form an irregular, upswept crown; occurs as a low shrub or krummholz form near timberline; grayish-brown, scaly bark
Distribution		Two longitudinally oriented distributions; the coastal distribution reaches from the Coast Ranges of British Columbia through the Cascade Range and the Sierra Nevada; the interior distribution occupies the Rocky Mountains of British Columbia and Alberta southward through Idaho and Wyoming; in Washington and Oregon, whitebark pine occurs in the Cascade and Olympic Ranges and in the mountains of northeastern Oregon
Successional stage		A pioneer species at all elevations within its range; an early seral species at its lower elevations; a climax species around timberline; in the upper timberline zone it may be the sole climax species
Associated forest cover		Occurs with subalpine fir, Engelmann spruce, lodgepole pine, mountain hemlock, and western white pine; pure whitebark pine stands occur at its highest elevations and on dry sites
Habitat	**Sites**	Exposed ridgetops and dry, rocky sites
	Soils	Found on a variety of soils types, although soils are generally rocky and poorly developed
	Moisture	Tolerates cool, droughty summer conditions; majority of precipitation occurs as snow; heavy snowpack is common
	Temperature	Tolerant of severe winter conditions; highly tolerant of frost; moderately tolerant of heat, although seedling may suffer heat damage
	Shade tolerance	Low to intermediate shade tolerance; less shade-tolerant than subalpine fir, Engelmann spruce, and mountain hemlock; more shade-tolerant than lodgepole pine but similar tolerance to western white pine
Interspecific interactions	**Animal damage**	High level of predation by species that disperse seed including Clark's nutcracker, pine squirrel (*Tamiasciurus* spp.), chipmunk (*Tamias* spp.), and deer mice (*Peromyscus* spp.)
	Mycorrhizal fungi	Associated with endomycorrhizae and ectomycorrhizae including *Cenococcum graniforme*

Reproduction and Growth

Mode of reproduction		Reproduces sexually and vegetatively; monoecious; vegetative reproduction is through layering, usually in its krummholz growth form
Reproductive phenology		Reproductive cycles spans two growing seasons; pollination occurs from May to August of the first year depending on elevation, latitude, and temperature; fertilization occurs 13 months after pollination and female cones ripen in August or September of the second year
Pollination		Wind-pollinated
Seed	**Seed type**	Egg-shaped cones 2 to 3.5 in (5 to 9 cm) long with large, wingless seeds
	Seed-bearing age	Seed production begins about age 20 to 30 years; full production reached at age 60 to 100 years
	Seed size/ weight	2,200 to 4,500 seeds per lb (4,850 to 9,900 seeds per kg)

	Seed longevity/ survivability	Apparently the only North American pine (*Pinus*) with a seed bank; seed has been stored successfully at sub-freezing temperatures for 8 years
	Seed crop and frequency	Individual trees produce large seed crops every 3 to 5 years; some seed produced every year at the stand level
Seed dissemination	**Time of year**	Seeds are dispersed by Clark's nutcracker when they ripen in the fall
	Method and dispersal agents	Clark's nutcracker is the primary dispersal agent; nutcrackers break open indehiscent cones using their beaks and then bury the seeds in shallow caches
	Distance	Many seeds cached within 1,640 ft (500 m) of source tree; emigrant nutcrackers cache seeds within 1.2 mi (2 km) of source trees; resident nutcrackers transport seeds an average of 6 mi (9.8 km) from source tree; some seeds have been transported as far as 18 mi (29 km)
Germination requirements		Seed must complete embryonic development, which often occurs after it is cached by Clark's nutcracker; stratification and seedcoat weathering required for germination; moist seedbed required; germination rate often low owing to these factors; germination epigeal
Seedling survival		Seedlings consumed by many animals including pocket gophers, elk, Clark's nutcracker and other bird species, and chipmunks; heat damage to unshaded seedlings may cause mortality
Vegetative phenology		Most growth occurs in mid-summer; growth rate is generally slow, and very slow on cold sites

Genetics

Mating system	Predominantly outcrossing but with moderate level of inbreeding present in some areas
Outcrossing % (t_m)	0.73-0.88
Genetic diversity	Genetic diversity average in Cascades; Olympic populations have somewhat lower diversity
Heterozygosity (H_e)	0.19 in Cascades, H_e = 0.16 in Olympics
Geographic differentiation	Weak differentiation based on molecular markers but strong differentiation based on quantitative traits
F_{st} or G_{st}	0.04
Patterns of variation	Q_{ST} = 0.36-0.47 for cold adaptation traits, 0.07-0.14 for growth traits
Genetic analysis research results	Significant population variation found in most traits; cold adaptation traits correlated with winter temperature while growth traits correlated with growing season length; predominantly outcrossing but some individuals highly inbreeding, although inbreeding depression detected only in biomass; northern and interior populations have highest cold hardiness in fall but lowest in spring and vice versa in the south

Threats and Management Considerations

Insects and disease	White pine blister rust, caused by *Cronartium ribicola*, is the most damaging pathogen; white pine blister rust increases susceptibility to mountain pine beetle, the most damaging insect; dwarf mistletoe and needle cast fungi can cause damage on some sites
Harvest	Rarely harvested
Fragmentation	Populations are scattered owing to discontinuous distribution of habitat in high-elevation terrain

Fire	Fire benefits whitebark pine by reducing competition and creating new habitat in which it may establish; whitebark pine is more resistant to fire than its later-seral associates
Other damaging agents	Potential damaging agents include landslides
NatureServe conservation status ranking	G3/G4: G3 Vulnerable—At moderate risk of extinction or elimination due to a restricted range, relatively few populations, recent and widespread declines, or other factors/G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors; range indicates some uncertainty about the exact status; populations of whitebark pine are affected by white pine blister rust, mountain pine beetle, and succession resulting from decades of fire suppression
Silvicultural considerations	Fire suppression has reduced regeneration of whitebark pine and increased the prevalence of shade-tolerant associates that overtop and shade whitebark pine; whitebark pine habitat is relatively inaccessible

References

Arno and Hammerly 2007; Arno and Hoff 1990; Aubry et al. 2008; Aubry and Rochefort [N.d.]; Bonner and Karrfalt 2008; Bower and Aitken 2006, 2007, 2008; Bower et al. [N.d.]; Bruederle et al. 1998; Howard 2002; Jorgensen and Hamrick 1997; Klinka et al. 2000; Krakowski et al. 2003; Lorenz et al. 2008; Lorenz and Sullivan 2009; Richardson et al. 2002a, 2002b, 2010; Rogers et al. 1999; Shoal and Aubry 2004, 2006; USDA NRCS 2010; Ward et al. 2006; Warwell et al. 2006

Knobcone Pine (*Pinus attenuata*)

Ecology

Description		A small, short-lived, evergreen conifer, typically 30 to 60 ft (9 to 18 m) in height; usually multi-stemmed; forms a broad, dense crown when young, becoming more open at maturity; branches may extend nearly to ground level; foliage is whitish green; cones are abundant and formed in clusters; bark is thin and smooth, becoming darker and scaly with age
Distribution		Occurs from southwestern Oregon southward through the Cascade, Klamath, and Coast ranges, and through the Sierra Nevada; populations are discontinuous through parts of its range, and widely disjunct in its southern distribution; elevation ranges from sea level to 5,500 ft (1,680 m), and from 1,000 to 2,500 ft (300 to 760 m) in southwestern Oregon
Successional stage		A pioneer species; establishes rapidly after fire; stands of this short-lived species begin to deteriorate by age 60; adapted to extremely harsh sites where other tree species cannot survive
Associated forest cover		Occupies a transitional zone between chaparral and woodlands and higher elevation forests; usually occurs in patches, surrounded by other communities; low-density knobcone pine stands may be referred to as woodlands; at lower elevations, knobcone pine is associated with oak (*Quercus* spp.) woodlands; it also is associated with a variety of species including Monterey pine (*Pinus radiata*), Coutler pine (*Pinus coulteri*), Digger pine (*Pinus sabiniana*), sugar pine (*Pinus lambertiana*), shore pine (*Pinus contorta* spp. *contorta*), bigcone Douglas-fir (*Pseudotsuga macrocarpa*), Pacific madrone, tanoak (*Lithocarpus densiflora*), giant chinquapin, incense-cedar, and Pacific yew
Habitat	**Sites**	Occurs on hot, dry, harsh sites, often on rocky, eroding slopes and on poor soils, including serpentine escarpments
	Soils	Frequently found on shallow, infertile soils; found on serpentine soils that are toxic to many other plants; soil parent materials are often of volcanic origin
	Moisture	Drought tolerant; occurs on soils too dry for most other tree species; also occurs on serpentine soils which have somewhat more available water than other soils on similar sites
	Temperature	Tolerant of heat
	Shade tolerance	Intolerant of shade and competition from other trees
Interspecific interactions	**Animal damage**	Unpalatable to browsing animals; some seed consumed by western gray squirrel and by birds
	Mycorrhizal fungi	Probably mycorrhizal, although specific information was not found

Reproduction and Growth

Mode of reproduction	Reproduces sexually; monoecious
Reproductive phenology	Pollination occurs between March and May; seeds mature in fall of the second year (16 to 18 months after pollination), but cones do not fully mature until late winter of the second year or in early spring of the third year
Pollination	Wind-pollinated

Seed	**Seed type**	Trees produces seed cones in clusters of four or five, firmly attached in a tight whorl; the cones remain attached to the tree and are never dropped; cones are serotinous, sealed with resin that allows them to open only after exposure to very high temperatures (i.e., heat from fire); after cones begin to open, they may drop seed over a period of 4 years or longer; without fire, cones may remain closed for 30 years or more, even after the tree dies; seeds are small and light, with thin seed coats and long wings
	Seed-bearing age	Trees begin to produce seed between 5 and 12 years of age
	Seed size/ weight	Averages 25,400 seeds per lb (56,000 seeds per kg)
	Seed longevity/ survivability	A limited number of tests have indicated that viability of seeds in cones does not decline over time; seed has been successfully stored in sub-freezing conditions for 16 years
	Seed crop and frequency	One study reported an average production of 176 cones per tree for trees over 20 years old (Vogl 1973); a cone crop is produced every year
Seed dissemination	**Time of year**	Cones open only after exposure to high temperatures associated with fire
	Method and dispersal agents	Wind-dispersed; birds and small mammals also may disseminate a small amount of seed
	Distance	Specific distances are undocumented, although seeds have a high ratio of wing length to seed size and are likely capable of long dispersal distances
Germination requirements		Seeds require cold stratification; germination occurs more rapidly than in related species; laboratory tests showed that germinative capacity of seed from mechanically opened cones ranged from 57 to 91 percent
Seedling survival		Survival of germinants requires bare mineral soil; seedlings are drought tolerant and deeply rooted; seedlings tolerate infertile soils

Genetics

Mating system	Strongly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.964
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.138
Geographic differentiation	Moderate population differentiation based on molecular markers
F_{st} or G_{st}	0.12

Threats and Management Considerations

Insects and disease	Can be severely impacted by western gall rust (caused by *Endocronartium harknesii*) and dwarf mistletoe; infestation by *Ips* spp. results in topkill and tree mortality
Harvest	Not a commercial timber species
Fire	Dependent on fire for regeneration and population survival; fire is necessary to open the fire-resistant, serotinous cones and to temporarily remove competing vegetation and prepare the seedbed; without fire, knobcone pine is replaced by chaparral at lower elevations and by other conifer species at higher elevations
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant

Silvicultural considerations	May be planted for restoration or erosion control purposes; planted seedlings have shown good survival and growth rates

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Burczyk et al. 1996, Conkle 1996, Howard 1992a, Kitzmiller and Stover 1996, Millar et al. 1988, Vogl 1973

Shore pine (*Pinus contorta* var. *contorta*)

Ecology

Taxonomy and nomenclature		Three varieties of lodgepole pine (*P. contorta*) are native to Washington and Oregon; *P. contorta* var. *contorta* (shore pine) grows in the coastal region, *P. contorta* var. *latifolia* (lodgepole pine) is typically found on interior mountains of Washington, and *P. contorta* var. *murrayana* (Sierra lodgepole pine) is found in the mountains of Oregon; shore pine and lodgepole pine overlap and intergrade from the Puget Sound region northward; *P. contorta* var. *murrayana* is recognized by most authorities, although some authorities consider var. *murrayana* to be synonymous with var. *latifolia*; *P. contorta* var. *murrayana* was not distinguished from var. *latifolia* by any of the sources from which we acquired occurrence data for mapping
Description		A small, evergreen conifer reaching 20 to 50 ft (6 to 15 m) in height; stunted, frequently irregular crown with many branches often occurring to the ground; twisted stem with thick, grooved bark
Distribution		Along the Pacific Coast from southeastern Alaska to northern California; usually occurs at elevations lower than 2,000 ft (600 m)
Successional stage		An early seral species where it is replaced by Douglas-fir or other species; a climax species on many extreme sites where other species cannot grow
Associated forest cover		Extensive pure stands in the northern part of its range; also a component of mixed stands in the southern part of its range including Washington and Oregon; forms thickets or groves in mixed stands with a number of species including Douglas-fir, western redcedar, Sitka spruce, western hemlock, and Oregon white oak
Habitat	**Sites**	Occurs in a maritime climate throughout its range; bogs and lowlands; poorly drained sites; poor-quality, disturbed sites; coastal dunes and seaside bluffs
	Soils	Poorly drained, deep organic soils; swamps; sandy or rocky coastal soils; glacial gravel; bedrock; hardpan; disturbed soils; frequent on very nutrient-poor sites
	Moisture	Tolerates very dry to very wet, seasonally flooded sites
	Temperature	Tolerant of heat; frost-tolerant
	Shade tolerance	Intolerant of shade
Interspecific interactions	**Animal damage**	Seeds may be consumed by rodents
	Mycorrhizal fungi	Associated with ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		Reproductive cycle lasts approximately 26 months; male and female strobili initiated in late summer; pollination occurs in May or June of the following growing season; fertilization occurs around June of the third year and seed development is completed by late summer
Pollination		Wind-pollinated
Seed	**Seed type**	Cones 1.5 to 2 in (4 to 5 cm) long; small, winged seeds; cones usually nonserotinous
	Seed-bearing age	Seed production usually begins by 10 years of age

	Seed size/ weight	135,000 seeds per lb (298,000 seeds per kg)
	Seed longevity/ survivability	Cones are persistent, remaining on trees for years open or closed; seeds have remained viable for 17 years at sub-freezing temperatures
	Seed crop and frequency	A prolific seed producer; large seed crops produced at 1- to 3-year intervals; some seed produced every year; seedfall in Oregon was measured at 14,000 to 500,000 seeds per ac (35,000 to 1,2000,000 seeds per ha)
Seed dissemination	**Time of year**	Seed from nonserotinous cones usually dispersed in late summer and fall and to a lesser extent in winter
	Method and dispersal agents	Seed primarily dispersed by wind; intense sunlight or fire opens serotinous cones; some seed dispersed by Douglas squirrels (*Tamiasciurus douglasi*), other rodents, or birds
	Distance	Seeds are usually dispersed less than 200 ft (60 m), although strong winds may carry them much farther
Germination requirements		Germination greatest in full sunlight on bare mineral soil or disturbed duff layer, assuming sufficient moisture; germination epigeal; stratification usually not necessary; germination rates high under favorable conditions
Seedling survival		Germinants very sensitive to dry conditions during first few weeks; seedlings shallow-rooted in first year and prone to drought mortality; young seedlings are prone to frost-heaving; seedlings are poor competitors relative to other herbaceous and woody vegetation
Vegetative phenology		Buds containing all the structures of the new shoots are formed throughout the previous growing season; these buds then begin to elongate around May; trees in coastal or mild climates often exhibit polycyclic shoot growth, with multiple periods of elongation during the growing season

Genetics

Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.148
Geographic differentiation	Weak genetic differentiation based on molecular markers
F_{st} or G_{st}	0.054
Patterns of variation	Strong differentiation among varieties and populations within varieties based on morphometric traits
Genetic analysis research results	Cone serotiny is absent or infrequent in this subspecies. Levels of gene flow among coastal populations are lower and therefore differentiation is high than var. *latifolia*. This variety likely persisted in multiple coastal refugia during glaciation

Threats and Management Considerations

Insects and disease	Susceptible to insect and fungal damage; damaging agents include the shore pine bark beetle (*Pseudohylesinus pini*), and *Ips* spp. wood borers, several species of needle cast fungi, western gall rust(caused by *Endocronartium harknessii)*, and *Phellinus pini*; dwarf mistletoe (*Arceuthobium siskiyouense*) is locally damaging on a disjunct inland population
Harvest	Shore pine is small and forms many branches, making it a poor species for timber production
Fragmentation	Widespread throughout its range
Fire	Low resistance to damage from fire; regenerates well following fire, but fire is infrequent in its maritime habitat

NatureServe conservation status ranking	G5T5 Secure—Common; widespread and abundant
Silvicultural considerations	Survives in saline coastal environments; used to stabilize soil and sand dunes

References

Arno and Hammerly 2007; Bonner and Karrfalt 2008; Cope 1993b; Despain 2001; Fazekas and Yeh 2006; Godbout et al. 2008; Klinka et al. 2000; Kurz et al. 2008; Lotan and Critchfield 1990; Owens 2006; Perry 1978; Perry and Dancik 1986; Rehfeldt et al. 1999, 2001; Rweyongeza et al. 2007; USDA NRCS 2010; Van Den Berg and Lanner 1971; Wagg et al. 2008; Wheeler and Guries 1982a, 1982b; Yang and Yeh 1993; Yeh and Layton 1979; Ying 1991; Ying and Liang 1994

Lodgepole pine (*Pinus contorta* var. *latifolia*)

