Juniperus occidentalis Hook. Western Juniper

Cupressaceae Cypress family

J. Edward Dealy

Western juniper *(Juniperus occidentalis)* is also called Sierra juniper. There are two subspecies separated geographically, *occidentalis* in the northern part and *australis* in the southern part of its range. Unless specifically identified, both are included in the following discussion. One of the largest western junipers recorded grows on the Stanislaus National Forest in California. It measures 414 cm (163 in) in d.b.h., is 26.5 m (87 ft) tall, and has a crown spread of 15.5 m (51 ft).

Habitat

Native Range

Western juniper (fig. 1) is found intermittently from latitude 34" N. in California to latitude 46" 37' N. in southeastern Washington, in a narrow belt from longitude 117" W. in Idaho and California to longitude 123" W. in northern California, and in sparse, scattered stands in south-central and southeastern Washington, southeastern Oregon, and the northwest corner of Nevada. In southwestern Idaho, it grows on approximately 162 000 ha (400,000 acres) (2). Western juniper reaches its greatest abundance as extensive and continuous stands in central Oregon. Stands more limited in size extend up the valleys and foothills of the southern Blue Mountain region, and small groups or individuals are scattered sparsely through the northern Blue Mountains. Extensive stands are common on the plains and in the foothills of north-central Oregon, and large stands occur down the high plains and foothills of south-central Oregon *(5,6)*. From north-central through south-central Oregon, western juniper grows in various densities on roughly 1 140 000 ha (2,816,000 acres) *(5)*. It is found near Mount Ashland in southwestern Oregon *(10)*, the only native stand documented west of the Cascade Range in Oregon. It grows in scattered locations west of the Cascades in northern California and extends south to Trinity County. Western juniper is present in extensive stands from the Oregon border south through the Pit River Valley in northeastern California and continues intermittently as sparse stands in a narrow corridor along eastern California south to disjunct stands in the San Bernardino Mountains *(17)*. The eastern limits of this species are in San Bernardino County, CA, and Owyhee County, ID. The western limit is Trinity County, CA.

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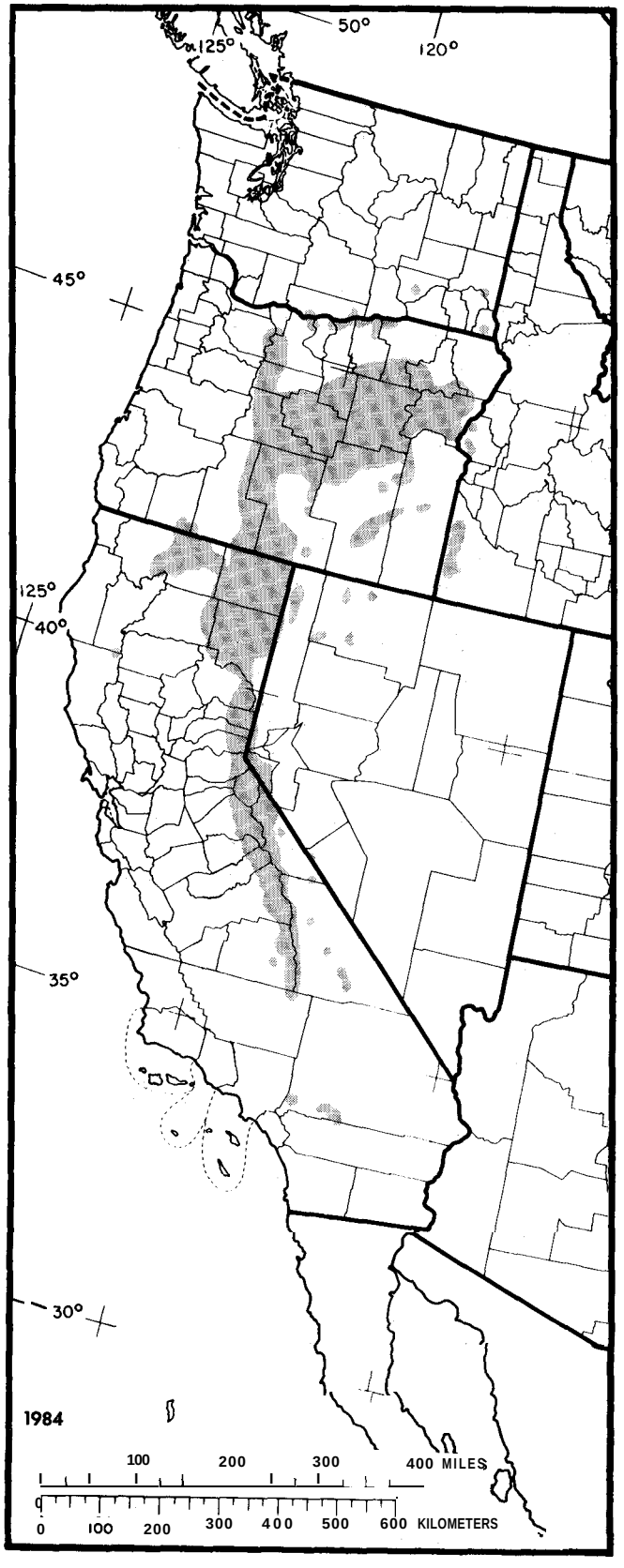
Climate