Ecology

Taxonomy and nomenclature		Three varieties of lodgepole pine (*P. contorta*) are native to Washington and Oregon; *P. contorta* var. *contorta* (shore pine) grows in the coastal region, *P. contorta* var. *latifolia* (lodgepole pine) is typically found on interior mountains of Washington, and *P. contorta* var. *murrayana* (Sierra lodgepole pine) is found in the Cascade Range of Oregon southward; shore pine and lodgepole pine overlap and intergrade from the Puget Sound region northward; *P. contorta* var. *murrayana* is recognized by most authorities, although some authorities consider var. *murrayana* to be synonymous with var. *latifolia*; *P. contorta* var. *murrayana* was not distinguished from var. *latifolia* by any of the sources from which we acquired occurrence data for mapping
Description		A small-to-medium, short-lived, evergreen conifer reaching 45 to 150 ft (13 to 45 m) in height, depending on the site; a straight, slender stem and a narrow, thin crown; self-prunes lower branches; thin, gray-brown, scaly bark
Distribution		From southeastern Alaska to northwestern Mexico; from the Pacific Coast eastward to South Dakota; in the Pacific Northwest, most common east of the Cascade crest, although also present west of the crest; found at elevations from 1,500 to 11,500 ft (450 to 3,500 m) throughout its range; authorities recognizing *P. contorta* var. *murrayana* consider the range of var. *latifolia* in the Pacific Northwest to include the Washington Cascade Range and eastern Oregon and Washington but not the Oregon Cascade Range, the Klamath Mountains, or any of California
Successional stage		An aggressive pioneer species frequently regenerating in single-aged stands after fire; replaced in less than 100 years by other conifer species on productive sites; a subclimax species on sites with periodic stand-replacing fire; a climax species on harsh sites where other conifers grow poorly or not at all
Associated forest cover		Often found in pure stands, but also occurs in mixed stands with a wide variety of other conifers including Douglas-fir, grand fir, western white pine, ponderosa pine, mountain hemlock, Engelmann spruce, subalpine fir, red fir, white fir, and Pacific silver fir
Habitat	**Sites**	Occurs in the Pacific Northwest at mid- to high elevations; tolerant of nearly all sites but most prevalent on sites where periodic stand-replacing fire occurs or where extreme conditions limit establishment of other species; occurs on rocky soils and steep slopes and ridges
	Soils	Grows on nearly all soil types within its range; tolerates extreme conditions where other tree species cannot survive; often found on poorly developed, shallow, and nutrient-poor soils
	Moisture	Tolerates very dry to very wet, seasonally flooded sites
	Temperature	Tolerant of heat; frost-tolerant
	Shade tolerance	Intolerant of shade
Interspecific interactions	**Animal damage**	Not a preferred browse species; damaged by porcupines feeding on bark
	Mycorrhizal fungi	Associated with ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction	Reproduction is sexual; monoecious

Reproductive phenology		Reproductive cycle lasts approximately 26 months; male and female strobili initiated in late summer; pollination occurs in May or June of the following growing season; fertilization occurs around June of the third year and seed development is completed by late summer
Pollination		Wind-pollinated
Seed	**Seed type**	Cones 1.5 to 2 in (4 to 5 cm) long; small, winged seeds; cone serotiny is a function of disturbance type; percentage of serotinous cones is greatest where stand-replacing fire is most frequent
	Seed-bearing age	Seed production usually begins between 5 and 15 years of age
	Seed size/ weight	94,000 seeds per lb (207,000 seeds per kg)
	Seed longevity/ survivability	Cones are persistent, remaining on trees for many years open or closed; seeds in closed cones in the tree canopy may remain viable for 80 years; seeds have remained viable for 20 years in storage at sub-freezing temperatures
	Seed crop and frequency	A prolific seed producer; large seed crops produced at 1- to 3-year intervals; some seed produced every year; annual seed production in a nonserotinous stand of *P. contorta* var. *latifolia* was greater than 600,000 seeds per ac (1,500,000 seeds per ha)
Seed dissemination	**Time of year**	Seed from nonserotinous cones usually dispersed in late summer and fall and to a lesser extent in winter
	Method and dispersal agents	Seed primarily dispersed by wind; intense sunlight or fire opens serotinous cones; some seed dispersed by Douglas squirrels (*Tamiasciurus douglasi*), other rodents, or birds
	Distance	Seeds are usually dispersed less than 200 ft (60 m), although strong winds may carry seeds much further
Germination requirements		Germination greatest in full sunlight on bare mineral soil or disturbed duff layer, assuming sufficient moisture; germination epigeal; stratification usually not necessary; germination rates high under favorable conditions; laboratory germination was 65 to 90 percent
Seedling survival		Germinants very sensitive to dry conditions during first few weeks; seedlings shallow-rooted in first year and prone to drought mortality; young seedlings are prone to frost-heaving; seedlings are poor competitors relative to other herbaceous and woody vegetation
Vegetative phenology		Buds containing all the structures of the new shoots are formed throughout the previous growing season; these buds then begin to elongate around May; trees in coastal or mild climates often exhibit polycyclic shoot growth, with multiple periods of elongation during the growing season

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.95
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.156
Geographic differentiation	Weak genetic differentiation based on molecular markers
F_{st} or G_{st}	0.036
Patterns of variation	Strong differentiation among varieties and populations within varieties based on morphometric traits

Genetic analysis research results	There is a relationship between geographic and genetic distance for this variety; recent interpretations of genetic and paleobotanical evidence seems to indicate a single glacial refugium south of the ice sheet and subsequent northward migration

Threats and Management Considerations

Insects and disease	Suffers extensive damage from insects and fungi, particularly mountain pine beetle (*Dendroctonus ponderosae*); also damaged by pine engraver, northern lodgepole pine needleminer, blister rust, gall rusts, stem rots, and stem cankers
Harvest	An important commercial species in the Pacific Northwest, especially in British Columbia
Fragmentation	Widespread throughout its range in the Pacific Northwest
Fire	Low resistance to damage from fire; regenerates rapidly following fire
Other damaging agents	Dwarf mistletoe (*Arceuthobium* spp.) causes damage; susceptible to windfall
NatureServe conservation status ranking	G5T5 Secure—Common; widespread and abundant
Silvicultural considerations	Natural regeneration following fire is sometimes very dense, and growth subsequently stagnates

References

Anderson 2003; Arno and Hammerly 2007; Bonner and Karrfalt 2008; Despain 2001; Fazekas and Yeh 2006; Godbout et al. 2008; Klinka et al. 2000; Kurz et al. 2008; Lotan and Critchfield 1990; Owens 2006; Perry 1978; Perry and Dancik 1986; Rehfeldt et al. 2001; Rehfeldt et al. 1999; Rweyongeza et al. 2007; USDA NRCS 2010; Van Den Berg and Lanner 1971; Wagg et al. 2008; Wheeler and Guries 1982a, 1982b; Yang and Yeh 1993; Yeh et al. 1985; Yeh and Layton 1979; Ying 1991; Ying and Liang 1994

Sierra lodgepole pine (*Pinus contorta* var. *murrayana*)

Ecology

Taxonomy and nomenclature		Three varieties of lodgepole pine (*P. contorta*) are native to Washington and Oregon; *P. contorta* var. *contorta* (shore pine) grows in the coastal region, *P. contorta* var. *latifolia* (lodgepole pine) is typically found on interior mountains of Washington, and *P. contorta* var. *murrayana* (Sierra lodgepole pine) is found in the mountains of Oregon; shore pine and lodgepole pine overlap and intergrade from the Puget Sound region northward; *P. contorta* var. *murrayana* is recognized by most authorities, although some authorities consider var. *murrayana* to be synonymous with var. *latifolia*; *P. contorta* var. *murrayana* was not distinguished from var. *latifolia* by any of the sources from which we acquired occurrence data for mapping
Description		A medium-sized, long-lived, evergreen conifer reaching 90 to 100 ft (28 to 30 m) in height; a straight stem and a mostly conical crown at maturity; short branches; thin, orange to purple-brown, scaly bark
Distribution		From the Cascade Range of Oregon into California; in the Klamath Mountains and the Sierra Nevada Range; disjunct populations occur in southern California and Mexico; occurs at elevations from 3,000 to 7,000 ft (910 to 2,130 m) in Oregon; var. *latifolia* and var. *murrayana* intergrade in the central and northern Cascades (Lotan and Critchfield 1990)
Successional stage		An aggressive pioneer species frequently regenerating in single-aged stands after fire; replaced in less than 100 years by other conifer species on productive sites; a subclimax species on sites with periodic stand-replacing fire; a climax species on harsh sites where other conifers grow poorly or not at all
Associated forest cover		Often found in pure stands, but also occurs in mixed stands with a wide variety of other conifers including Douglas-fir, grand fir, western white pine, ponderosa pine, mountain hemlock, Engelmann spruce, subalpine fir, red fir, white fir, and Pacific silver fir
Habitat	**Sites**	Occurs in the Pacific Northwest at mid- to high elevations; tolerant of nearly all sites but most prevalent on sites where periodic stand-replacing fire occurs or where extreme conditions limit establishment of other species; occurs on rocky soils and steep slopes and ridges
	Soils	Grows on nearly all soil types within its range; tolerates extreme conditions where other tree species cannot survive; often found on poorly developed, shallow, and nutrient-poor soils
	Moisture	Tolerates very dry to very wet, seasonally flooded sites
	Temperature	Tolerant of heat; frost-tolerant
	Shade tolerance	Moderately tolerant of shade
Interspecific interactions	**Animal damage**	Not a preferred browse species; damaged by porcupines feeding on bark
	Mycorrhizal fungi	Associated with ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction	Reproduction is sexual; monoecious
Reproductive phenology	Reproductive cycle lasts approximately 26 months; male and female strobili initiated in late summer; pollination occurs in May or June of the following growing season; fertilization occurs around June of the third year and seed development is completed by late summer

Pollination		Wind-pollinated
Seed	**Seed type**	Cones 1.6 to 2.4 in (4 to 6 cm) long; non-serotinous
	Seed-bearing age	Seed production usually begins between 5 and 15 years of age
	Seed size/ weight	117,000 seeds per lb (258,000 seeds per kg)
	Seed longevity/ survivability	Cones not persistent; seeds have remained viable for 17 years in storage at sub-freezing temperatures
	Seed crop and frequency	A prolific seed producer; large seed crops produced at 1- to 3-year intervals; some seed produced every year
Seed dissemination	**Time of year**	Cones open and disperse seed from late August to mid-October
	Method and dispersal agents	Seed dispersed by wind
	Distance	Seeds are usually dispersed less than 200 ft (60 m), although strong winds may carry seeds much further
Germination requirements		Germination greatest in full sunlight on bare mineral soil or disturbed duff layer, assuming sufficient moisture; germination epigeal; stratification usually not necessary; germination rates high under favorable conditions; laboratory germination was 65 to 90 percent
Seedling survival		Germinants very sensitive to dry conditions during first few weeks; seedlings shallow-rooted in first year and prone to drought mortality; young seedlings are prone to frost-heaving; seedlings are poor competitors relative to other herbaceous and woody vegetation
Vegetative phenology		Buds containing all the structures of the new shoots are formed throughout the previous growing season; these buds then begin to elongate around May; trees in coastal or mild climates often exhibit polycyclic shoot growth, with multiple periods of elongation during the growing season

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.98
Genetic diversity	Average genetic diversity based on molecular markers
Heterozygosity (H_e)	0.12
Geographic differentiation	Weak genetic differentiation based on molecular markers
F_{st} or G_{st}	0.03 (at the species level)
Patterns of variation	Strong differentiation among varieties and populations within varieties based on morphometric traits
Genetic analysis research results	There is a relationship between geographic and genetic distance for this variety; recent interpretations of genetic and paleobotanical evidence seems to indicate a single glacial refugium south of the ice sheet and subsequent northward migration

Threats and Management Considerations

Insects and disease	Suffers extensive damage from insects, particularly mountain pine beetle (*Dendroctonus ponderosae*); also damaged by pine engraver, western gall rust (caused by *Endocronartium harknessii*), and several species of decay fungi. Needle cast fungi may be damaging during moist springs. Dwarf mistletoe (*Arceuthobium americanum*) may cause severe damage locally
Harvest	An important commercial species in the Pacific Northwest, especially in British Columbia
Fragmentation	Widespread throughout its range in the Pacific Northwest
Fire	Low resistance to damage from fire; regenerates rapidly following fire
Other damaging agents	Susceptible to windfall
NatureServe conservation status ranking	G5T4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors
Silvicultural considerations	Natural regeneration following fire is sometimes very dense, and growth subsequently stagnates

References

Anderson 2003; Arno and Hammerly 2007; Bonner and Karrfalt 2008; Despain 2001; Fazekas and Yeh 2006; Godbout et al. 2008; Klinka et al. 2000; Kurz et al. 2008; Lotan and Critchfield 1990; Owens 2006; Perry 1978; Perry and Dancik 1986; Rehfeldt et al. 1999, 2001; Rweyongeza et al. 2007; Sorensen 2001; USDA NRCS 2010; Van Den Berg and Lanner 1971; Wagg et al. 2008; Wheeler and Guries 1982a, 1982b; Yang and Yeh 1993; Yeh et al. 1985; Yeh and Layton 1979; Ying 1991; Ying and Liang 1994

Limber pine (*Pinus flexilis*)

Ecology

Description		A small, long-lived, slow-growing, evergreen conifer, typically reaching 40 ft (12 m) in height at mid-elevations and only 20 ft (6 m) at high elevations; crowns are usually irregular in shape and quite variable; branches are upswept and the stem is typically divided; may have krummholz form at treeline; bark is rough and dark brown with large plates
Distribution		From Alberta and British Columbia south to southern California, Arizona, and New Mexico; from eastern Idaho and Nevada eastward to the edge of the Great Plains; a disjunct population occurs at high elevations in Oregon's Wallowa Mountains; limber pine's distribution is highly fragmented throughout western North America
Successional stage		A pioneer species on harsh montane sites; eventually replaced by other conifers except on the most extreme sites where it is a climax species in self-maintained, all-aged populations
Associated forest cover		Occurs with Rocky Mountain Douglas-fir, Rocky Mountain juniper, Engelmann spruce, whitebark pine, subalpine fir, bristlecone pine (*Pinus longaeva*), quaking aspen, and lodgepole pine
Habitat	**Sites**	Occupies a wide elevational range across its distribution (2,850 to 12,500 ft; 870 to 3,810 m); occurs on dry sites near lower treeline and near grassland edges; also occurs on high-elevation sites near upper treeline; often found on rocky, steep, exposed, and infertile sites; occurs from 5,000 to 7,000 ft (1,500 to 2,100 m) elevation in Oregon
	Soils	Grows on well-drained soils of many parent materials; often found on calcareous soils; commonly occurs on infertile soils including serpentines
	Moisture	Highly drought tolerant; intolerant of saturated soils; mostly absent from Pacific Northwest sites with maritime weather patterns
	Temperature	High frost tolerance
	Shade tolerance	Intolerant of shade
Interspecific interactions	**Animal damage**	Porcupine damage has been reported
	Mycorrhizal fungi	Associated with both ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		Flowers emerge in spring and pollination occurs during a relatively short period in June or July; pollen phenology is influenced by elevation, and populations differing by more than 1,300 ft (400 m) elevation do not have overlapping pollination periods; fertilization occurs in spring or early summer of the second year; seeds and cones mature in August and September of the second year
Pollination		Wind-pollinated
Seed	**Seed type**	Large seeds, sometimes with a vestigial wing, borne in cones 3 to 6 in (8 to 15 cm) long
	Seed-bearing age	Minimum seed-bearing age is at least 20 to 40 years

	Seed size/ weight	Averages 4,900 seeds per lb (10,800 seeds per kg)
	Seed longevity/ survivability	Seed has been successfully stored for 5 years
	Seed crop and frequency	Large seed crops are produced every 2 to 4 years
Seed dissemination	**Time of year**	Clark's nutcrackers begin to harvest seed in August when cones are still green and not fully opened; cones open in September and October
	Method and dispersal agents	Seeds are dispersed by bird and rodent caching; Clark's nutcracker is the most important seed dispersal agent; the location of limber pine stands may be a result of site preferences of dispersal agents
	Distance	Clark's nutcrackers may transport seed at least 14 mi (23 km)
Germination requirements		Seeds may germinate without stratification, but cold, moist stratification increases germination; germination epigeal
Seedling survival		Seedlings are very drought tolerant; seedlings often develop in clusters, as multiple seedlings emerge from the same seed cache; seedlings within clusters are often from different parent trees

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.98 (from limited sample size)
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.186
Geographic differentiation	Average population differentiation based on molecular markers
F_{st} or G_{st}	0.101
Patterns of variation	Little genetic variation in seedling trials was observed for growth, survival, and morphological traits from low, medium, and high elevations; however, physiological traits (carbon and water relations) differed with source elevation
Genetic analysis research results	The fundamental and realized niche of limber pine is broad with respect to air temperature, indicating that the species has more of a generalist adaptive strategy with wide phenotypic plasticity

Threats and Management Considerations

Insects and disease	Susceptible to numerous fungal diseases, but the most damaging and widespread is white pine blister rust; limber pine is apparently less resistant than other North American white pines; also susceptible to injury from mountain pine beetles and a variety of other insects; suffers damage or mortality from limber pine dwarf-mistletoe (*Arceuthobium cyanocarpum*)
Fragmentation	The distribution of limber pine is highly discontinuous within its range, likely as a result of seed dispersal vectors; the population in Oregon is apparently disjunct
Harvest	Not an important commercial species
Fire	Sparse fuels and long, irregular fire return intervals result in infrequent fire in most limber pine communities; young trees are easily killed by fire; older trees have thick bark and are resistant to low-severity surface fire
NatureServe conservation status ranking	G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors

Silvicultural considerations	Limber pine seed is an important food source for many wildlife species

References

Bonner and Karrfalt 2008, Johnson 2001, Jørgensen et al. 2002, Klinka et al. 2000, Owens et al. 1998, Reinhardt et al. 2011, Schoettle and Rochelle 2000, Schuster and Mitton 2000, Steele 1990, USDA NRCS 2010

Jeffrey pine (*Pinus jeffreyi*)

Ecology

Description		A large, long-lived, evergreen conifer, occasionally reaching 200 ft (60 m) in height; young trees have pyramidal crowns, and older trees have rounded crowns; large, lower branches may droop while upper branches are ascending; bark becomes thick and reddish brown with age and consists of large, thick plates; trees are deeply taprooted and have extensive lateral root systems; Jeffrey pine was once classified as a variety of ponderosa pine because the species closely resemble one another
Distribution		From the Siskiyou and Klamath mountains of southwestern Oregon to northern California and southward through the Sierra Nevada Range to southern California and Mexico; occurs in Oregon from 1,200 to 6,000 ft (370 to 1,830 m) elevation
Successional stage		An early successional species, eventually replaced by shade-tolerant conifers in the absence of fire or other disturbance; trees become fire-resistant with age, and regular, low-intensity fire facilitates the persistence of Jeffrey pine; a potential climax species on very harsh sites and on serpentine soils
Associated forest cover		Most frequently associated with Douglas-fir, ponderosa pine, and incense-cedar; on serpentine soils, most often associated with incense-cedar
Habitat	**Sites**	Found on relatively harsh sites throughout its range; in the North Coast Range and Klamath Mountains it is almost always found on serpentine soils; competes well with other conifers on droughty, infertile, cold sites; more cold-tolerant than ponderosa pine; prevalent in montane forests above the ponderosa pine zone;
	Soils	Grows on any well-drained soil, including the very infertile soils formed in ultramafic parent materials; soils are typically coarse-textured, rocky, shallow, and infertile
	Moisture	Very low tolerance of saturated soils; drought-tolerant; lowest average annual precipitation within its full range is 15 to 17 in (38 to 43 cm); considered more drought-tolerant than ponderosa pine
	Temperature	Tolerates short growing seasons and cold; throughout its range, average January temperatures range from 9 to 36 °F (-13 to 2 °C); more cold-tolerant than ponderosa pine
	Shade tolerance	Intolerant of shade
Interspecific interactions	**Animal damage**	Young trees may be killed or damaged by a variety of mammals, including deer, rabbits, and pocket gophers
	Mycorrhizal fungi	Known to have ectomycorrhizal associations

Reproduction and Growth

Mode of reproduction		Reproduces sexually; monoecious
Reproductive phenology		Flowers from June to July, depending on climate, elevation, and aspect; fertilization occurs approximately 13 months after pollination; cones ripen from August to September of the second year
Pollination		Wind-pollinated
Seed	**Seed type**	Cones 5 to 9 in (13 to 23 cm) long containing relatively heavy, winged seeds
	Seed-bearing age	Cones are usually not produced until trees are at least 20 years of age

	Seed size/ weight	Averages 3,700 seeds per lb (8,200 seeds per kg)
	Seed longevity/ survivability	Seed banks are created through the unrecovered animal caches of small mammals and birds; germination was not affected by storage for 8.5 years at 40 °F (5 °C); seed was successfully stored at a subfreezing temperature for 18 years
	Seed crop and frequency	Large cone crops occur every 2 to 4 years
Seed dissemination	**Time of year**	Seeds are shed within a period of a few weeks in September or October
	Method and dispersal agents	Seeds are dispersed by a variety of bird and small mammal species as well as by gravity and wind; unrecovered seed caches are important to regeneration of Jeffrey pine
	Distance	Measured dispersal distances were as long as 89 ft (27 m) for wind and 206 ft (63 m) for animal seed caches; estimated dispersal distances by strong winds are much greater
Germination requirements		Germinates readily in spring; germination epigeal; cold stratification for 60 days increases rate of germination but is not necessary; best germination apparently occurs in mineral soil in full sunlight; emergence is greatest for cached seed
Seedling survival		Seedling growth and survival are sensitive to competing vegetation and annual weather conditions; establishment is increased in wet years and in open areas
Vegetative phenology		At 5,300 ft (1,600 m) elevation in the Sierra Nevada, annual growth of young trees began, on average, 16 May, was 50 percent complete after 21 days, and ended after 78 days

Genetics

Mating system	Strongly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.935
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.185
Geographic differentiation	Weak population differentiation based on molecular markers
F_{st} or G_{st}	0.045

Threats and Management Considerations

Insects and disease	Jeffrey pine is host to western dwarf mistletoe (*Arceuthobium campylopodum*); the most damaging insect is the Jeffrey pine beetle (*Dendroctonus jeffreyi*); insects also may cause significant damage to cones and seeds
Fragmentation	The northernmost extent of Jeffrey pine's range is southwestern Oregon, and several small disjunct populations occur in this area
Harvest	Wood of Jeffrey pine is comparable to that of ponderosa pine
Fire	Similar to ponderosa pine, Jeffrey pine is adapted to a regime of frequent, low-intensity fire; mature trees are considered highly resistant to surface fires where there has not been significant accumulation of ladder fuels; trees as small as 2- to 4-in (5- to 10-cm) diameter are considered fire resistant; under fire suppression, recruitment and prevalence of Jeffrey pine decreases, mortality and canopy closure increases, and conditions favor succession to more shade-tolerant tree species

NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Growth is slower than that of ponderosa pine in the sapling stage but faster in the pole stage; rotation-age yield data have not been collected for Jeffrey pine but are assumed to be similar to ponderosa pine

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Furnier and Adams 1986, Gucker 2007a, Jenkinson 1990, Wang and Qiu 2006

Sugar Pine (*Pinus lambertiana*)

Ecology

Description		A large, long-lived, evergreen conifer, commonly reaching 175 to 200 ft (53 to 60 m) in height; the tallest pine species (*Pinus* spp.); young trees have broad, conical crowns extending to near the ground; self-prunes over time to create a long, clear bole; mature trees have long, spreading limbs forming an asymmetrical crown; bark is reddish brown to purple and fissured
Distribution		Occurs in the Cascade Range in north-central Oregon southward and in the Siskiyous; small, scattered populations occur in the Cascade Range as far north as Mount Jefferson and in the mountains east of the Cascades, south of Bend; on the western slope of central Oregon's Cascades, Sugar pine usually occurs between elevations of 1,700 and 3,700 ft (500 to 1,100 m); on the eastern slope and in southern and southwestern Oregon, sugar pine reaches elevations of 5,000 ft (1,500 m)
Successional stage		An early successional species that may persist into late-successional stages owing to its longevity
Associated forest cover		Typically found in mixed-species conifer stands with a wide variety of associates including Douglas-fir, ponderosa pine, western white pine, true firs (*Abies* spp.), incense-cedar, western hemlock, western redcedar, Port-Orford-cedar, tanoak, and Pacific madrone
Habitat	**Sites**	Occurs on moist, mid-elevation sites; found on all aspects at lower-elevation sites and on southern and western aspects at higher elevations
	Soils	Found on a wide variety of soils, usually of medium to fine texture; best growth occurs on deep, well-drained soils
	Moisture	Less drought-tolerant than many associated species including Douglas-fir, ponderosa pine, incense-cedar, and grand fir
	Temperature	Intermediate frost tolerance
	Shade tolerance	More shade-tolerant than ponderosa pine, but slightly less shade-tolerance than Douglas-fir and incense-cedar
Interspecific interactions	**Animal damage**	Squirrels and birds consume seeds; rodents sometimes consume germinated seed and young seedlings
	Mycorrhizal fungi	Known to be ectomycorrhizal

Reproduction and Growth

Mode of reproduction		Reproduces sexually; monoecious
Reproductive phenology		Pollination occurs between late May and early August, depending on elevation and latitude; fertilization occurs the following year, approximately 12 months after pollination; cones then elongate until late summer when they reach maturity
Pollination		Wind-pollinated
Seed	**Seed type**	Large heavy seeds with relatively small wings are borne in very large cones that average 12 in (30 cm) long and sometimes reach 22 in (56 cm) long; averages 150 sound seeds per cone
	Seed-bearing age	Seed production begins between ages 40 and 80; in California, only 50 percent of trees 12 in (30 cm) in diameter produced cones, while 80 percent of trees 20 in (51 cm) in diameter produced cones

	Seed size/ weight	Averages 2,100 seeds per lb (4,630 seeds per kg)
	Seed longevity/ survivability	Seed was successfully stored in a controlled environment for 21 years
	Seed crop and frequency	Mature trees are abundant seed producers; 40 to 50 percent of pollinated conelets reach maturity; heavy cone crops are produced every 4 years on average; proportion of sound seed is high (67 to 99 percent) in heavy crop years and as low as 28 percent in light years; seedfall estimates in heavy crop years range from 35,000 to 180,000 per ac (86,500 to 44,800) per ha
Seed dissemination	**Time of year**	Seedfall begins as early as late August at lower-elevation sites and is completed by the end of October at higher-elevation sites
	Method and dispersal agents	Heavy seeds are dispersed short distances by wind; birds and small mammals also disperse seed
	Distance	Eighty percent of seed falls within 100 ft (30 m) of the parent tree
Germination requirements		Seeds require cold stratification; germination epigeal; germination is uniformly rapid and high (over 90 percent) under controlled conditions
Seedling survival		First-year mortality is often drought-related; mortality in subsequent years may result from rodents or heavy brush competition; bare mineral seedbeds are best
Vegetative phenology		Shoot growth begins later and terminates earlier than in associated conifer species; in the central Sierra Nevada, elongation of shoots begins in late May and continues for approximately 7 weeks; radial growth begins approximately 6 weeks before shoot elongation begins and continues throughout summer

Genetics

Mating system	Predominantly outcrossing
Outcrossing % (t_m)	Unknown
Genetic diversity	Above average genetic diversity
Heterozygosity (H_e)	0.22
Geographic differentiation	Weak population differentiation based on molecular markers
F_{st} or G_{st}	0.09
Patterns of variation	Seedling trials in California showed abundant genetic variation in growth and phenology traits distributed across geographic gradients among seed zones, elevation bands, and trees within zones and bands. Among family variation in height appears to be related to elevation and latitude of origin, likely reflecting local adaptation to temperature
Genetic analysis research results	Genetic variation in seedling traits was fairly consistent across test environments; height growth was under moderate genetic control

Threats and Management Considerations

Insects and disease	Sugar pine is substantially affected by white pine blister rust (caused by *Cronartium ribicola*) and mountain pine beetle (*Dendroctonus ponderosae*); white pine blister rust affects regeneration as well as older trees; mountain pine beetle affects mature trees; *Ips* species are frequently associated with topkill. Needle cast fungi may cause locally damaging defoliation in young stands during moist springs; effects of insects and disease are exacerbated by a lack of fire and a subsequent increases in competition from other vegetation; Armillaria root disease (caused by *A. ostoyae*) can cause severe damage locally; insect predation by the sugar pine cone beetle (*Conophthorus lambertianae*) can significantly reduce seed crops
Fragmentation	Small, disjunct populations occur in north-central, central, and southwestern Oregon
Harvest	Sugar pine produces high-quality lumber, and was heavily harvested in the 1800s; it is presently harvested to a limited extent
Fire	Because of its thick bark and open crown, mature sugar pine trees are very resistant to low- and moderate-severity fire; seeds are dropped on exposed mineral soil following fire
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Prescribed fire and thinning may be useful tools for reducing competition from more shade-tolerant tree species that compete for water in dense stands

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Conkle 1981, 1992, Doede and Hildebrand 2007, Habeck 1992a, Kinloch and Schuener 1990, Kinloch et al. 1996, Kitzmiller and Stover 1996, NatureServe 2010, Plamboeck et al. 2007, USDA NRCS 2010, Wang and Qiu 2006, Westfall and Conkle 1992

Western white pine (*Pinus monticola*)

Ecology

Description		A medium-to-large, evergreen conifer, occasionally surpassing 200 ft (60 m) in height, but usually less than 120 ft (37 m) tall; crown is sparse with branches in distinct whorls; smooth grayish bark forming rectangular plates by maturity
Distribution		Coastal and interior distributions in the Pacific Northwest; coastal distribution extends from southwestern British Columbia to Tulare County, California; interior distribution extends from southeastern British Columbia to northern Idaho; in Washington, occurs from the coast to the Cascade Range and in the eastern part of the state; occurs in the Olympic Range from sea level to 1,800 ft (550 m) elevation; occurs in the Cascade Range at elevations below 3,000 ft (900 m); in Oregon, occurs sporadically in the Coast Range, throughout the Cascade Range, and in the Blue Mountains; typically occurs between 2,000 and 6,000 ft (600 and 1,800 m) elevation in Oregon
Successional stage		Establishes after major disturbances including stand-replacing fires; may persist through all stages of secondary succession
Associated forest cover		Associated with numerous species including Pacific silver fir, grand fir, subalpine fir, noble fir, western hemlock, western redcedar, whitebark pine, and Engelmann spruce
Habitat	**Sites**	Most often occurs on moist sites on mountain slopes
	Soils	Occurs on a wide range of soil parent materials and textures; most abundant on poor sites where it is a strong competitor
	Moisture	Tolerant of wet soils and periodic flooding; tolerant of heavy snowpack; low drought tolerance
	Temperature	Moderate to high frost tolerance; relatively tolerant of heat
	Shade tolerance	Intermediate in shade tolerance relative to associated species
Interspecific interactions	**Animal damage**	Low palatability as browse; seeds consumed by squirrels and mice
	Mycorrhizal fungi	Associated with ectomycorrhizae and arbuscular mycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction sexual; monoecious
Reproductive phenology		Reproductive cycle lasts approximately 26 months; 15 months from pollination to seed maturity; pollen-cone buds differentiate around August; seed-cone buds differentiate around April of the year 2; flowering occurs around June, 8 weeks after dormancy is broken; fertilization occurs in year 3, approximately 12 months after pollination; seeds mature within 3 months of fertilization
Pollination		Wind-pollinated
Seed	**Seed type**	Cones 6 to 11 in (15 to 28 cm) long, containing single-winged seeds
	Seed-bearing age	Production of seed cones begins around age 10 to 15 years, and pollen cones are produced a few years later;
	Seed size/ weight	Seed weight ranges from 14,000 to 32,000 seeds per lb (30,900 to 70,500 seeds per kg) and averages 27,000 seeds per lb (59,000 seeds per kg)
	Seed longevity/ survivability	Seed viability 40 percent after one winter, 25 percent after the second winter, and less than 1 percent after 3 and 4 years; stored under sub-freezing conditions, seed remains viable for at least 20 years

	Seed crop and frequency	Heavy crops every 3 to 4 years; some cones produced nearly every year
Seed dissemination	**Time of year**	Seeds mature from mid-August to September depending on site and summer temperatures
	Method and dispersal agents	Seeds dispersed by wind, and to a lesser extent, by squirrels, mice, and birds
	Distance	Most seeds fall within 390 ft (120 m) of source tree; some seeds travel more than 2,600 ft (800 m)
Germination requirements		Requires a stratification period of 30 to 120 days under cold, moist conditions; dormancy likely controlled by seed coat, seed membrane, and embryo physiology; mineral soil increases germination; germination often occurs while surface soils are wet following snowmelt; strong genetic component to germination rate, with high family heritability; germination epigeal
Seedling survival		High mortality during first growing season owing to fungal pathogens, drought, heat, insects, birds, and rodents; on harsh sites, partial shade increases establishment; once established, growth best in full sunlight
Vegetative phenology		Height and radial growth begins in May or June depending on latitude, elevation, and aspect; shoot buds formed during previous spring and summer

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.98
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.147
Geographic differentiation	Moderate genetic differentiation based on molecular markers
F_{st} or G_{st}	0.124
Patterns of variation	Population variation in quantitative traits within the northern and southern regions is weak or non-existent; western white pine is considered a “generalist” species with broad climate and environmental tolerances
Genetic analysis research results	Research has indicated two wide-ranging “populations” of western white pine; a broad “northern” population (Rocky Mountains, northern Cascades, and northern coastal areas) that have generally high growth potential and low cold hardiness, and a “southern” population in the Sierra Nevada with low growth potential and high cold hardiness; populations in the central and southern Cascades are arranged along a steep latitudinal gradient that connects the northern and southern population

Threats and Management Considerations

Insects and disease	Highly susceptible to insect damage, primarily from mountain pine beetle and pine engraver; highly susceptible to *Cronartium ribicola*, the non-native pathogen that causes white pine blister rust; white pine blister rust causes extensive mortality of young western white pines on high hazard sites; seedlings with increased resistance to white pine blister rust have been planted since 1970; Armillaria root disease may be locally important; needle cast fungi may cause locally damaging defoliation during moist springs; twig dieback and stem damage from *Atropellis piniphila* occasionally cause damage, especially on young trees. Dwarf mistletoe infection occurs locally
Harvest	A valuable timber species prized for the quality of its wood; heavily logged since the late 1800s

Fragmentation	In its coastal distribution, western white pine often occurs scattered throughout forests dominated by other species
Fire	A fire-dependent species, its extent decreased by fire suppression; high level of natural regeneration following stand-replacing fire; young trees often killed by fire; mature trees moderately resistant to fire damage
NatureServe conservation status ranking	G4/G5: G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors/ G5 Secure—Common; widespread and abundant; range indicates some uncertainty about the exact status; populations of western white pine are affected by white pine blister rust and several species of bark beetles
Silvicultural considerations	West of the Cascade Range, the lack of stand-replacing disturbance is leading to a decline of western white pine; the prevalence of western white pine was greatly diminished during the 1900s by heavy logging, extensive wildfires, fungal diseases, and bark beetles

References

Arno and Hammerly 2007, Bishaw et al. 2003, Bonner and Karrfalt 2008, El-Kassaby et al. 1993, El-Kassaby et al. 1987, Graham 1990, Griffith 1992c, Kim et al. 2003, Kinloch et al. 1999, Klinka et al. 2000, Mehes et al. 2009, Owens 2004, Rehfeldt et al. 1984, Richardson et al. 2009, Steinhoff et al. 1983, USDA NRCS 2010

Ponderosa pine (*Pinus ponderosa*)

Ecology

Taxonomy and nomenclature		The variety of ponderosa pine occurring in the Pacific Northwest is *Pinus ponderosa* var. *ponderosa*; the other recognized variety is interior ponderosa pine (*Pinus ponderosa* var. *scopulorum*); some sources refer to ponderosa pine west of the Cascade Range and throughout nearly all of California as *Pinus ponderosa* subsp. *benthamiana* or *Pinus benthamiana*
Description		A medium-to-large, evergreen conifer, often reaching 130 ft (40 m) in height; an open, conical crown with long branches bearing tufts of long needles; bark composed of large, scaly, orange-brown plates
Distribution		*Pinus ponderosa* var. *ponderosa* occurs from southern British Columbia southward through the Pacific Northwest and California and in Idaho and western Montana; *Pinus ponderosa* var. *scopulorum* occurs from north-central Montana, throughout the Rocky Mountains, and into Mexico; ponderosa pine occurs in Washington from 330 to 5,000 ft (100 to 1,520 m), primarily east of the Cascade crest; it occurs to a limited extent in south Puget Sound lowlands and on Mount Rainier; it occurs through much of Oregon, including the Willamette Valley, the Cascade Range, the mountains of central and eastern Oregon, and throughout southwestern Oregon; occurs to a maximum elevation of 6,600 ft (2,010 m) in Oregon
Successional stage		An early seral species on higher-elevation or relatively moist sites, replaced by more shade-tolerant species; a climax species on harsh sites where other tree species cannot establish; on intermediate sites, ponderosa pine depends on recurring fire to maintain its dominance
Associated forest cover		Occurs in pure and mixed stands; succeeds to Douglas-fir, true firs, and lodgepole pine on moist sites; in climax stands, may occur with Rocky Mountain juniper, quaking aspen, lodgepole pine, or oak; pure climax stands consist of a mosaic of small, even-aged groups
Habitat	**Sites**	Occurrence heavily influenced by its regeneration after fire, its fire tolerance at maturity, and its tolerance of sites too dry for other trees
	Soils	Occurs on a wide range of soil types, including soils where the presence of trees is limited by soil moisture availability; in Washington and Oregon, coarse-textured, sandy soils are more likely sites than clayey soils because grass and shrubs dominate the latter sites
	Moisture	High tolerance of seasonal drought and very dry sites; tolerant of flooding
	Temperature	Highly tolerant of heat; moderately tolerant of frost
	Shade tolerance	Intolerant of shade; often regenerates in even-aged groups or stands after fire
Interspecific interactions	**Animal damage**	Seeds consumed by small mammals and birds; a high proportion of seeds may be consumed in years of small crops; seedlings browsed by deer; seedlings may be damaged by rabbits or gophers
	Mycorrhizal fungi	Ectomycorrhizal fungi have been reported on ponderosa pine