Northern populations of western juniper grow in a climate characterized as continental. The climate is semiarid with typical intermountain characteristics of dry hot summers, cold winters, and precipitation of 230 to 355 mm (9 to 14 in), which occurs principally as snow during the winter and as rain in the spring and fall (5). Precipitation is generally sparse in the summer. Frost can occur during any month in central Oregon, the area of western juniper's most extensive stands; however, July and August are generally frost free. Temperatures in central Oregon range from a record low of -32" C (-26" F) during January to a record high of 41°C (105° F) during August. The average temperature in January is -1" C (30° F) and in July, 18" C (64" F). Southern populations of western juniper grow in a similar climate; however, winter temperatures are less extreme than in northern areas. Summer lightning storms are common in the western juniper zone and result in natural fires which have historically had a major influence on distribution and past occurrence of juniper.

Although western juniper grows in extensive stands in a narrow range of precipitation (230 to 355 mm; 9 to 14 in) in central Oregon, it is a minor species in many upper elevation areas of higher precipitation. The latter areas have shallow, rocky soils too droughty to support other more common upper-slope conifers.

Soils and Topography

Western juniper grows on soils developed in parent materials originating from metamorphic, sedimentary, and igneous sources. Included are tuff, welded tuff, pumice, volcanic ash, rhyolite, andesite, granite, basalt, and eolian soils, and colluvial or alluvial mixtures of these soils. Western juniper forms complex patterns on zonal, intrazonal, and azonal soils. Profile development is often weak. Soils are generally stony but can be nearly free of stones. They are commonly shallow (25 to 38 cm; 10 to 15 in) but range to deep (more than 122 cm or 48 in). Fractured bedrock or broken indurated subsoil layers commonly occur under shallow overburdened soils. Surface



horizons are often of medium texture, and subsoils of medium to fine texture; however, textures can vary from sandy to clayey. Indurated layers can occur and are associated with accumulations of clay, calcium carbonate, and silica. They may be less than 1.5 cm (0.6 in) to several centimeters thick *(5,6,8)*.

Under mature western juniper trees in central Oregon, soil Ca, K, and pH are higher than in interspace soils and soils under young trees. These changes appear to increase the ability of western juniper to compete with other vegetation *(7)*.

Soils supporting juniper at high densities are frequently Mollisols. Argixerolls, Haploxerolls, and Haplaquolls are common great groups. Soils supporting scattered juniper are commonly Aridisols—including Camborthids, Durargids, and Haplargids; however, Argixerolls are also common. Other soils on which western juniper can be found are Durixerolls and Cryoborolls of the order Mollisols, Torriorthents of the order Entisols, and Chromoxererts of the order Vertisols *(5,6)*.

Western juniper is found on all exposures and slopes. In central Oregon, it is common in large continuous stands on level to gentle topography. In other areas, it grows less continuously on terraces, moderately sloping alluvial fans, canyon slopes, and steep, rocky escarpments *(5,6,8)*. Elevations at which western juniper is found range from about 185 m (600 ft) along the Columbia River to more than 3050 m (10,000 ft) in the Sierra Nevada (24). In central Oregon, there are large, continuous stands between 670 and 1525 m (2,200 and 5,000 ft) *(8)*.