Reproduction and Growth

Mode of reproduction	Reproduction is sexual; monoecious
Reproductive phenology	Reproductive cycle spans three growing seasons; reproductive buds initiated in year 1; pollination occurs between April and June of year 2; seeds ripen in late August or September of year 3
Pollination	Wind-pollinated

Seed	**Seed type**	Cones 3 to 6 in (8 to 15 cm) long; average number of seeds per cone varies by region, with 31 in Arizona and 70 in California
	Seed-bearing age	Cone production begins as early as age 7 years, but more commonly begins around age 16 to 20 years; seed production reaches its maximum level around age 60 years
	Seed size/ weight	Cleaned seeds vary from 6,900 to 23,000 seeds per lb (15,200 to 50,700 seeds per kg) and average 12,000 seeds per lb (26,500 seeds per kg)
	Seed longevity/ survivability	Seed stored at sub-freezing temperatures remained viable for 17 years
	Seed crop and frequency	Heavy cone crops produced every 4 to 5 years in the Pacific Northwest; in a heavy seed year 345,000 seeds per ac (850,000 seeds per ha) may be dropped
Seed dissemination	**Time of year**	Cones open in August or September and most seed is dropped by November
	Method and dispersal agents	Seeds dispersed by wind and, to a lesser extent, animals including Clark's nutcracker
	Distance	Most seed falls within 100 ft (30 m) of the source tree; a small amount of seed falls beyond 400 ft (120 m) of the source
Germination requirements		Greatest regeneration results from a heavy seed crop, exposed mineral soil, and favorable growing-season weather; germination reduced by moisture stress; insects such as the ponderosa pine cone beetle (*Conophthorus ponderosae*) and the pine seed chalcid (*Megastigmus albifrons*) may destroy seed before germination; germination epigeal
Seedling survival		Survival reduced by moisture stress and competing vegetation; frost and high soil temperatures may cause mortality; seedlings may be destroyed by gophers or rabbits; seedlings can survive very dry conditions by reducing transpiration rates and vigorously extending root systems, including the taproot
Vegetative phenology		With increasing elevation, height growth begins later in the year and growing-season length is shorter; growth rate during the growing season does not change with elevation; radial growth begins about one month before height growth

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.95
Genetic diversity	Above-average genetic variation
Heterozygosity (H_e)	0.23
Geographic differentiation	Weak genetic differentiation based on molecular markers
F_{st} or G_{st}	0.75
Patterns of variation	Strong population differentiation based on quantitative traits; ponderosa pine is considered intermediate with regard to adaptive strategy; both individuals and populations are suited to a broad range of environments, but populations still show habitat specificity
Genetic analysis research results	Inland Northwest populations differed for seedling growth and shoot elongation traits; differences followed relatively steep clines in elevation and gentle clines in latitude and longitude

Threats and Management Considerations

Insects and disease	Moderately susceptible to mountain and western pine beetles in overly dense stands; pine engravers may become damaging in situations where populations build up in slash or blowdown; dwarf mistletoe (*Arceuthobium campylopdum*) is locally damaging; Armillaria root disease may be locally damaging; can be infected by several other stem decay and root disease fungi
Harvest	Ponderosa pine is planted and harvested east of the Cascade crest
Fragmentation	A disjunct population occurs in the southeastern part of the Puget Sound region
Fire	Ponderosa pine evolved under a regime of frequent fire that favored it over other species such as Douglas-fir and true firs that are less tolerant of fire; ponderosa pine seedlings are killed by fire, but large trees survive surface fires owing to thick bark and self-pruning of low branches; severe fires may kill trees via crown scorch
Other damaging agents	Heavy, wet snow may damage young trees; high ozone levels may cause foliar damage
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	The structure of most ponderosa pine stands has been dramatically changed by fire suppression over the past century; formerly open, park-like stands now contain numerous small trees of ponderosa pine and other species; harvest of large trees has contributed to younger, denser stands; dense stands are less vigorous and more prone to disease and crown fire

References

Agee 1993; Arno and Hammerly 2007; Bonner and Karrfalt 2008; Carey et al. 1997; DeLucia et al. 1994; Gooding 1998; Habeck 1992b; Klinka et al. 2000; Mitton et al. 1981; Niebling and Conkle 1990; Oliver and Ryker 1990; Owens and Blake 1985; Rehfeldt 1991; Rotach 1997; Rygiewicz et al. 1997; Sorensen 1994a, 1994b; USDA NRCS 2010

Black cottonwood (*Populus balsamifera* ssp. *trichocarpa*)

Ecology

Taxonomy and nomenclature		Also known as *Populus trichocarpa*; one of two subspecies of *Populus balsamifera*
Description		A large, deciduous, broadleaf tree reaching heights of 160 to 200 ft (50 to 60 m); crown is broad and spreading when open-grown, but narrow in a closed canopy; few low branches; deeply furrowed, gray bark
Distribution		From Alaska's Kenai Peninsula to Baja, California; from the Pacific Coast east to Montana, Wyoming, and Utah; occurs from sea level to 5,000 ft (1,500 m) elevation in the Pacific Northwest
Successional stage		A fast-growing pioneer and early seral species found on disturbed sites
Associated forest cover		Often found on alluvial sites with willows (*Salix* spp.), red alder, Sitka spruce, and bigleaf maple; may form pure stands as a pioneer but associates with conifers and other hardwoods in subsequent seral stages; found with Douglas-fir, western hemlock, western redcedar, grand fir, black hawthorn, cherry (*Prunus* spp.), and Oregon ash; east of the Cascade Range, associated with western white pine, ponderosa pine, Douglas-fir, quaking aspen, and Douglas maple
Habitat	**Sites**	Most prevalent on low-elevation, alluvial sites and in disturbed areas; occurs in valleys and canyon bottoms, riparian zones, and other moist sites east of the Cascade crest
	Soils	Most often occurs on the deep alluvial silts and sands of floodplains, but also found on upland sites where moisture is sufficient; occurs on soils of moderate to high fertility; best growth occurs on well-drained soils
	Moisture	Tolerant of flooding and sediment deposition; tolerant of a fluctuating water table; intolerant of drought; intolerant of brackish water
	Temperature	Moderate frost tolerance; moderately tolerant of heat
	Shade tolerance	Very intolerant of shade
Interspecific interactions	**Animal damage**	Voles, mice, and rabbits may damage seedlings; occasional browse damage from ungulates
	Mycorrhizal fungi	Recently established or flooded trees may be associated with arbuscular mycorrhizae, although black cottonwood is more typically associated with ectomycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; typically dioecious; regenerates vegetatively from stump sprouts, from fragments of branches, and occasionally from root sprouts
Reproductive phenology		Flowers between early March and late May; prior to flowering, the next year's inflorescences begin to develop at leaf nodes
Pollination		Wind-pollinated
Seed	**Seed type**	Catkins 3 to 8 in (8 to 20 cm) long contain capsules with 30 to 50 seeds in each; seeds have long, white hairs
	Seed-bearing age	Seed production begins by age 10
	Seed size/ weight	95,000 to 190,000 seeds per oz (3,300 to 6,700 seeds per g)

	Seed longevity/ survivability	Initial viability high; under natural conditions, seed remains viable for less than 1 month; remains viable for at least 1 year in storage; storage temperatures should be between -11 and 23 °F (-24 and -5 °C)
	Seed crop and frequency	Abundant seed crop produced every year
Seed dissemination	**Time of year**	By late May to late June
	Method and dispersal agents	Seed is dispersed by wind and water
	Distance	Seed may be transported miles (kilometers) by wind or water
Germination requirements		Best seedbed is exposed mineral soil or new alluvium; seedbed moisture is vital to establishment; germination epigeal
Seedling survival		Major causes of mortality and damage are overtopping vegetation, insufficient moisture during the first month after germination, late or early frosts, and damage from rodents
Vegetative phenology		Leaf growth initiated after spring flowering; shoot elongation and leaf growth continues through the growing season

Genetics

Genetic diversity	Low genetic diversity
Heterozygosity (H_e)	0.06
Geographic differentiation	Weak genetic differentiation
F_{st} or G_{st}	0.063
Patterns of variation	Morphological traits exhibit abundant genetic diversity
Genetic analysis research results	Seedling common garden studies showed significant variation among populations for numerous traits such as survival, growth, leaf morphology, crown morphology, phenology, and rust incidence; differences were related to moisture conditions (mesic vs. xeric) and temperature (upper vs. lower canyon positions)

Threats and Management Considerations

Insects and disease	A variety of fungal diseases including leaf rust (*Melampsora* spp.) have been observed ; damage is most extensive in plantations; older trees are commonly affected by decay fungi that contribute to breakage
Harvest	Not a major commercial species in natural stands; hybrids established in plantations
Fire	Highly susceptible to damage and top-kill from fire; sprouts following top-kill; establishes from seed after fire
Other damaging agents	Ice storms and heavy snowfall may cause significant damage; top damage from wind is common
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Clones of hybrid *Populus* grown for pulp, veneer, and lumber production; planted as a windbreak; often planted from cuttings

References

Arno and Hammerly 2007; Bergha et al. 2003; Boes and Strauss 1994; Bonner and Karrfalt 2008; DeBell 1990; Dunlap et al. 1994, 1995; Dunlap and Stettler 1996; Gornall and Guy 2007; Klinka et al. 2000; Steinberg 2001; USDA NRCS 2010; Weber and Stettler 1981

Quaking aspen (*Populus tremuloides*)

Ecology

Description		A small- to medium-sized, deciduous, broadleaf tree reaching 50 to 60 ft (15 to 18 m) in height; a narrow, domed crown with slender, bent limbs; smooth, thin, whitish bark
Distribution		Widest distribution of any native tree species in North America, from western Alaska across Canada to the Atlantic coast; occurs in the northern hardwood forests of the United States and throughout the Rocky Mountains south to Mexico, at increasing elevations at lower latitudes; less prevalent in the Pacific Northwest and California; in Washington, occurs in scattered locations west of the Cascade, as low as sea level in the Puget Sound region; much more common in Washington and Oregon east of the Cascade crest
Successional stage		An aggressive pioneer species; maintains dominance where wildfire regularly occurs; a fire climax species in some locations; in the absence of fire, succeeds to shade-tolerant conifers
Associated forest cover		Associated with numerous species throughout its range; also occurs in pure stands and groves; east of the Cascade crest in Washington, quaking aspen occurs with scattered ponderosa pine and Douglas-fir
Habitat	**Sites**	Found on a variety of sites, where soil moisture is not limiting; east of Washington's Cascades, occurs in moist meadows, canyons, avalanche chutes, and riparian zones
	Soils	Found on numerous soil types; requires sufficient drainage and soil moisture, typically with a water table between 2 and 8 ft (0.6 and 2.5 m) below the surface
	Moisture	Occurrence is limited to sites with adequate drainage; does not tolerate long-term flooding; low tolerance of drought; drought stress lowers resistance to insects and disease
	Temperature	High frost tolerance; moderately tolerant of high temperatures
	Shade tolerance	Very intolerant of shade
Interspecific interactions	**Animal damage**	Occasional browse damage and girdling by ungulates and small mammals
	Mycorrhizal fungi	Roots are ectomycorrhizal

Reproduction and Growth

Mode of reproduction		Sexual and vegetative reproduction; primarily dioecious; commonly regenerates by sprouting from its vigorous, spreading root system; this sprouting results in large colonies of genetically identical stems; in some locations of the Pacific Northwest, reproduction is predominantly vegetative
Reproductive phenology		Flowers in April or May; fruiting catkins reach maturity in May or June, 4 to 6 weeks after flowering; timing of flowering is influenced by air temperature
Pollination		Wind-pollinated
Seed	**Seed type**	Catkins approximately 4 in (10 cm) long; catkins contain several dozen capsules, each containing approximately 10 seeds; seeds surrounded by tufts of silky hairs

	Seed-bearing age	Flowers at age 2 to 3 years; large seed crops begin between ages 10 to 20 years; seed production reaches a maximum at 50 years of age
	Seed size/ weight	Cleaned seeds average 156,000 to 250,000 seeds per oz (5,500 to 8,000 seeds per g)
	Seed longevity/ survivability	Under favorable conditions, seeds remain viable for 2 to 4 weeks after reaching maturity; storage tests have produced varied results, but seed should be stored between -11 and 23 °F (-24 and -5 °C)
	Seed crop and frequency	Heavy seed crops every 4 to 5 years; light seed crops in other years
Seed dissemination	**Time of year**	Seeds dispersed beginning a few days after they ripen in May or June; dispersal continues for 3 to 5 weeks
	Method and dispersal agents	Seeds dispersed by wind and water
	Distance	Seeds carried by wind for distances of 1,600 ft (500 m) to several miles (kilometers)
Germination requirements		Seeds germinate within days of dispersal; germination requires a water-saturated substrate; bare mineral soil is best seedbed; seeds may germinate underwater or in the dark; seed viability 80 to 95 percent; germination epigeal
Seedling survival		Seedling mortality is high; survival reduced by insufficient moisture, high soil temperatures, the brief period of seed viability, and fungal pathogens; natural thinning of dense, young stands is rapid, whether stems are of seed or sprout origin
Vegetative phenology		Leaf growth initiated after spring flowering; shoot elongation and leaf growth continues through the growing season

Genetics

Genetic diversity	Above-average genetic diversity
Heterozygosity (H_e)	0.32
Geographic differentiation	Weak genetic differentiation based on molecular markers
F_{st} or G_{st}	0.03
Patterns of variation	Strong population differentiation in phenotypic traits
Genetic analysis research results	Substantial phenotypic variation has been found in both field and common garden studies; populations throughout the range in the western United States varied in leaf size and shape, a trail that was strongly correlated with latitude; while high levels of genetic diversity have been observed in quaking aspen, it also commonly grows as large clonal stands, some of which are thought to be tens of thousands of years old and potentially the largest living organisms on earth, covering dozens of hectares

Threats and Management Considerations

Insects and disease	Low susceptibility to insect damage; although many defoliating insects attack quaking aspen, damage is usually not serious; quaking aspen is moderately susceptible to damage from a wide variety of fungal pathogens including butt and root rots, cankers, shoot and leaf blight, leaf spot, and leaf rust

Harvest	A fast-growing species capable of producing timber under even-aged silvicultural systems in the inland West; not an important commercial species in Washington
Fragmentation	Populations are scattered and infrequent in western Washington
Fire	Highly susceptible to fire damage; fires kill trees or damage them to an extent that fungal pathogens can exacerbate the injury; fires may kill or damage shallow roots; quaking aspen regenerates vigorously following stand-replacing fire
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	The combination of fire suppression and grazing has reduced the extent of aspen in the western United States

References

Arno and Hammerly 2007, Barnes 1975, Bonner and Karrfalt 2008, De Woody et al. 2009, Howard 1996, Jelinski and Cheliak 1992, Kanaga et al. 2008, Klinka et al. 2000, Namroud et al. 2005, Ostry and Anderson 2009, Perala 1990, Rehfeldt et al. 2009, St. Clair et al. 2010, USDA NRCS 2010, Yeh et al. 1995

Bitter cherry (*Prunus emarginata*)

Ecology

Taxonomy and nomenclature		There are two recognized varieties of bitter cherry: *Prunus emarginata* var. *mollis*, the variety described here, is a small tree occurring west of the Cascade crest, and *Prunus emarginata* var. *emarginata* is a shrub found east of the Cascade crest
Description		A small, short-lived, deciduous, broadleaf tree reaching 50 ft (15 m) or more in height; spreading and ascending branches; smooth, reddish-brown bark
Distribution		From British Columbia to southern California and eastward to western Montana; common in western Washington and Oregon and on moist sites in the eastern parts of these states
Successional stage		An early seral species; declines in frequency as the canopy closes; scattered in young hardwood and conifer forests
Associated forest cover		A minor component of numerous early seral cover types; colonizes open areas; east of the Cascade crest, associates include Douglas maple, Scouler's willow, and chokecherry; may occur in dense, pure stands
Habitat	**Sites**	Typically occurs on moist, low- to mid-elevation sites; often found near water; requires at least partial shade on dry, exposed slopes
	Soils	Occurs on loamy, sandy, and gravelly soils; often found on nutrient-poor and acidic soils
	Moisture	Most often occurs on moist soils; tolerant of flooding and a fluctuating water table; infrequent on dry sites
	Temperature	Moderately tolerant of heat; frost damage typically not a problem
	Shade tolerance	Tolerant of partial shade; grows best in full sunlight
Interspecific interactions	**Animal damage**	Commonly browsed by deer and elk
	Mycorrhizal fungi	Other species in the genus *Prunus* are associated with arbuscular mycorrhizae and ectomycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; monoecious; vegetative reproduction by root collar and root sprouts
Reproductive phenology		Flowers between April and June; fruit ripens from July through September
Pollination		Insect-pollinated
Seed	**Seed type**	Red drupe-like ovoid fruit 0.25 to 0.55 in (6 to 14 mm) in diameter containing one seed; seed surrounded by a stony endocarp
	Seed-bearing age	Unknown; other North American *Prunus* species flower by age 4 and bear fruit by age 10
	Seed size/ weight	Ranges from 4,120 to 8,790 cleaned seeds per lb (9,060 to 19,340 seeds per kg); averages 7,020 seeds per lb (15,440 seeds per kg); 1 pound seed extracted from 4 pounds fruit
	Seed longevity/ survivability	Seeds remain viable in soil and duff for many years
	Seed crop and frequency	Prolific producer of seed

Seed dissemination	**Time of year**	August through September
	Method and dispersal agents	Birds, bears, and small mammals
	Distance	Unknown; dependent on movement of birds and mammals
Germination requirements		Undergoes embryo dormancy; after-ripening period necessary for germination; requires exposure to moisture and oxygen during after-ripening; cold stratification for 90 to 160 days increases germination
Seedling survival		Regeneration abundant where adequate sunlight and exposed mineral soil occur

Threats and Management Considerations

Insects and disease	Numerous insects and fungal pathogens are associated with the genus *Prunus*; susceptible to stem- and root-rot fungi
Harvest	Not a commercial timber species
Fragmentation	Widespread throughout its range in the Pacific Northwest
Fire	Top-killed by fire; sprouts vigorously after top-kill; high-severity fire favors bitter cherry over associated species
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Propagated from seed and cuttings; planted for land reclamation and slope stabilization

References

Arno and Hammerly 2007, Esser 1995, Klinka et al. 2000, USDA NRCS 2010

Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)