Associated Forest Cover

Western juniper is a single species overstory in many northern stands. In ecotones or transitions, ponderosa pine *(Pinus ponderosa)* and curlleaf mountain-mahogany *(Cercocarpus ledifolius)* are the most common tree associates at the lower edge of the conifer zone *(5,6)*. At upper elevations, western juniper often grows in narrow ecotones where deep, forested soils grade into shallow, rocky scab flats. Small stands or groups of trees commonly grow where rock outcrops produce shallow soil inclusions in ponderosa pine, Douglas-fir *(Pseudotsuga menziesii)*, white fir *(Abies concolor)*, lodgepole pine *(Pinus contorta)*, and other forest types *(5,6,11)*. In the Sierra Nevada, western juniper may be found on shallow soils with Jeffrey pine *(Pinus jeffreyi)*, California red fir *(Abies magnifica)*, whitebark pine *(Pinus albicaulis)*, mountain hemlock *(Tsuga mertensiana)*, or lodgepole pine *(24)*. At the southern extension of its range in San

Figure *1--The native range of western juniper.*

Bernardino County, it generally grows at a higher elevation than California juniper *(Juniperus californica)* and Utah juniper *(J. osteosperma)* (20). This is the only documented area where western juniper and singleleaf pinyon *(Pinus monophylla)* grow together in a pinyon-juniper woodland vegetation type, although distributions are known to overlap geographically near the west edge of Nevada and from east-central to southern California *(10,13)*. Western juniper is the associate of singleleaf pinyon only in the high altitude section of the type, primarily near Big Bear Lake, CA *(13)*.

Western juniper is recognized in five forest cover types (9). It is the dominant species in Western Juniper (Society of American Foresters Type 238); an associate species in Interior Ponderosa Pine (Type 237) and Jeffrey Pine (Type 247); and a minor or occasional species in Blue Oak-Digger Pine (Type 250) and California Mixed Subalpine (Type 256).

Big sagebrush *(Artemisia tridentata)* is the most common shrub species associated with western juniper throughout its range. Other shrubs common to western juniper communities in the northern portion of its range are gray rabbitbrush *(Chrysothamnus nauseosus)*, green rabbitbrush *(C. viscidiflorus)*, antelope-brush *(Purshia tridentata)*, wax currant *(Ribes cereum)*, and horsebrush *(Tetradymia* spp.). Less common shrubs are low sagebrush *(Artemisia arbuscula)*, stiff sagebrush *(A. rigida)*, spiny hopsage *(Atriplex spinosa)*, broom snakeweed *(Gutierrezia sarothrae)*, prickly phlox *(Leptodactylon pungens)*, and desert gooseberry *(Ribes velutinum)* (2,5,8).

Common grass or grasslike species in northern areas are bluebunch wheatgrass *(Agropyron spicatum)*, cheatgrass *(Bromus tectorum)*, Idaho fescue *(Festuca idahoensis)*, prairie Junegrass *(Koeleria cristata)*, Sandberg bluegrass *(Poa sandbergii)*, bottlebrush squirreltail *(Sitanion hystrix)*, and Thurber needlegrass *(Stipa thurberiana)*. Less common are threadleaf sedge *(Carex filifolia)*, Ross sedge *(C. rossii)*, sixweeks fescue *(Festuca octoflora)*, needle-andthread *(Stipa comata)*, and western needlegrass *(S. occidentalis)*. Forb species common to northern communities include western yarrow *(Achillea millefolium)*, milkvetch *(Astragalus* spp.), littleflower collinsia *(Collinsia parviflora)*, obscure cryptantha *(Cryptantha ambigua)*, lineleaf fleabane *(Erigeron linearis)*, woolly eriophyllum *(Eriophyllum lanatum)*, spreading groundsmoke *(Gayophytum diffusum)*, lupine *(Lupinus* spp.), a suffrutescent wild buckwheat *(Eriogonum* spp.), and tufted phlox *(Phlox caespitosa)*. Less common associates are sulfur eriogonum *(Eriogonum umbellatum)*, small bluebells *(Mertensia longiflora)*, and Hooker silene *(Silene hookeri)* (2,5,8).

Major western juniper associations in central Oregon include Juniperus/Artemisia/Festuca, Juniperus/Artemisia/Festuca-Lupinus, Juniperus/Festuca, Juniperus/Artemisia/Agropyron–Chaenactis, Juniperus/ Artemisia/Agropyron, Juniperus/Artemisia/Agropyron-Astragalus, Juniperus/Artemisia–Purshia, Juniperus/Agropyron, and Juniperus/Agropyron-Festuca (8).

In one treatment of vegetation types in the conterminous United States, western juniper is considered the dominant species in the Juniper Steppe Woodland *(Juniperus–Artemisia–Agropyron)*, number 24, and is a secondary species in the Juniper-Pinyon Woodland *(Juniperus–Pinus)*, number 23 *(8,10,17)*.

Life History

Reproduction and Early Growth

Flowering and Fruiting-The northern *Juniperus occidentalis* ssp. *occidentalis* is submonoecious; the southern subspecies *australis* is dioecious.

In Oregon and Washington, western juniper flowers in spring and sheds pollen in May. Yellowish-brown staminate cones are terminal, ovoid, and 3 to 4 mm (0.12 to 0.16 in) long. They have 12 to 15 microsporophylls. Ovulate cones are 6 to 8 mm (0.24 to 0.31 in) long, subglobose to ellipsoid, bluish-black when mature, and very glaucous. Ovulate cones, referred to as berries, have resinous pulp and mature in September of the second season in Oregon, Washington, and Idaho. Ovulate cones commonly have two to three developed seeds, rarely one. The seed has a thick, bony outer coat and a thin, membranous inner coat. The membranous coat surrounds a fleshy endosperm within which a straight embryo with cotyledons occurs *(4,14,24,26)*.

Seed Production and Dissemination--Good seed production in western juniper occurs nearly every year. Seed yield from 45 kg (100 lb) of fruit averages 9 kg (20 lb). Cleaned seeds average 27 000/kg (12,300/lb) and range from 17 600 to 35 000/kg (8,000 to 15,860/lb) (14).

Seeds are disseminated during the fall, primarily by birds and mammals. Animals ingest the fruit but do not digest the seeds. Dissemination of seeds by animals is evidenced by seed-filled droppings, particularly from robins and coyotes. Western juniper is often found growing along fence rows, seeds having been deposited there by perched birds *(14,19,24)*.

Fruit can be collected after it has fallen from the tree or by handpicking it from the tree. Care must be taken when collecting fruit directly from the tree because the new, unripe crop and the 2-year-old, ripe

crop are mixed. Fruit should be collected as soon after ripening as possible to prevent removal by animals. It should be stored in shallow trays or piles to prevent excessive heating until seeds are extracted.

Seeds of western juniper may be extracted from fruit by use of a macerator or hammermill in conjunction with water. Because of its resinous nature, pulp is more easily removed from the seeds if berries are presoaked in a lye solution consisting of 1.25 grams of sodium hydroxide or potassium hydroxide per liter (1 teaspoon to 1 gallon) of water for 1 to 2 days. After they are cleaned, seeds should be washed to remove the lye and then stored dry in sealed containers at -2" to 4" C (29° to 40" F) and with a moisture content of approximately 10 percent (14).

Seedling Development-Natural germination of western juniper occurs during April in Oregon. Germination is epigeal. How long after fruit ripening germination occurs and what dormancy characteristics are present are not known. Seeds of many juniper species show delayed germination because of dormant embryos or hard seed coats. Seeds of western juniper are thought to have both these characteristics. Stratification of seeds should be conducted in a sand or peat medium. A warm stratification is suggested for western juniper, fluctuating from 20" C (68" F) at night to 27" C (81° F) during the day for 45 to 90 days, and then cold stratification of approximately 4" C (39" F) to induce germination (14). After stratification, seeds can be sown in the fall or spring. For spring planting, seeds should be sown before air temperatures reach 21" C (70" F).

Bare mineral soil seedbeds are reported as best for successful germination of seed and establishment of seedlings *(24)*. Young plants are normally vigorous, single stemmed, and have pyramidal forms.

Western juniper is very hardy in the early growth stage, resists disease and insect attacks well, and is not preferred as a food item by domestic or wild animals. Considerable browsing, however, occurs on deer winter ranges when other forage is limited; heavy use results in a hedged growth form.

Vegetative Reproduction-Planting stock has been successfully grafted and cuttings have been successfully rooted in experimental trials. Some stock has been developed by layering (24).

Sapling and Pole Stages to Maturity

Growth and Yield-In the sapling and pole stages, western juniper (fig. 2) has straight boles, and the crown varies from medium tapered to round.