Ecology

Taxonomy and nomenclature		There are two varieties of Douglas-fir: *Pseudotsuga menziesii* var. *menziesii* occurs in the maritime zone along the Pacific Coast, and *Pseudotsuga menziesii* var. *glauca* occurs in eastern Washington and Oregon and throughout much of the western United States
Description		A medium-to-large, long-lived, evergreen conifer commonly reaching 100 to 130 ft (30 to 42 m) with a dense conical to columnar crown of long branches; lower branches are self-pruned except for open-grown trees; bark is smooth when young, becoming deeply furrowed and corky at maturity
Distribution		From central British Columbia throughout the Rocky Mountains and into central Mexico; occurs throughout the inland mountains of the Pacific Northwest, including eastern Washington and Oregon; occurs most commonly at elevations from 2500 to 5000 ft (750 to 1520 m) in Washington and Oregon
Successional stage		In dry forests, Rocky Mountain Douglas-fir is typically a late-successional species; in moist forests, it tends to be less shade tolerant
Associated forest cover		Sometimes occurs in pure stands, but common associates are ponderosa pine, grand fir, lodgepole pine, and western larch
Habitat	**Sites**	Grows on a wide range of sites, at all slopes, aspects, and on most soils; most abundant on low- to mid-elevation sites
	Soils	Shallow to deep soils derived from a broad range of parent materials; texture ranges from clay to sand; fertility ranges from low to very high
	Moisture	Intolerant of flooding and shallow water tables; tolerant of very dry soils
	Temperature	Medium frost tolerance; high heat tolerance
	Shade tolerance	Shade tolerant on dry, interior sites; intermediate shade tolerance on moist sites
Interspecific interactions	**Animal damage**	Browsed by deer and elk; damage may be heavy locally; seeds are consumed and cached by small mammals
	Mycorrhizal fungi	Associated with arbuscular mycorrhizae and ectomycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual; monoecious
Reproductive phenology		The reproductive cycle last approximately 17 months; reproductive primordia develop throughout the growing season prior to the cone crop; flowering and pollination occur between April and June of the following year; cones ripen between mid-August and mid-September; phenology is influenced by elevation and latitude
Pollination		Wind-pollinated
Seed	**Seed type**	Cones 1.5 to 3 in (4 to 7 cm) long; cones average 20 to 30 filled seeds; seeds have a large, single wing
	Seed-bearing age	Minimum seed-bearing age is approximately 20 years
	Seed size/ weight	Seed weight averages 46,400 cleaned seeds per lb (102,400 seeds per kg)
	Seed longevity/ survivability	Under natural conditions, seed remains viable for 1 or occasionally 2 years; seed of *Pseudotsuga menziesii* var. *menziesii* has been successfully stored at 0 °F (-18 °C) for 27 years

	Seed crop and frequency	Seed production is irregular; heavy crops occur every 3 to 10 years
Seed dissemination	**Time of year**	Seedfall begins in August or September; the majority of seeds are often dropped by the end of October, but some seedfall continues throughout winter
	Method and dispersal agents	Seeds are primarily dispersed by wind; small amounts of seed are dispersed by small mammals and birds including Clark's nutcracker
	Distance	Most seed falls within 330 ft (100 m) of the source tree; a small portion of seed may be dispersed as far as 0.6 to 1.2 mi (1 to 2 km)
Germination requirements		Most germination occurs within 150 days of seedfall depending on climate; germination is affected by cold stratification and light; seed viability is highest during good seed crops; germination best on moist mineral soil
Seedling survival		Seedling survival highest on bare mineral soil or mineral soil with light litter layer; excessive heat and drying results in mortality; first-year growth limited by moisture availability; onset of dormancy occurs in mid-summer of first year; first-year survival increased by shade
Vegetative phenology		Budburst usually occurs from April to May; vegetative shoots usually elongate from late April or May through July; phenology varies significantly according to yearly weather, elevation, and latitude

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate
Outcrossing % (t_m)	Unknown
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.157
Geographic differentiation	Weak population differentiation based on molecular markers but strong for quantitative traits
F_{st} or G_{st}	0.06
Genetic analysis research results	More cold tolerant than var. *menziesii*; growth and cold hardiness are strongly correlated; populations from milder sites grew taller but have low freezing tolerance, while populations from harsh sites are short and cold-hardy

Threats and Management Considerations

Insects and disease	Susceptible to numerous insects and fungal pathogens; significant damage results from *Armillaria* root disease and *Phellinus* root rot; Douglas-fir beetle, western spruce budworm, and Douglas-fir tussock moth are the most damaging insects
Harvest	A valuable commercial species
Fire	With age, becomes increasingly resistant to surface fire; young trees and saplings are often killed as a result of their thin bark
Other damaging agents	Douglas-fir dwarf mistletoe
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Regenerated under a wide variety of silvicultural systems, including clear-cutting, group selection, shelterwood, and seed tree harvests

References

Aagaard et al. 1998, Aitken and Adams 1996, Anekonda et al. 2002, Arno and Hammerly 2007, Balduman et al. 1999, Bonner and Karrfalt 2008; El-Kassaby and Ritland 1996, El-Kassaby et al. 1981, Hawkins 2007, Hawkins and Stoehr 2009, Hermann and Lavender 1990, Hoffmann and Geburek 1995, Klinka et al. 2000, Krakowski and Stoehr 2009, Krutovsky et al. 2009, Li and Adams 1989, Rehfeldt 1989, Shaw and Allard 1982, Silen 1963, St. Clair 2006, St. Clair et al. 2005, USDA NRCS 2010, Viard et al. 2001

Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*)

Ecology

Taxonomy and nomenclature		There are two varieties of Douglas-fir: *Pseudotsuga menziesii* var. *menziesii*, the variety described here, occurs in the maritime zone along the Pacific Coast, and *Pseudotsuga menziesii* var. *glauca* occurs predominantly in the Rocky Mountains, extending into northeastern Washington and into eastern and central Oregon, but not into the Cascade Range
Description		A large, evergreen conifer reaching heights over 250 ft (75 m), with a dense conical to columnar crown of long branches; lower branches are self-pruned except for open-grown trees; deeply furrowed, reddish brown bark
Distribution		From west-central British Columbia to central California; var. *menziesii* occurs from the coast through the Cascade Range, occurs from sea level to around 5,000 ft (1,520 m) elevation in Washington and to around 6,000 ft (1,800 m) in Oregon; var. *glauca* occurs from central British Columbia throughout the Rocky Mountains and into central Mexico
Successional stage		A long-lived species occurring in all stages of secondary succession; west of the Cascade crest it typically regenerates in nearly pure stands following large-scale, stand-replacing disturbances including wildfire, logging, and windthrow; a pioneer, but owing to its longevity, it often remains a major component of such stands for well over 300 years; also a major or minor component of old-growth stands; east of the Cascade crest, Douglas-fir is often a late-successional species
Associated forest cover		The most dominant tree species in the region; in western Washington and Oregon, Douglas-fir typically regenerates after disturbance as a pure stand or as the dominant species; associates include western hemlock, western redcedar, Pacific silver fir, Sitka spruce, grand fir, red alder, bigleaf maple, and shore pine; east of the Cascade crest, common associates are ponderosa pine, grand fir, lodgepole pine, and western larch
Habitat	**Sites**	Competes well on a wide range of sites, at all slopes, aspects, and on most soils
	Soils	Shallow to deep soils derived from a broad range of parent materials; texture ranges from clay to sand; fertility ranges from low to very high
	Moisture	Intolerant of flooding and shallow water tables; tolerant of very dry soils
	Temperature	Low frost tolerance; intolerant of temperatures below 14 °F (-10 °C) for more than 1 week; moderate heat tolerance
	Shade tolerance	Intermediate shade tolerance; shade tolerance decreases with age
Interspecific interactions	**Animal damage**	New growth of young trees is highly palatable and often browsed by deer and elk; small mammals, birds, and insects destroy seeds; impact is greatest in years of low seed production
	Mycorrhizal fungi	Associated with arbuscular mycorrhizae and ectomycorrhizae

Reproduction and Growth

Mode of reproduction	Reproduction is sexual; monoecious
Reproductive phenology	The reproductive cycle last approximately 17 months; reproductive primordia develop throughout the growing season prior to the cone crop; flowering and pollination occur between March and May of the following year, 7 to 8 weeks after dormancy is broken; cones ripen between mid-August and mid-September; phenology strongly influenced by elevation and latitude; pollen shedding is delayed by 1 day for each 77-ft (23-m) increase in elevation

Pollination		Wind-pollinated
Seed	**Seed type**	Cones 2 to 4 in (5 to 10 cm) long, primarily in the upper crown; cones usually contain 26 to 50 seeds; seeds have a large, single wing
	Seed-bearing age	Cones occasionally may be produced by age 10 years or younger; significant seed production does not begin until age 20 to 30 years
	Seed size/ weight	Seed weight is highly variable but averages 39,300 cleaned seeds per lb (86,600 seeds per kg)
	Seed longevity/ survivability	Under natural conditions, seed remains viable for 1 or occasionally 2 years; seed has been successfully stored at 0 °F (-18 °C) for 27 years
	Seed crop and frequency	Seed production is irregular; heavy crops occur every 5 to 7 years, and crop failures occur at the same frequency; in heavy crop years, most of the seed is produced by only about 25 percent of trees
Seed dissemination	**Time of year**	Seedfall begins in August or September; the majority of seeds are often dropped by the end of October, but some seedfall continues throughout winter
	Method and dispersal agents	Seeds are primarily dispersed by wind; small amounts of seed are dispersed by small mammals and birds including Clark's nutcracker
	Distance	Most seed falls within 330 ft (100 m) of the source tree; a small portion of seed may be dispersed as far as 0.6 to 1.2 mi (1 to 2 km)
Germination requirements		Germination occurs between March and May, depending on climate; seed viability typically only 40 to 50 percent, sometimes less; germination best on moist mineral soil
Seedling survival		Seedling survival highest on bare mineral soil or mineral soil with light litter layer; excessive heat and drying results in mortality; first-year growth limited by moisture availability; onset of dormancy occurs in mid-summer of first year; first-year survival increased by shade; growth in subsequent years greater under full sunlight
Vegetative phenology		Budburst occurs from May to early June; vegetative shoots elongate for approximately 6 weeks; most shoot growth occurs as part of this initial flush, although young trees also exhibit lammas growth if sufficient soil water is available; diameter growth begins in April and continues through October, given adequate moisture; diameter growth ceases in mid-summer on droughty sites; lateral bud primordia enlarge in June and July

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.925
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.17
Geographic differentiation	Weak population differentiation based on molecular markers but strong for quantitative traits
F_{st} or G_{st}	0.043
Patterns of variation	Q_{ST} = 0.62, 0.34, 0.51 for fall cold injury, growth, and phenology traits, respectively; Douglas-fir is considered a specialist species, with fairly narrow climatic tolerances within populations
Genetic analysis research results	Probably the most studied Pacific Northwest conifer; substantial genetic variation has been found in many traits including spring and fall cold hardiness, drought hardiness, growth, phenology, and wood quality

Threats and Management Considerations

Insects and disease	Susceptible to numerous insects and fungal pathogens; significant damage results from shoestring root rot (*Armillaria mellea*), laminated root rot (*Phillinus weirii*), and red ring rot (*Phillinus pini*); Douglas-fir beetle is the most damaging insect; subregional threats vary, for example, in southwestern Oregon the following occurs: at elevations below 3,500 feet suffers substantial mortality as a result of infestation by flatheaded fir borer (*Phaenops drummondi*); Douglas-fir beetle may kill numerous trees in association with significant windthrow or snowbreak events; dwarf mistletoe (*Arceuthobium douglasii*) causes substantial decline and mortality; significant mortality results from root diseases caused by *Phellinus weirii, Armillaria ostoyae,* and *Leptographium wageneri*; stem decay caused by *Phellinus pini* is common and often extensive; butt decay caused by *Phaeolus schweinitzii* is common and damaging in older trees; Swiss needle cast causes defoliation in young Douglas-fir plantations on the southwestern Oregon coast; canker fungi (*Phomopsis* spp. and others) can cause severe damage in young stands on dry sites during drought conditions
Harvest	The most important commercial species in the region and one of the most important commercial species in the world
Fire	At maturity, more resistant to surface fire than many of its associates; older trees have thick bark and few low branches; historically, the moist Douglas-fir forests of western Washington and Oregon burned in large, stand-replacing wildfires at very long intervals
Other damaging agents	High winds may cause significant windthrow when soils are wet; heavy snow and ice may cause top breakage
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	By far the most frequently planted species in the region; regenerated in single-age silvicultural systems, rarely in multi-age systems

References

Aagaard et al. 1998, Aitken and Adams 1996, Anekonda et al. 2002, Arno and Hammerly 2007, Balduman et al. 1999, Bonner and Karrfalt 2008; El-Kassaby and Ritland 1996, El-Kassaby et al. 1981, Hawkins 2007, Hawkins and Stoehr 2009, Hermann and Lavender 1990, Hoffmann and Geburek 1995, Klinka et al. 2000, Krakowski and Stoehr 2009, Krutovsky et al. 2009, Li and Adams 1989, Shaw and Allard 1982, Silen 1963, St. Clair 2006, St. Clair et al. 2005, Uchytil 1991d, USDA NRCS 2010, Viard et al. 2001

Canyon live oak (*Quercus chrysolepis*)

Ecology

Taxonomy and nomenclature		Two varieties are recognized: *Q. chrysolepis* var. *chrysolepis* (tree form occurring throughout the species' range) and *Q. chrysolepis* var. *nana* (shrub form occurring in California)
Description		A medium-size, long-lived, evergreen broadleaf tree, commonly reaching 60 to 80 ft (18 to 24 m) in height where open-grown on deep soils; on rocky slopes and shallow soils, height may reach only 15 ft (5 m); where open-grown, forms a very broad, rounded crown, nearly reaching the ground; in mixed evergreen forests, crowns are high and more slender; on rocky slopes, trees have small, irregular crowns and crooked stems; leaves are thick and leathery, spiny in younger trees; bark is thin, grayish brown, and flaky; the root system is extensive, deeply penetrating fractures in rocks
Distribution		Occurs from southwestern Oregon southward through California to Arizona and Mexico; found in Oregon's coast range eastward to the lower, western slopes of the Cascade Range; occurs in Oregon at elevations from 1,600 to 5,000 ft (490 to1525 m)
Successional stage		Present in early and late-successional and climax communities; a vigorously sprouting pioneer species on disturbed sites; an early successional species on productive sites where it is soon replaced by larger, faster-growing species; on drier, less-productive sites, it persists to late-successional stages; on very harsh sites, such as steep canyon walls, it is a dominant climax species
Associated forest cover		Occurs in mixed-evergreen forests with species including Douglas-fir, tanoak, golden chinquapin, and Pacific madrone as a co-dominant tree; on shallow soils it may occur with tanoak and golden chinquapin in its shrub form; occurs in woodlands with California black oak and Oregon white oak; also present in mixed-chaparral communities and in pure stands
Habitat	**Sites**	Found on a wide range of sites, from moist, shady canyon bottoms and riparian sites to steep canyon walls and exposed ridges
	Soils	Occurs on many soil types formed in a variety of parent materials; soils range from deep, rich alluvium to shallow rocky infertile soils and rock crevices; unlikely to survive in serpentine soils
	Moisture	Extremely drought tolerant, more drought tolerant than associates oak species; grows on sites receiving as little as 6 in (15 cm) of annual precipitation; canyon live oak acquires moisture through a deep and extensive root system; also occurs on sites with as much as 110 in (279 cm) of annual precipitation
	Temperature	In Oregon, occurs in a climate of wet, mild winters and hot, dry summers; frost-free period within its full range varies from 160 to 230 days
	Shade tolerance	Shade-tolerant; tolerance allows it to persist into late-successional stages in a variety of forest types
Interspecific interactions	**Animal damage**	May be browsed by deer; numerous animal species use acorns as food
	Mycorrhizal fungi	Associates with ectomycorrhizae

Reproduction and Growth

Mode of reproduction	Reproduces sexually and vegetatively; monoecious; vegetative reproduction is through vigorous sprouting from the bole and root crown, particularly after fire or other types of disturbance

Reproductive phenology		Flowers from April to June, later than associated oak species; acorns mature in the second year
Pollination		Wind-pollinated
Seed	**Seed type**	Acorns, borne singly or in clusters of two to five
	Seed-bearing age	Approximately 20 years
	Seed size/ weight	Averages 150 acorns per lb (330 acorns per kg); acorns are 1 to 2 in (2.5 to 5.1 cm) long and 0.5 to 0.75 in (1.3 to 1.9 cm) diameter
	Seed longevity/ survivability	Unknown; seeds lack dormancy and germinate in late winter or early spring
	Seed crop and frequency	Acorn production is greater than for associated oak species; good acorn crops produced every 2 to 6 years; some trees produce acorns every year; acorn crops in dense stands range from 9 to 1,960 lb per ac (10 to 2,195 kg per ha); open-grown trees may produce as many as 400 lb (180 kg) of acorns per tree
Seed dissemination	**Time of year**	Acorns are dropped in fall
	Method and dispersal agents	Acorns are dispersed by small mammals, birds, and gravity
	Distance	Not documented; dispersal distance depends on behavior of animals
Germination requirements		Germination is predominantly in early spring, generally later than that of associated oak species; germination ranges from 5 to 75 percent; germination hypogeal; germination most likely for acorns that are covered by litter or cached by animals; ideal seedbed is moist soil and a cover of leaf litter; cold stratification increases germination, although some acorns germinate without stratification; germination not impeded by shade
Seedling survival		Seedling survival is greatest beneath the shelter of an overstory; aboveground growth of young seedlings is slow but early root growth is rapid; limited data suggest that seedling survival is relative high
Vegetative phenology		New leaves expand between April and June, concurrently with or after flowering

Genetics

Mating system	Oaks generally have high outcrossing rates
Outcrossing % (t_m)	Unknown
Genetic diversity	High genetic diversity
Heterozygosity (H_e)	0.443
Geographic differentiation	Weak population differentiation based on molecular markers
F_{st} or G_{st}	0.018
Genetic analysis research results	Both clonal and sexual reproduction have been observed, high genetic diversity suspected to be due to high outcrossing rates or high levels of gene flow among populations

Threats and Management Considerations

Insects and disease	Armillara root disease occasionally kills canyon live oak; several fungal species cause twig and stem dieback; canyon live oak incurs less insect damage than associated oak species; acorn crops may be heavily damaged by the filbert weevil and the filbertworm; canyon live oak is a host of *Phytophthora ramorum*, the cause of sudden oak death, in California; *P. ramorum* has not been observed infecting canyon live oak in Oregon
Fragmentation	At least on apparently disjunct population exists in Oregon near the northern edge of the species' range
Harvest	Not an important commercial species
Fire	Canyon live oak is easily top-killed by fire owing to its flammable foliage and thin, flaky bark; top-kill by fire triggers a strong sprouting response; repeated fire produces a shrubby form as a result of this sprouting
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Prolific sprouting results in strong competition for conifer regeneration in clearcuts; herbicides are not effective in controlling these sprouts; acorns are an important source of food for many wildlife species