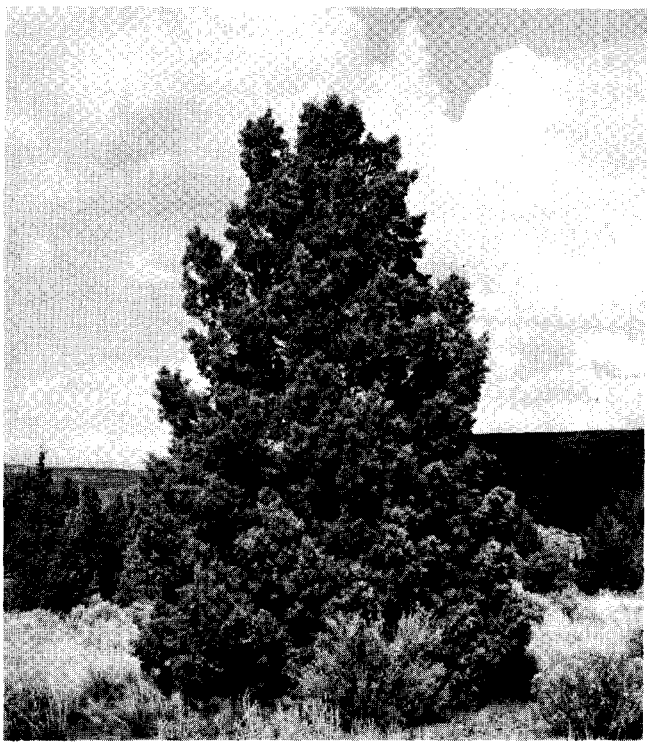


Figure *2-A mature western juniper tree.*

Early growth rate varies by site; however, growth throughout its range is poor, relative to most conifer species.

Height of mature trees ranges from 4 to 10 m (13 to 33 ft), with exceptions at both ends of the spectrum, depending on site conditions. Occasionally, trees reach exceptional heights, such as one recorded as 26.5 m (87 ft) tall and 396 cm (156 in) in d.b.h.; and another, 26.5 m (87 ft) tall and 414 cm (163 in) in d.b.h. *(4,211.* Boles of mature trees are massive and more tapered than those of many conifer species, and the butt section is often slightly fluted. This species commonly develops full crowns and heavy limbs at maturity and, in the overmature stage, has a ragged, dead-topped, gnarled appearance. Western juniper is a long-lived and ruggedly picturesque species, reaching ages estimated to be more than 1,000 years *(24)*. Old-growth stands in central Oregon are between 200 and 400 years old.

Rooting Habit-Seedlings of western juniper, typical of arid site species, produce rapid spring root extension with minimal top growth. There is a greater downward growth than lateral growth of roots, again characteristic of arid site species. As seedlings become established, their roots extend

laterally to take maximum advantage of nutrients and seasonal moisture in upper soil horizons. As a mature tree, western juniper lacks a central taproot. It has roots that are wide spreading and strong, often penetrating deep into cracks of bedrock.

Reaction to Competition-Western juniper is intolerant of shade and competes poorly with conifers on upper slope sites. Although many individual specimens are found growing as seedlings or saplings in upper slope conifer communities with moderate to dense crowns, they are usually small and suppressed and have low vigor. Establishment of western juniper in this situation apparently occurs when the stand is opened by disturbance.

Western juniper is intolerant of fire and historically was kept in restricted sites by natural fires. Since the advent of effective fire control and intensive livestock grazing (reducing ground fuel and understory competition), regeneration and establishment of western juniper have expanded into suitable sites previously dominated by mountain big sagebrush ***(Artemisia tridentata*** ssp. ***vaseyana).*** This expansion of young stands is common in Oregon, Idaho, and northeastern California *(2,3,5,6)*.

Damaging Agents-Because of the characteristic wide spacing in most stands, the short stature of the trees, and the extensive, strong root systems that often penetrate cracked rock under the soil mantle, western juniper is very resistant to wind. Most damage from wind occurs as top breakage in mature and over-mature trees, and little damage occurs in young stands. Fire resistance varies with age. Seedlings, saplings, and poles are highly vulnerable to fire ***(18).*** Mature trees have some resistance to fire because they have little fuel near the stem and relatively thick bark, and because foliage is fairly high above the ground. Old-growth stands remain in existence because, historically, intense natural fires have not occurred and human-caused fires have been controlled *(2,3,5,6)*. Because of effective fire controls, young stands are expanding into shrublands that would otherwise be maintained by periodic natural fires (fig. 3) (2). Where desired, it is easiest to control or eliminate western juniper on rangelands with fire management when trees are less than 2 m (6 ft) tall. The taller the trees become, the more intense the fire must be to obtain good control. If a site has developed a dense stand of large trees, fuel consisting of shrubs and bunchgrass is often inadequate for burning trees under any weather conditions that management can safely tolerate ***(18).***