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Montalvo et al. 1997, Thornburgh 1990b, Tollefson 2008b

Oregon white oak (*Quercus garryana*)

Ecology

Taxonomy and nomenclature		Known regionally as *Quercus garryana*, this is actually *Quercus garryana* var. *garryana*, one of three varieties of *Quercus garryana*; var. *fruticosa* (also known as var. *breweri*) and var. *semota* are shrub varieties occurring in California and Oregon
Description		A small-to-medium, deciduous, broadleaf tree reaching 80 ft (25 m) in height; long, crooked, ascending limbs form a spreading crown, except in dense stands where crowns are narrow; gray to grayish-brown, furrowed, scaly bark
Distribution		From Vancouver Island, British Columbia, to southern California; in Washington, occurs in the lowlands surrounding Puget Sound and south to the Columbia River; follows the Columbia River Gorge, and to a lesser extent, occurs in the foothills east of the Cascade Range; occurs from sea level to 3,800 ft (1,160 m) elevation in Washington; common at low elevations in western Oregon and in the Klamath Mountains
Successional stage		A pioneer species; a climax species where fire occurs frequently and on very dry sites where other trees cannot survive
Associated forest cover		Occasionally occurs as the sole tree species in oak woodlands and savannas; more frequently occurs with conifers and other hardwoods; often present as a mid-story species beneath Douglas-fir, although it cannot survive in that condition due to shade intolerance; occurs with a wide variety of species including Oregon ash, bigleaf maple, lodgepole pine, ponderosa pine, grand fir, Port-Orford-cedar, tanoak, Pacific madrone, and California black oak
Habitat	**Sites**	Found on sites where other trees have historically been excluded by fire and on harsh sites where other species cannot survive or compete; occurs on a wide range of sites from seasonally flooded riparian zones to dry rock outcrops; in the Puget Sound region, typically occurs on plains and terraces of glacial origin
	Soils	Soil texture ranges from heavy clay to coarse glacial outwash; soil fertility ranges from poor to rich; grows on serpentine soils
	Moisture	High drought tolerance; tolerates flooding and a fluctuating water table
	Temperature	High tolerance of heat; frost damage is infrequent
	Shade tolerance	Shade-intolerant to moderately shade-tolerant; shade tolerance decreases with age; regenerates beneath a partial canopy but cannot survive at maturity if overtopped
Interspecific interactions	**Animal damage**	Seedlings browsed by deer and elk; seedling roots may be damaged by rodents
	Mycorrhizal fungi	Associated with numerous species of mycorrhizae

Reproduction and Growth

Mode of reproduction	Reproduces sexually and vegetatively; monoecious; vegetative reproduction typically occurs through root crown sprouts; sprouts prolifically after stem damage, harvest, or fire
Reproductive phenology	Reproductive primordia initiated in June, approximately 11 months before pollination; pollination occurs between April and June; flowering lasts approximately 1 week; acorns reach maturity from late August to September, 4 to 5 months after pollination
Pollination	Wind-pollinated

Seed	**Seed type**	Acorn usually 0.75 to 1.25 in (2 to 3 cm) in length with a shallow cup
	Seed-bearing age	Seed production begins between 20 and 40 years of age; production continues beyond age 180 years
	Seed size/ weight	Approximately 90 acorns per lb (200 per kg)
	Seed longevity/ survivability	Under natural conditions, acorns do not remain viable longer than the growing season after they are formed; acorns may be stored at near-freezing temperatures for two years, although they frequently germinate during storage
	Seed crop and frequency	Crop size varies substantially by year, although some acorns are produced every year; heavy crops occur every 2 to 4 years; there is synchrony in crop size within a region (e.g., the Puget Sound region), but synchrony among regions occurs only in years of very high or very low production; production (dry weight) has been measured at 500 to 1,550 pounds per ac (560 to 1,740 kg per ha)
Seed dissemination	**Time of year**	Most acorns are dispersed from late August through September
	Method and dispersal agents	Gravity, small mammals, and birds, including Steller's Jays
	Distance	Squirrels and birds were observed transporting acorns from 30 ft (8 m) to 1,300 ft (400 m) from the source before burying, dropping, or consuming them
Germination requirements		Acorns begin to germinate in fall, when conditions are sufficiently warm and moist; germination hypogeal; acorn viability high; acorn moisture content must remain above 30 percent to maintain viability; predation is high as acorns are eaten by animals or damaged by insect larvae
Seedling survival		After germination, seedlings form a vigorous taproot; taproot enables survival on dry sites and where vegetative competition is severe; top dieback is common but seedlings frequently sprout from the root crown following dieback
Vegetative phenology		Leaves expand around the time of flowering; radial growth also is initiated at this time and continues through July; shoot elongation occurs primarily during May and June; leaf and flower primordia occupy the same overwintered bud

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.962
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.17
Geographic differentiation	Strong population differentiation based on chloroplast microsatellites but weak differentiation based on nuclear microsatellites; relatively weak population differentiation for seedling traits
F_{st} or G_{st}	0.86 for chloroplast and 0.05 for nuclear microsatellites
Patterns of variation	Q_{ST} = 0.1 for growth and phenology, 0.3 for cold hardiness
Genetic analysis research results	High pollen flow among populations likely the reason for the low population differentiation in nuclear microsatellites; significant genetic clines exist for height, germinant emergence date, and cold hardiness. Height and germinant emergence were strongly correlated with environmental variables associated with summer aridity, while cold hardiness was strongly correlated with temperature differential and mean warmest month temperature

Threats and Management Considerations

Insects and disease	Host to numerous insects and fungal pathogens, true mistletoe (*Phoradendron villosum*) can cause extensive dieback and tree mortality when trees are heavily infected and under drought stress; several decay fungi cause stem decay in older trees; defoliating insects commonly cause leaf damage particularly after mild winters; as a member of the white oak group, it is not susceptible to sudden oak death (caused by *Phytophthora ramorum)*
Harvest	Not a major timber species; sometimes used for firewood; recognized as an important wildlife species on public lands
Fragmentation	Distribution in western Washington and in Oregon's Willamette Valley has been heavily fragmented by agriculture, development, and expansion of conifer forests; most existing oak woodlands were established after European settlement
Fire	Oregon white oak has evolved to tolerate fire; competing tree species are less tolerant of fire; seedlings and saplings may be top-killed by surface fire; larger trees have thick bark and are resistant to fire damage, particularly that of surface fires burning herbaceous fuels; Oregon white oak may sometimes recover from a growing-season crown fire
Other damaging agents	Invasive understory species such as Scotch broom (*Cytisus scoparius*) suppress oak regeneration; many Oregon white oak woodlands and savannas in western Washington and Oregon have been invaded by conifers; if these conifers create a dense canopy, the resulting shade will eventually kill the oak trees
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Some state-listed, threatened herbaceous species occur in the vicinity of Oregon white oak trees, but they are not dependent on the trees; some Oregon white oak plant associations are listed as imperiled or critically imperiled according to NatureServe (G2 or G1)

References

Agee 1993; Arno and Hammerly 2007; Devine et al. 2010; Gucker 2007b; Klinka et al. 2000; Marsico et al. 2009; Peter and Harrington 2002, 2009; Ritland et al. 2005; Stein 1990; Taylor and Boss 1975; USDA NRCS 2010

California black oak (*Quercus kelloggii*)

Ecology

Description		A medium-size, deciduous broadleaf tree, typically reaching 30 to 80 ft (9 to 24 m) in height; forms a broad, rounded crown; foliage is bright green; at maturity, bark is thin and smooth in young trees and dark and platy in older trees
Distribution		Occurs in the vicinity of Eugene, Oregon, southward through the valleys west of the Cascade Range; increases in abundance and elevation in southern Oregon, on lower slopes of the Klamath and Cascade Ranges; range extends to southern California; occurs at elevations in Oregon from 450 ft (135 m) to 3,000 ft (915 m)
Successional stage		Present in both early and late-successional stages; regenerates from sprouts after stand-replacing disturbance; under a regime of frequent disturbance, California black oak may retain dominance as a persistent subclimax species; in the absence of disturbance, associated conifers including Douglas-fir and ponderosa pine will regenerate beneath California black oak and eventually overtop and replace it
Associated forest cover		Common as a minor component of ponderosa pine and mixed-conifer forests; frequently associated with Douglas-fir, white fir, incense-cedar, and sugar pine; also associated with tanoak, Pacific madrone, and Oregon white oak
Habitat	**Sites**	Most likely to occur on low-productivity sites and on sites with a history of disturbance; drought tolerance allows it to grow on sites where other trees cannot survive; found on level valley floors, steep slopes, canyons, and rocky ridges; in the northern portion of its range, including Oregon, California black oak is favored on south- and west-facing slopes
	Soils	Found on well-drained soils formed in a wide variety of parent materials; found on soils of most textures except heavy clays; competes best on dry soils
	Moisture	Highly drought tolerant; establishes on harsh, dry sites where other tree species cannot grow; does not grow on saturated soils; a poor competitor on moist soils
	Temperature	Grows in a climate of wet mild winters and hot, dry summers; in Oregon, an indicator of relatively hot sites, where it is a strong competitor; temperate extremes measured in the center of its range were -15 °C (5 °F) and 103 °F (39 °C)
	Shade tolerance	Moderately shade tolerant when young; mature trees are shade-intolerant and require direct sunlight
Interspecific interactions	**Animal damage**	Browsed by deer and domestic livestock; new leaves in spring are especially palatable
	Mycorrhizal fungi	Probably mycorrhizal; closely related oak species are mycorrhizal

Reproduction and Growth

Mode of reproduction		Reproduces sexually and vegetatively; monoecious; vegetative reproduction is through profuse sprouting from near the root collar or stump; sprouts after harvest, damage, or fire
Reproductive phenology		Flowers from mid-March to mid-May, depending on elevation and climate; trees near the coast and at lower elevations flower earlier; acorns reach maturity 18 to 20 months after pollination, from mid-August to mid-September
Pollination		Wind-pollinated
Seed	**Seed type**	Acorns, borne singly or in clusters of two to six

	Seed-bearing age	Approximately 30 years in natural stands; large acorn crops are not produced until trees reach 80 to 100 years of age
	Seed size/ weight	Averages 95 acorns per lb (209 acorns per kg); acorns are 0.7 to 1.7 in (1.9 to 4.4 cm) long and 0.4 to 1.5 in (0.9 to 3.8 cm) diameter
	Seed longevity/ survivability	Under natural conditions, acorns may lose viability rapidly from desiccation; acorns in animal caches may remain viable for several months; under controlled storage conditions, acorns may remain viable for 2 to 5 years
	Seed crop and frequency	Acorn production varies significantly from year to year; abundant acorn crops occur approximately every 2 to 3 years, although production levels may vary within a population and among different populations; very heavy crops occur at longer intervals; production of 150- to 200-year-old trees averaged 6,500 acorns per tree
Seed dissemination	**Time of year**	Mature acorns begin falling from mid-August to mid-September, although the first acorns dropped have low viability; sound acorns usually fall from late September to early November
	Method and dispersal agents	Acorns are dispersed by small mammals and birds, including western gray squirrels, Steller's jays, and scrub jays
	Distance	Not documented; dispersal distance depends on behavior of animals
Germination requirements		Germination is favored on moist mineral soil or light duff; acorns cached by animals are more likely to germinate than those on the soil surface or in litter; germination hypogeal; most, but not all, acorns are dormant and require overwinter stratification; acorn viability is quite variable, ranging from 30 to 95 percent; most germination occurs between February and April
Seedling survival		Seedling mortality is usually a result of drought or damage by pocket gophers; seedlings injured by animal browsing, frost, or insect damage may sprout
Vegetative phenology		New seedlings emerge from the ground between April and early July; leaves are dropped from September to October

Genetics

Mating system	Oaks generally have high outcrossing rates
Outcrossing % (t_m)	Unknown
Genetic diversity	Average genetic diversity using DNA markers
Heterozygosity (H_e)	0.20
Geographic differentiation	Above average geographic differentiation (from a sample of limited distribution)

Threats and Management Considerations

Insects and disease	Susceptible to damage from a wide variety of insects and fungal pathogens, various rot fungi enter the stem through broken limbs or scars from fire or other damage; a significant portion of mature trees are affected by heart rot; many species of insects attack California black oak; insect damage may reduce growth but usually does not kill trees; filbertworm (*Melissopus latiferreanus*) and filbert weevil (*Curculio uniformis*) reduce acorn viability; is a host of *Phytophthora ramorum*, the cause of sudden oak death, in California; *P. ramorum* has not been observed infecting California black oak in Oregon
Fragmentation	Distribution in Oregon is somewhat fragmented based on presence of habitat
Harvest	Comprises a significant portion of the hardwood timber resource in California

Fire	California black oak is well-adapted to fire and is most prevalent in ecosystems that are fire-dependent; it regenerates by both seed and prolific sprouting following stand-replacing fire; mature trees have thick bark and usually survive fire, particularly low-severity fire; seedlings are typically top-killed by fire
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Responds to release from conifer competition; growth of young trees is relatively slow; growth may be increased by stand thinning; California black oak is an important species for habitat of numerous wildlife species

References

Anderson and Roberts 2009, Arno and Hammerly 2007, Bonner and Karrfalt 2008, Dodd and Kashani 2003, Fryer 2007, McDonald 1990

Peachleaf willow (*Salix amygdaloides*)

Ecology

Description		A typically small, short-lived, deciduous broadleaf tree, usually growing to a height of 20 to 40 ft (6 to 12 m), but sometimes reaching heights of 65 to 80 feet (20 to 24 m); a broad crown with drooping branches; bark is thick, yellowish brown to dark brown, irregularly fissured bark with wide, flat ridges
Distribution		From New York and Quebec west to southern British Columbia, Washington, and Oregon; south to New Mexico and Texas; in Washington and Oregon, occurs primarily east of the Cascade crest
Successional stage		A riparian pioneer species; establishes on fresh floodplain alluvium; peachleaf willow stands persist for approximately 30 years until they are overtopped by more shade-tolerant tree species
Associated forest cover		Riparian species including black cottonwood, other willows (*Salix* spp.), alder (*Alnus* spp.), Oregon ash, and Oregon white oak
Habitat	**Sites**	Along the edges of streams, rivers, ponds, and lakes; in moist ravines, ditches, and sloughs
	Soils	Usually found on sandy or silty alluvium; growth on gravel and clay is poor to fair
	Moisture	Tolerant of poorly drained soils and prolonged flooding; requires moisture and is intolerant of drought
	Temperature	Undocumented; presumably tolerant of a wide range of temperatures as it occurs from southern Canada to southern Texas
	Shade tolerance	Intolerant of shade
Interspecific interactions	**Animal damage**	Browsed by livestock and wildlife; a preferred species of beaver
	Mycorrhizal fungi	Unknown, but other *Salix* species are mycorrhizal

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; dioecious; vegetative reproduction originates from sprouts from the root crown or stem base or from fragments of stems and roots transported by floodwaters
Reproductive phenology		Flowering occurs between April and June in the Rocky Mountain region; catkins emerge with new leaves in spring; seed is dispersed from spring to early summer
Pollination		Primarily insect-pollinated, often by bees
Seed	**Seed type**	Ovoid capsules, 0.1 to 0.2 in (3 to 5 mm) in length, in a loose, open catkin; capsules contain tiny seeds with silky hairs at their base
	Seed-bearing age	Unknown; other willows produce seed by age 10 years
	Seed size/ weight	Averages 2,600,000 seeds per lb (5,727,000 seeds per kg)
	Seed longevity/ survivability	No seed dormancy; viability lasts only a few days
	Seed crop and frequency	Unknown; produces large quantities of small seeds

Seed dissemination	**Time of year**	Spring to early summer
	Method and dispersal agents	Wind and water
	Distance	Seeds are dispersed long distances by wind or on water
Germination requirements		Seeds usually germinate within 12 to 24 hours of dispersal, given a moist seedbed; photosynthesis begins immediately
Seedling survival		Seedlings are sensitive to competition; survival is diminished by presence of grasses and other vegetation

Threats and Management Considerations

Insects and disease	Unknown; associated willow species are attacked by insects and fungal diseases although the extent of damage is not quantified
Harvest	Not a commercial timber species
Fragmentation	Eastern Oregon and Washington represent the western edge of the species' range
Fire	Proximity to water suggests that fire frequency may be reduced in this species' habitat; fires usually top-kill trees; roots in moist soils survive and sprout after top-kill; prolific seed production facilitates rapid establishment in burned areas
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	May be planted to stabilize stream banks

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Lyons 1999, Stevens and Dozier 2003, Uchytil 1989e, USDA NRCS 2010

Pacific willow (*Salix lucida* ssp. *lasiandra*)

Ecology

Taxonomy and nomenclature		One of three subspecies of *Salix lucida*
Description		A deciduous, broadleaf, tall shrub or small tree reaching 50 ft (15 m) in height; stout, crooked limbs form a tall, shaggy crown; bark gray to black
Distribution		From interior Alaska south along the Pacific Coast to southern California; also occurs through the Rocky Mountains to New Mexico; common in Washington and Oregon on sites with sufficient moisture
Successional stage		A pioneering early seral species; rapidly colonizes disturbed sites, typically fresh alluvium; persists as a result of repeated flooding
Associated forest cover		Black cottonwood, red alder, other willows (*Salix* spp.), Oregon ash, bigleaf maple
Habitat	**Sites**	Along streams and rivers; in wetlands; low to middle elevations
	Soils	Typically occurs on alluvial deposits; soils may be of any texture, but are most often coarse-textured
	Moisture	Very tolerant of flooding and a fluctuating water table; occurs primarily near water
	Temperature	Unknown
	Shade tolerance	Shade-intolerant; will not regenerate in the shade of tall grasses
Interspecific interactions	**Animal damage**	Browsed by deer and elk; consumed by beaver in winter
	Mycorrhizal fungi	Species of the genus *Salix* are associated with both arbuscular mycorrhizae and ectomycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; dioecious; sexual reproduction more common; vegetative reproduction usually occurs through pieces of broken stem or branches; no root sprouting
Reproductive phenology		Flowers appear in the spring at the same time as the leaves; in Idaho, flowers from April to May, and fruit ripens and is dispersed from June to August
Pollination		Other *Salix* species are known to be pollinated by wind, insects, or both
Seed	**Seed type**	Fruits are capsules containing numerous, very small seeds with hairs
	Seed-bearing age	Unknown; other willows produce seed by age 10 years
	Seed size/ weight	11,500,000 cleaned seeds per lb (25,300,000 seeds per kg)
	Seed longevity/ survivability	Unknown; for other *Salix* spp. germination declines rapidly after 10 days; seed of *Salix* spp. has been successfully stored for 36 months at 14 °F (-10 °C) and for 44 months at -4 °F (-20 °C)
	Seed crop and frequency	A prolific seed producer
Seed dissemination	**Time of year**	Spring through early summer
	Method and dispersal agents	Seeds dispersed by wind and water

	Distance	Unknown; other willows disperse seeds very long distances (i.e., several miles (kilometers))
Germination requirements		Moist seedbed and sunlight required for germination; seeds landing on a moist seedbed germinate within 12 to 24 hours of dispersal; no seed dormancy; seeds begin photosynthesis as soon as they are moistened; germination rate is positively correlated with the amount of light seeds receive

Threats and Management Considerations

Insects and disease	Unknown; associated willow species are attacked by insects and fungal diseases although the extent of damage is not quantified
Harvest	Not a commercial timber species
Fragmentation	Widespread within its range and habitat
Fire	Fires infrequent in moist habitats where Pacific willow is often found; colonizes burned sites rapidly via prolific seed production; potential for sprouting following top-kill is unknown
Other damaging agents	May be heavily browsed; occurs on sites prone to disturbance by flooding
NatureServe Conservation Status Ranking	G5T5 Secure—Common; widespread and abundant
Silvicultural considerations	Well-suited for use in streambank stabilization

References

Arno and Hammerly 2007, Bonner and Karrfalt 2008, Lyons 1999, Uchytil 1989f, USDA NRCS 2010

Scouler's willow (*Salix scouleriana*)

Ecology

Description		A deciduous, broadleaf, tall shrub or small tree reaching 40 ft (12 m) in height; often multi-stemmed; sprawling, twisted, stout limbs form a rounded crown; smooth to flaky bark
Distribution		From interior Alaska east to Manitoba and south through the western United States into Mexico; occurs at higher elevations (up to 10,000 ft; 3,050 m) with decreasing latitude; occurs in eastern and western Washington and Oregon in riparian areas and on upland sites
Successional stage		A persistent, early to mid-seral species; rapidly colonizes disturbed sites, including burned areas; sometimes persists into late seral stages east of the Cascade Range
Associated forest cover		Occurs in many different vegetation types but is rarely a dominant species; found in disturbed areas and gaps; semi-arid ponderosa pine-Douglas-fir forests
Habitat	**Sites**	Found on a wide range of sites, from moist floodplain sites and gravel bars to dry uplands east of the Cascade Range; most often found on upland sites and in transitional upland-riparian zones; capable of growing on drier sites than most other willow species; found on drier, low-elevation sites in the Pacific Northwest; common on depositional land forms including colluvial soils and glacial deposits
	Soils	Shallow to deep soils of a wide variety of parent materials; moderately well-drained to well-drained soils
	Moisture	Tolerant of a wide range of moisture conditions; often occurs on moist but well-drained sites as well as dry, shallow soils
	Temperature	Occurs in a mild, maritime climate in the Pacific Northwest but also tolerates greater temperature extremes in the Rocky Mountains
	Shade tolerance	Slight tolerance of shade; may persist beneath a thin canopy
Interspecific interactions	**Animal damage**	A preferred browse species, but very tolerant of browse damage
	Mycorrhizal fungi	Species of the genus *Salix* are associated with both arbuscular mycorrhizae and ectomycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; dioecious; sprouts vigorously from the root crown beneath the soil surface
Reproductive phenology		Flowering occurs between April and June; catkins appear before leaves; fruit ripens and is dispersed from May to July
Pollination		Insects are important pollinators
Seed	**Seed type**	Catkins bear capsules 0.2 to 0.3 in (5 to 8 mm) long that contain numerous, tiny seeds with hairs
	Seed-bearing age	Likely begins to produce by age 10 years
	Seed size/ weight	6,500,000 seeds per lb (14,300,000 seeds per kg)

	Seed longevity/ survivability	Seeds do not undergo dormancy; seeds remain viable for only a few days unless exposed to moisture; seed of *Salix* spp. has been successfully stored for 36 months at 14 °F (-10 °C) and for 44 months at -4 °F (-20 °C)
	Seed crop and frequency	Abundant seed crop
Seed dissemination	**Time of year**	Late spring
	Method and dispersal agents	Wind and water
	Distance	Seeds may be carried several miles (kilometers) by wind
Germination requirements		Seeds are short-lived and germinate within 12 to 24 hours of dispersal; moist mineral soil and sunlight required for germination; seed viability very high under laboratory conditions
Seedling survival		Survival is high where seedlings establish following a stand-replacing fire
Vegetative phenology		Buds develop in April and leaves appear in April or May; stem elongates from May through July; leaves are dropped between July and November, depending on moisture availability

Threats and Management Considerations

Insects and disease	Unknown; associated willow species are attacked by insects and fungal diseases although the extent of damage is not quantified
Harvest	Not a commercial timber species
Fragmentation	Widespread in Washington and Oregon
Fire	Favored by fire owing to vigorous sprouting and rapid colonization of burned sites; moderately susceptible to fire damage; sprouts from belowground buds near the root crown following top-kill or damage; sprouts grow vigorously and increase overall crown size
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Competes vigorously with conifer seedlings

References

Anderson 2001b, Arno and Hammerly 2007, Bonner and Karrfalt 2008, Royle and Ostry 1995, USDA NRCS 2010

Coast redwood (*Sequoia sempervirens*)

Ecology

Description		A very large, long-lived, evergreen conifer, sometimes reaching heights over 300 ft (91 m); an open, conical crown; self-prunes well; red-brown bark is very thick and fibrous
Distribution		Confined to foggy, coastal areas of northwestern California and the southwestern corner of Oregon; usually at elevations below 2,300 ft (700 m)
Successional stage		Considered either a climax species or a fire-dependent seral species
Associated forest cover		Occasionally occurs in pure stands on the best sites; occurs most often with Douglas-fir, grand fir, western hemlock, and Sitka spruce; also occurs with tanoak and Pacific madrone
Habitat	**Sites**	The best sites in the heart of its range in California are alluvial fans, coastal plains, and benches along large streams; growth is reduced at higher elevations and on steeper slopes; in Oregon, it is typically found on slopes, a few miles inland from the coast
	Soils	Found primarily on deep, moist , alluvial soils
	Moisture	Low tolerance of drought; typically occurs in the fog belt
	Temperature	Occurs in a mild maritime climate; sensitive to frost when planted outside its range
	Shade tolerance	Very tolerant of shade
Interspecific interactions	**Animal damage**	Wood rats can cause significant damage to seedlings
	Mycorrhizal fungi	Forms mycorrhizal associations; root hairs are apparently absent

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; monoecious; vegetative reproduction occurs through sprouts from the root crown
Reproductive phenology		Pollen is shed in between late November and early March; flowering usually ends by late January; cones mature by fall; cones open and disperse seed soon after ripening, from early September through late December
Pollination		Wind-pollinated
Seed	**Seed type**	Winged seed occurs in terminal cones 0.5 to 1.1 in (13 to 29 mm) long, with a similar diameter; cones average 60 seeds each, with 2 to 5 seeds per cone scale; seeds have small wings approximately the same width as the seed
	Seed-bearing age	Seed production may begin between 5 and 15 years of age, but seed viability is less than 1 percent before age 20; peak viability is reached when trees are 250 years old
	Seed size/ weight	Averages 88,000 seeds per lb (194,000 per kg)
	Seed longevity/ survivability	Seeds may be stored at subfreezing temperatures for 10 years or longer with no loss of viability
	Seed crop and frequency	Abundant seed crops are produced every 5 to 7 years; lighter crops are produced in other years

Seed dissemination	**Time of year**	Seedfall occurs from early September through late December; in the northern part of its range, coast redwood seed dispersal occurs during winter months
	Method and dispersal agents	Wind
	Distance	Owing to small wings, seeds fall faster than those of most other wind-dispersed tree species; effective dispersal distance is 200 to 400 ft (61 to 122 m)
Germination requirements		Germinates on a variety of seedbeds, if sufficient moisture is available; mineral soil is the best seedbed; stratification not necessary; germination epigeal; germination may occur beneath a forest canopy or in full sunlight
Seedling survival		Seedlings require a relatively high level of moisture to survive; late spring and early fall rains are important for survival; seedlings can withstand warm temperatures and full sunlight if they have soil moisture
Vegetative phenology		Undocumented

Genetics

Mating system	Mostly outcrossing but commonly reproduces asexually via sprouting
Outcrossing % (t_m)	Unknown
Genetic diversity	High levels of genetic diversity are reported, possibly because this species is hexaploid
Patterns of variation	Genetic variation exists *within* families for several growth traits, and relatively little genetic variation was *among* the tested populations; modest genetic differentiation exists among regions of coast redwood, with more variation among clones within the same stand
Genetic analysis research results	Patterns of genetic variation in allozymes show relationships with elevation on the upland sites and with distance from the river on lowland sites

Threats and Management Considerations

Insects and disease	The only diseases resulting in mortality are those that affect seedlings, including damping-off and Botrytis fungi; has been found infected by *Phytophthora ramorum*, the cause of sudden oak death, in one locale in coastal southwestern Oregon; damage from *P. ramorum* consisted of minor needle damage in an area of high inoculum pressure; heart rot in the southern part of its range is caused by brown cubical rot (*Poria sequoiae*); a white ring rot is caused by *P. albipellucida* ; insects do not cause significant damage
Harvest	A very valuable commercial species; fast-growing
Fragmentation	Native range is generally continuous except for a discontinuity in Humboldt County, California; at the northern and southern extremes of its range, detached populations are more common
Fire	Young trees are usually top-killed owing to thin bark; older trees are protected from fire damage by thick bark; seedlings and trees sprout from the root crown after top-kill
NatureServe conservation status ranking	G4 - Apparently secure
Silvicultural considerations	The preferred silvicultural system is small clearcuts (30 to 40 acres)

References

Ahuja 2009; Anekonda 1992; Arno and Hammerly 2007; Bonner and Karrfalt 2008; Griffith 1992d; Millar et al. 1985; Olson et al. 1990; Rogers 1994, 2000; USDA NRCS 2010

Pacific yew (*Taxus brevifolia*)

Ecology

Description		A long-lived, coniferous, evergreen, tall shrub or small tree rarely reaching 60 ft (18 m) in height; an often contorted, malformed stem; long branches form an irregular crown; thin, purplish, scaly bark
Distribution		Along the Pacific Coast from southeastern Alaska to central California; an inland distribution occurs from southeastern British Columbia into northern Idaho and adjacent states; occurs throughout western Washington and Oregon, from the coast to the Cascade Range at low to moderate elevations; occurs in the Blue Mountains of Oregon
Successional stage		Present in all stages of secondary succession, but uncommon in young stands; typically increases in cover with stand age; present in many climax communities and most prevalent in old-growth forests
Associated forest cover		Most often occurs beneath canopies of western hemlock, Douglas-fir, western redcedar, and Pacific silver fir; also found beneath Sitka spruce, ponderosa pine, western larch, and grand fir; sometimes occurs in moist microsites beneath Oregon white oak and Oregon ash
Habitat	**Sites**	Capable of growing on a wide range of sites; typically found in cool, moist, shaded locations in lowlands and mountains; also occurs on warm, dry, sites
	Soils	Occurs most often on deep, moist, well-drained soils; soil fertility ranges from poor to very high
	Moisture	Tolerant of flooding; moderately tolerant of drought; more abundant on moist sites
	Temperature	Moderately frost tolerant; moderately tolerant of heat
	Shade tolerance	The most shade-tolerant tree in the Pacific Northwest; may require shade on hot, dry sites; may establish and grow in deep shade but also can survive after canopy removal
Interspecific interactions	**Animal damage**	A preferred browse species of ungulates; may suffer damage from rabbits; may be heavily browsed in open areas, although delayed germination may reduce exposure to browsing
	Mycorrhizal fungi	Associated with arbuscular mycorrhizae; some observations of ectomycorrhizal associations in old-growth forests

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; dioecious; vegetative reproduction is through layering and stump sprouts
Reproductive phenology		In Washington, flowering occurs in June and fruit ripens between August and October; fruit is dropped around October
Pollination		Wind-pollinated
Seed	**Seed type**	Ovoid-oblong seed approximately 0.3 in (8 mm) long; seed is partially encased in a fleshy, cup-shaped aril; the seed has a bony inner seedcoat and a membranous outer seedcoat
	Seed-bearing age	Unknown; English yew (*Taxus baccata*) begins to bear seed at age 80
	Seed size/ weight	Cleaned seeds average 15,000 seeds per lb (33,100 seeds per kg)

	Seed longevity/ survivability	Some seeds germinate the first year and some germinate the second year; it is possible that a portion of seeds remain in the soil for many years before germinating; seed can likely be stored for many years at -4 to 0 °F (-20 to -18 °C)
	Seed crop and frequency	A prolific seeder; frequency of heavy crops is unknown
Seed dissemination	**Time of year**	Seeds ripen and are dispersed from August to October
	Method and dispersal agents	Seed falls to the ground or is taken from the tree by birds and rodents; rodents and some birds cache seed
	Distance	Some seed transported long distances by birds
Germination requirements		Seed germinates slowly over a period of at least 2 years; stratification required; germination epigeal; germination typically in heavy organic matter
Seedling survival		Seedling establishment generally greater in the understory than in openings

Genetics

Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.145
Geographic differentiation	Weak population differentiation based on molecular markers
F_{st} or G_{st}	0.096
Genetic analysis research results	Populations and individuals within populations differ significantly in taxane content

Threats and Management Considerations

Insects and disease	Insects and fungal pathogens are not a major concern; host of *Phytophthora lateralis*, the non-native pathogen that causes Port-Orford-cedar root disease; infection of Pacific yew by *P. lateralis* has only been found in areas of high inoculum pressure
Harvest	Once harvested to produce the medication Taxol, which is now created synthetically or harvested from other *Taxus* spp. that are planted for that purpose
Fragmentation	Widespread within its range
Fire	Very susceptible to fire; killed by light surface fires; most prevalent in stands with long fire-free intervals
NatureServe conservation status ranking	G4/G5: G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors/ G5 Secure—Common; widespread and abundant; range indicates some uncertainty about the exact status; concerns are slow growth, the fact that it does not reproduce rapidly, its somewhat narrow ecological range, and loss of habitat as a result of logging activity
Silvicultural considerations	Pacific yew typically becomes most prevalent after centuries of stand development; it grows and reproduces slowly in the understory; Pacific yew released through complete overstory removal apparently undergoes stress but often adapts to the new conditions

References

Arno and Hammerly 2007, Bolsinger and Jaramillo 1990, Bonner and Karrfalt 2008; Busing et al. 1995, Daoust 1992, DiFazio et al. 1997, Doede et al. 1993, El-Kassaby and Yanchuk 1994, Griffiths et al. 1995, Klinka et al. 2000, Scher and Jimerson 1989, Tirmenstein 1990b, USDA NRCS 2010, Wheeler et al. 1995

Western redcedar (*Thuja plicata*)

Ecology

Description		A long-lived, medium-to-large, evergreen conifer occasionally reaching 200 ft (60 m) in height; a pointed, conical crown of drooping branches; hanging sprays of scale leaves; thin, reddish, fibrous bark; a frequently tapered, fluted base
Distribution		Occupies coastal and interior ranges; coastal range extends from southeastern Alaska to northern California, from the coast to the Cascade Range; less frequent on the eastern slope of the Cascades; interior range reaches from southeastern British Columbia into northern Idaho and includes northeastern Washington; common below 4,100 ft (1,250 m) in Washington; occurs to a maximum of 7,500 ft (2,290 m) elevation in Oregon
Successional stage		Occurs in all stages of succession; often considered a climax species because of its shade tolerance
Associated forest cover		Typically occurs in mixed-species stands, often with Douglas-fir and western hemlock; also occurs with a wide variety of other species including Sitka spruce, mountain hemlock, western white pine, shore pine, Port-Orford-cedar, incense-cedar, Pacific silver fir, grand-fir, red alder, and black cottonwood
Habitat	**Sites**	Found on low- and mid-elevation sites in western Washington and Oregon, from forested swamps to shallow, rocky soils on slopes
	Soils	Occurs on a wide variety of soils and parent materials; soils range from very nutrient-poor to very nutrient-rich
	Moisture	Tolerant of wet soils and seasonal flooding; moderate drought tolerance
	Temperature	Low frost tolerance; moderately tolerant of heat; requires protection on hot, dry sites
	Shade tolerance	Very shade tolerant; nearly as tolerant as Pacific silver fir and western hemlock
Interspecific interactions	**Animal damage**	Preferred browse species for deer and elk; seedlings and saplings heavily browsed; bears occasionally strip bark to feed from sapwood
	Mycorrhizal fungi	Associated with arbuscular mycorrhizae; seedlings responsive to mycorrhizal inoculation

Reproduction and Growth

Mode of reproduction		Reproduces sexually and vegetatively; monoecious; vegetative reproduction occurs through layering, from fallen limbs, or from the branches of fallen trees; vegetative reproduction is most common in moist, closed-canopy stands; reproduction from seed is most common after disturbance
Reproductive phenology		Reproductive cycle lasts approximately 16 months, beginning in early June of year 1 with the initiation of cone primordia; 6 to 7 weeks after breaking dormancy in year 2, pollination occurs over a period of 1 to 2 weeks from mid-February (mild climates) to early April (higher elevations); fertilization occurs around late May; west of the Cascades, redcedar cones mature approximately 5 months after pollination
Pollination		Wind-pollinated
Seed	**Seed type**	Ellipsoid cones 0.4 to 0.6 in (10 to 14 mm) long; 8 to 14 seeds per cone; winged seeds
	Seed-bearing age	Seed production usually begins between ages 15 and 25 years; peak production occurs after age 70 to 80 years

	Seed size/ weight	Averages 414,000 seeds per lb (912,700 seeds per kg) ranges from 203,000 to 592,000 seeds per lb (448,000 to 1,305,000 seeds per kg); seeds 0.16 to 0.30 in (4 to 7.5 mm) in diameter including wings
	Seed longevity/ survivability	High initial viability; under natural conditions viability declines rapidly; viability remains high for 7 to 20 years stored at -4 °F (-20 °C)
	Seed crop and frequency	Relatively high capacity for regeneration; ranges from 100,000 to 1,000,000 seeds per ac (247,000 to 2,470,000 per ha); seed crops usually every other year for individual trees; heavy seed crops every 3 to 4 years
Seed dissemination	**Time of year**	Begins in September, peaks in October and November, and continues through February or March; warm, dry conditions may lead to earlier seedfall
	Method & dispersal agents	Seeds dispersed by wind; seeds have small wings; birds eat seeds but not a confirmed vector
	Distance	Adequate dispersal to 330 ft (100 m); seeds rarely found beyond 400 ft (122 m) from source
Germination requirements		Germinates well without stratification in fall, winter, or spring; germination minimal after first year; shaded mineral soil best for germination; mortality high during germination period and thereafter
Seedling survival		Seedling survival generally low; seedlings in exposed areas less tolerant of high soil temperatures, drought, and frost than associated species; high resistance to flooding; a preferred browse species
Vegetative phenology		Shoot elongation begins as early as mid-March, peaks in May, and ends between August and November; radial growth occurs from May to September