Figure *3-Fire control has allowed western juniper* (Juniperus occidentalis) *to establish itself where natural fire would have maintained a mountain big sagebrush-bunchgrass community. This is a young stand, but an old seed tree in the upper right-hand corner has escaped previous fires.*

Because the species has relatively little commercial value, little attention has been given to the identification or effect of insects that attack western juniper. Serious damage in western juniper by insects is infrequent. The juniper bark beetle ***(Phloeosinus serratus)*** can cause mortality, particularly to trees in a weakened condition, during a drought (24). Gall midges feed on western juniper and produce galls; however, their effect on productivity has not been studied. Although termites are not considered a problem in use of products made from western juniper wood, an unidentified species of termite has been observed in dead material on lower portions of overmature trees, as well as in juniper fenceposts in central Oregon.

The principal damaging agents to western juniper are a white trunk rot ***(Pyrofomes*** *demidoffii)* that attacks living trees and an unidentified brown cubicle rot usually found in the basal portions of the trunk (24). These rots cause high losses and have prevented the use of western juniper wood for pencils. A single sporophore in evidence usually indicates a tree is unmerchantable. The endophytic fungi ***Retinocyclus abietis anamorpha*** and ***Hormoneme*** sp. have been found on the foliage of western juniper. Infection rates increase with age, density, and purity of stands. In general, western juniper is minimally susceptible to infection (22). Two mistletoes, identified as constricted mistletoe ***(Phoradendron ligatum)*** and dense mistletoe *(P.* ***densom),*** cause lower vigor, deformity of branches, and brooming of the foliage ***(12).*** A third mistletoe, *P.* ***juniperinum*** (Viscaceae), also occurs on western juniper (25). Brooming of foliage is also caused by the stem rusts ***Gymnosporangium kernianum*** and ***G.*** *betheli*. One other rust of the same genus has been reported ***(12).*** Except for the white trunk rot and the unidentified

brown one, none of the diseases that attack western juniper has been assessed.

Special Uses

Western juniper has had no widespread commercial value. During the pioneer era, it was important as firewood and as poles for fences, corrals, and simple shelters. Locally, it is still important for many of the same uses *(5)*. Heartwood is extremely durable and far outlasts other local materials in northern areas when placed in contact with the ground. It probably equals durability of other junipers and of cedars in more southern areas.

Western juniper logs are difficult to process. They are rough, limby, short, and have rapid taper. They also have bark inclusions deep in the wood. Juniper is reputed to be difficult to cure because it twists and warps while drying, and to be difficult to plane, splitting easily. The reputation is undeserved-local specialty manufacturers have been air-drying this wood successfully for many years *(12)*. Thin boards can be kiln-dried successfully without checking. In fact, any slow drying process works well. Local manufacturers use western juniper for making furniture, novelty items, toys, tongue-and-groove interior paneling, fenceposts, and firewood. Products experimentally manufactured that are considered commercially feasible include hardboard, particle board, veneer, and exposed and decorative interior studs. Research in extracted essential oils indicates that cedrol, used in scenting and flavoring, could be extracted in quantities and would be of a quality to be commercially competitive with cedrol from other juniper species *(1, 12)*.

Western juniper is valuable for wildlife cover, food (primarily berries), and nest sites, and as shade for livestock *(16,19)*. Also, management agencies use harvested trees as riprap for stabilizing streambanks. Natural stands in developing areas are highly valuable for landscaping homesites, but the species has not been popular for horticultural uses.

Genet ics

Two subspecies of western juniper have been identified, ***Juniperus occidentalis*** ssp. ***occidentalis*** and ssp. ***australis***. Distribution of the former is in south-central and southeastern Washington, eastern Oregon, southwestern Idaho, northeastern California, and the northwestern corner of Nevada; that of the latter is near Susanville in Lassen County, CA, south to San Bernardino County, CA *(4,10,20,23,26)*. The only other divergence reported is a variant that has a narrow spirelike habit and occurs in a very restricted location in central Oregon (24).

Western juniper may be hybridizing with Utah juniper where the two species grow together in northwestern Nevada east of California's Warner Mountains. Two relict individuals in the White Mountains of California may be hybrids of western juniper and Utah juniper (26).

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