Genetics

Mating system	Outcrossing with widely varying but often substantial inbreeding
Outcrossing % (t_m)	0.72 (range 0.173–1.257)
Genetic diversity	Very low genetic diversity
Heterozygosity (H_e)	0.039
Geographic differentiation	Weak population differentiation
F_{st} or G_{st}	0.033
Patterns of variation	Generally low levels of population differentiation in quantitative traits have led to western redcedar being considered a “generalist” species with relatively wide climatic and environmental tolerances
Genetic analysis research results	Early isozyme studies found zero genetic diversity in seed from trees in Oregon and Washington; families with lower terpene content are more palatable to deer; interior populations (northern Idaho area) differ significantly in some growth and cold hardiness traits, but the clines are gentle and populations need to be >600 m apart in elevation or >2^{o} in latitude to be genetically differentiated

Threats and Management Considerations

Insects and disease	Insect damage infrequently a problem; has a variety of fungal pathogens; trunk decay common (often caused by *Posta sericiomollis*) in old or wounded trees
Harvest	A valuable commercial species harvested from second-growth stands and occasionally from old-growth stands
Fragmentation	Common throughout its range in the Pacific Northwest

Fire	More susceptible to fire damage than associated species; young trees have thin bark, low branches, and flammable foliage; large trees are less susceptible to fire; in western Washington, the fire-return interval is long (50 to 350 years) in most stands containing western redcedar
Other damaging agents	Susceptible to windthrow on wet sites
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Increasingly planted although browse damage to planted seedlings is a concern; research is ongoing to develop browse-resistant trees; often relegated to sub-canopy positions by faster-growing conifers in mixed-species stands

References

Arno and Hammerly 2007; El-Kassaby et al. 1994; Glaubitz et al. 2000; Harrington 2010; Klinka et al. 2000; Minore 1983, 1990; O'Connell et al. 2001, 2004, 2008; Tesky 1992a; USDA NRCS 2010; Yeh 1988

Western hemlock (*Tsuga heterophylla*)

Ecology

Description		A medium-to-large evergreen conifer, occasionally reaching 200 ft (60 m) in height; a slender stem and a dense, narrow crown with a drooping leader; thin, reddish-brown bark becoming furrowed with age
Distribution		Coastal and inland ranges; coastal range extends from Alaska's Kenai Peninsula to central California; inland range extends through southeastern British Columbia into northern Idaho, northeastern Washington, and northwestern Montana; occurs from the coast of Washington to the eastern slopes of the Cascade Range; occurs in the coastal ranges of Oregon and in the Oregon Cascades
Successional stage		A climax species; present in all stages of secondary succession; frequent in old-growth stands
Associated forest cover		Occurs in pure and mixed-species stands; frequently occurs with Douglas-fir, Pacific silver fir, Sitka spruce, and western redcedar; also occurs with noble fir, bigleaf maple, red alder, Port-Orford-cedar, tanoak, golden chinquapin, and incense-cedar
Habitat	**Sites**	Grows best in mild, humid climates with growing-season fog and precipitation
	Soils	Tolerates soils of very low fertility including acidic, organic soils; tolerates soils of most textures, although growth rate is reduced on compacted or clayey soils
	Moisture	Low drought tolerance; intolerant of very shallow water tables; prefers well-drained soils
	Temperature	Low heat tolerance; intolerant of frozen soil; shallow-rooted and requires snowpack to insulate soil
	Shade tolerance	Very shade-tolerant; shade tolerance similar to Pacific silver fir and western redcedar
Interspecific interactions	**Animal damage**	Sometimes browsed by deer and elk, though not a preferred species; small stems may be clipped by rodents
	Mycorrhizal fungi	Associated with arbuscular mycorrhizae and ectomycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is sexual and vegetative; monoecious; vegetative reproduction occurs through layering; seedlings may sprout from the root crown
Reproductive phenology		Pollen and seed cones differentiate in June and July, respectively, of the year prior to pollination; pollination occurs from mid to late April in Oregon and from late May to June in Alaska; seed cones mature 120 to 160 days after pollination, although time of maturation is variable within a tree
Pollination		Wind-pollinated
Seed	**Seed type**	Cones 0.75 to 1.25 in (19 to 32 mm) long containing 30 to 40 seeds with large wings
	Seed-bearing age	Regular cone production begins around age 25 to 30 years
	Seed size/ weight	Weight ranges from 189,000 to 508,000 seeds per lb (417,000 to 1,120,000 seeds per kg), with an average of 260,000 seeds per lb (573,000 seeds per kg)

	Seed longevity/ survivability	Seeds viable only during the first growing season after seedfall; seed can be stored at 0 °F (-18 °C) for 5 years or longer
	Seed crop and frequency	Mature trees produce abundant seed; some cones produced every year; heavy crops every 3 to 4 years; a 100-year-old stand produced 8,000,000 seeds per ac (19,800,000 seeds per ha) in good seed years
Seed dissemination	**Time of year**	Cone scales open and seeds drop in late October; most seeds shed in fall; cone scales open and close in response to atmospheric moisture
	Method and dispersal agents	Seed dispersed by wind
	Distance	In open stands, most seeds fall within 2,000 ft (600 m) of the parent tree, although some travel as far as 3,800 ft (1,150 m); distances are much less in dense stands
Germination requirements		Cold stratification increases germination; following stratification, germination rate increased by warmer temperatures; seeds germinate on mineral soil and a wide range of organic substrates, given sufficient moisture; decaying logs and rotten wood are favorable seedbeds; germination epigeal
Seedling survival		Mortality results when organic seedbeds become dry in direct sunlight; seedling survival is highest on mineral soil and other materials that provide adequate moisture; early growth is slow
Vegetative phenology		Vegetative phenology varies substantially by latitude; buds begin to swell in late March and burst around May; shoots elongate rapidly until early July; shoot elongation then slows and ends around August

Genetics

Mating system	Predominantly outcrossing with high outcrossing rate
Outcrossing % (t_m)	0.93
Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.12
Genetic analysis research results	Differences in 5-year height among four populations in Washington and Oregon were significant, but variation among families within sites was not; in 5-year old seedlings, fall and spring cold hardiness and date of budburst increased and height growth decreased with latitude; significant variation was found in seed weight, number of cotyledons, and seedling growth rate, growth rate was related to soil and air temperature; seedlings in southern latitudes, middle elevations, and coastal provenances grew fastest, although a strong north-south cline exists in coastal provenances

Threats and Management Considerations

Insects and disease	Hemlock dwarf mistletoe (*Arceuthobium tsugense* subsp*. tsugense*) is common on western hemlock in coastal and Cascade populations; root and butt decays caused by the pathogens *Heterobasidion occidentale* and *Phellinus weirii* can be damaging in older stands; Armillaria root disease (caused by *Armillaria ostoyae*) can be locally damaging in trees of all ages; *Echinodontium tinctorium* is associated with substantial amounts of stem decay in older trees; while several insects are associated with western hemlock, few cause serious damage
Harvest	An important commercial species harvested for timber and pulp
Fragmentation	Common throughout its range in Washington and Oregon

Fire	Very susceptible to fire damage owing to thin bark, shallow roots, low branches, and highly flammable foliage; fire-return interval is low (150 to 400 or more years) in the moist maritime stands where western hemlock is prevalent
Other damaging agents	Low resistance to windthrow
NatureServe Conservation Status Ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	An extremely productive species; more productive than Douglas-fir on some sites; can be regenerated under many different silvicultural systems; responds well to release from suppression

References

Arno and Hammerly 2007; Bonner and Karrfalt 2008; El-Kassaby et al. 2003; Foster and Lester 1983; Hannerz et al. 1999; Klinka et al. 2000; Kuser and Ching 1980, 1981; Owens and Molder 1984; Packee 1990; Tesky 1992b; USDA NRCS 2010; Wellman et al. 2003, 2004

Mountain hemlock (*Tsuga mertensiana*)

Ecology

Description		A small-to-medium, evergreen conifer reaching 75 to 150 ft (23 to 45 m) in height depending on the site; a narrow conical crown of drooping and spreading branches; dark, thick bark becomes deeply furrowed and plated with age
Distribution		Along the Pacific Coast from the Kenai Peninsula of Alaska to central California, increasing in elevation southward; occurs in Washington in the Olympic Range and on the western slopes and relatively moist, upper eastern slopes of the Cascade Range; reported at elevations of 4,200 to 5,600 ft (1,300 to 1,700 m) in Washington's North Cascades; occurs near the Cascade crest in Oregon to a maximum elevation of about 7,500 ft (2,290 m) and in the Blue Mountains
Successional stage		Occurs in all stages of succession; a long-lived climax species in most of its habitat
Associated forest cover		Occurs in mixed stands, less often in pure stands; near treeline occurs as scattered individuals or in clumps; occurs in mixed stands with Pacific silver fir, subalpine fir, and Alaska yellow-cedar; occurs less frequently with whitebark pine, Engelmann spruce, western white pine, lodgepole pine, western hemlock, western redcedar, and Douglas-fir
Habitat	**Sites**	Present in the highest forested zones; occurs on most landforms, but often in mixed stands on sheltered slopes, in draws, and on north-facing slopes
	Soils	Present on a wide range of soil types; fertility ranges from very poor to moderate; tolerant of organic soils, very acidic soils, and low nutrient availability
	Moisture	Low drought tolerance; usually found on moist soils; tolerates soils ranging from slightly dry to very moist; mean annual precipitation in its range is 107 in (272 cm), mostly as snow
	Temperature	Low tolerance of heat; moderate to high frost tolerance; low tolerance of frozen soil; requires snowpack to insulate soil in winter
	Shade tolerance	Shade-tolerant; exceeded in shade tolerance only by Pacific silver fir, western hemlock, and Alaska yellow-cedar
Interspecific interactions	**Animal damage**	Not reported
	Mycorrhizal fungi	Associated with arbuscular mycorrhizae with ectomycorrhizae

Reproduction and Growth

Mode of reproduction		Reproduction is predominantly sexual; monoecious; occasionally reproduces vegetatively through layering
Reproductive phenology		Reproductive cycle spans two growing seasons; pollen and seed cone differentiate in late July of year 1; cones develop until dormancy in October; ovules initiated after winter dormancy; post-dormancy development is strongly affected by temperature; flowering occurs in June or July, approximately 12 weeks after the end of dormancy, depending on elevation; seed cones receptive for 1 to 2 weeks; fertilization occurs around early August; seeds mature around mid-September; seedfall begins between late September and November, 90 to 120 days after pollination
Pollination		Wind-pollinated; pollen released on warm, dry days
Seed	**Seed type**	Cones are 0.75 to 3.5 in (2 to 9 cm) long; bear winged seeds

	Seed-bearing age	Seed production begins around age 20 years; mature trees (175 to 250 years) produce moderate to heavy cone crops
	Seed size/ weight	Averages 114,000 seeds per lb (251,300 seeds per kg); ranges from 102,000 to 207,000 seeds per lb (225,000 to 456,000 seeds per kg)
	Seed longevity/ survivability	Unknown under natural conditions; seed is stored at 0 °F (-18 °C), although success of long-term storage is likely variable and influenced by genetics
	Seed crop and frequency	Large seed crops occur about every 3 years; seed crops may be very low in other years; very heavy seedfall estimated at 87,000 to 1,677,000 seeds per ac (215,000 to 4,144,000 seeds per ha); warm summer in the previous year yields heaviest crops
Seed dissemination	**Time of year**	Majority of seedfall occurs when cones initially open between late September and November; warm, dry weather causes earlier seed release; wet, cool weather may delay release
	Method and dispersal agents	Seed predominantly wind-dispersed; occasionally consumed by birds
	Distance	Seed dispersed to approximately 500 ft (150 m) from source tree
Germination requirements		Moist organic soil, mineral soil, and snow are suitable substrates; cold stratification may increase germination; germination epigeal; germination ranges from 47 to 75 percent
Seedling survival		Young seedling growth best in partial shade; early growth slow; seedlings have relatively low drought tolerance; slow to regenerate in disturbed areas
Vegetative phenology		Late snowpack shortens the growing season; growth positively related to summer temperature, length of growing season, and depth of snowpack

Genetics

Genetic diversity	Average genetic diversity
Heterozygosity (H_e)	0.087
Geographic differentiation	Weak genetic differentiation based on molecular markers
F_{st} or G_{st}	0.077
Patterns of variation	Moderate population differentiation based on quantitative traits
Genetic analysis research results	Populations and families within populations in southern coastal British Columbia differed in height growth, fall cold hardiness, gas exchange, and biomass allocation, but most of the genetic variation was within populations (77 to 87 percent); populations from higher latitudes or elevations had higher growth rates and the variation was related to climate coldness

Threats and Management Considerations

Insects and disease	Susceptibility to insect damage is generally low; prone to serious damage by root disease fungi *Phellinus weiri* and *Heterobasidion occidentale*; highly susceptible to dwarf mistletoe (*Arceuthobium tsugense* subsp*. mertensianae)* which frequently kills trees; often infected by stem decay fungi including *Echinodontium tinctorium*
Harvest	Occasionally harvested in mixed stands; high-elevation stands have very limited access
Fragmentation	Distribution in Oregon is discontinuous, as trees occupy only high elevation habitats

Fire	More susceptible to fire damage than its associates, owing to retention of low branches, flammable foliage, and occurrence in dense clusters; wildfire return interval is typically very long
Other damaging agents	Susceptible to windthrow owing to shallow root system
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Natural regeneration is slow after disturbance; early growth is slow; planting often ineffective at high elevations

References

Ally and Ritland 2007, Ally et al. 2000, Arno and Hammerly 2007, Benowicz and El-Kassaby 1999, Benowicz et al. 2001b, Bonner and Karrfalt 2008; Franklin and Krueger 1968, Klinka et al. 2000, Means 1990, Owens and Molder 1984, Tesky 1992c, USDA NRCS 2010, Woodward et al. 1994

Oregon myrtle (*Umbellularia californica*)

Ecology

Taxonomy and nomenclature		Also known as California-bay and Oregon-myrtle
Description		A small- to medium-sized, evergreen broadleaf tree, typically reaching a height of 40 to 80 ft (12 to 24 m); forms a wide, rounded crown that may extend to near the ground; often multi-stemmed; bark is smooth and gray on young trees, becoming reddish brown and scaly on older trees
Distribution		Occurs near the Pacific coast from the Umpqua River Valley in Oregon south to San Diego County, California; extends from the coast inland to the foothills of the Cascade Range; occurs in the western Sierra Nevada; found from sea level to an elevation of 4,000 ft (1,220 m) in Oregon and northern California
Successional stage		A seral species in mixed evergreen forests, where it occurs as a pioneer but persists as a subcanopy dominant into late seral stages; a climax species in hardwood forests, where it is dominant or codominant in the canopy; also occurs in chaparral communities
Associated forest cover		Occurs in mixed evergreen forests and hardwood forests with Douglas-fir, sugar pine, ponderosa pine, white fir, tanoak, Oregon white oak, California black oak, canyon live oak, incense cedar, and ponderosa pine; occasionally occurs in pure stands
Habitat	**Sites**	Grows on a wide variety of sites: mountain slopes, canyons, ravines, exposed ridges, rocky outcrops, valley bottoms, and low hills; grows in diverse climates including cool, humid coastal forests and hot, dry inland woodlands and chaparral
	Soils	Occurs on coarse- to fine-textured soils formed in alluvium or in sedimentary or volcanic parent materials; found on serpentine soils in the Siskiyou Range
	Moisture	Found where average annual precipitation is as little as 13 in (33 cm); tolerates occasional inundation on valley bottom sites; average annual snowfall ranges from 0 to 292 in (742 cm) within its distribution
	Temperature	Average January temperature ranges from 31 to 50 °F (-1 to 10 °C) and average July temperature ranges from 56 to 84 °F (13 to 29 °C) within Oregon myrtle's range
	Shade tolerance	Moderately shade-tolerant
Interspecific interactions	**Animal damage**	May be browsed by black-tailed deer
	Mycorrhizal fungi	Unknown

Reproduction and Growth

Mode of reproduction		Sexual and asexual reproduction; monoecious; asexual reproduction occurs through vigorous sprouting from the root collar, stump, or stem
Reproductive phenology		In northern California: flower buds first appear in September or November of the year prior to flowering; flowering occurs from April through September; fruit reaches maturity from September to November
Pollination		Insect-pollinated
Seed	**Seed type**	Drupes containing a single, thin-coated seed, approximately 0.6 in (15 mm) in diameter
	Seed-bearing age	Unknown; young trees may produce flowers; abundant seed production occurs after trees reach 30 to 40 years of age

	Seed size/ weight	300 cleaned seeds per lb (661 per kg)
	Seed longevity/ survivability	Limited information; viability is maintained through the first winter after seedfall, but declines rapidly thereafter
	Seed crop and frequency	Abundant seed crops in most years
Seed dissemination	**Time of year**	Seedfall occurs in late fall and winter
	Method and dispersal agents	Animals, gravity, and water
	Distance	Unknown; likely depends on movement of animal vectors
Germination requirements		Some germination occurs without stratification or scarification; germination rates increase somewhat after 2 to 3 months of cold stratification or after scarification; germination greatest in riparian areas; germination hypogeal
Seedling survival		Unless the soil surface is disturbed, survival is poor under dry conditions; seedlings are strong competitors relative to other species of similar shade tolerance; few seedlings survive beneath other Oregon myrtle trees
Vegetative phenology		In northern California, new leaves appear from May to June

Genetics

Genetic analysis research results	Little geographic variation was found among populations in foliar monoterpenoid composition

Threats and Management Considerations

Insects and disease	Foliar infections by *Phytophthora ramorum*, the cause of sudden oak death, have been found in areas of high inoculum pressure in coastal Curry County; heart rot, caused by *Ganoderma applanatum*, can be significant ; insects are not a significant problem
Harvest	Wood is highly valued for specialty uses
Fragmentation	Distribution becomes scattered near the northern edge of its range in northwestern Oregon
Fire	Fire kills seedlings and top-kills the thin-barked saplings and trees; top-killed individuals sprout vigorously
Other damaging agents	Susceptible to blowdown and snow damage; wind damage is more common near the coast
NatureServe conservation status ranking	G5 Secure—Common; widespread and abundant
Silvicultural considerations	Reduces growth of conifer seeds through allelopathy; California bay laurel grows vigorously after a conifer overstory is removed

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Arno and Hammerly 2007, Bonner and Karrfalt 2008, Goralka and Langerheim 1995, Howard 1992b

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