CupressaceaeCCypress family

Juniperus L.

juniper

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Growth habit, occurrence, and use. There are about 50 species of junipers widely distributed throughout the temperate and subtropical regions of the Northern Hemisphere and south of the Equator in Africa. Most are evergreen shrubs and small trees. Thirteen species are native to the United States (Little 1979), and 11 of these are included in this book (table 1). Eastern redcedar is the most widespread juniper in the eastern United States, and Rocky Mountain juniper and Utah juniper are very common in the West. Common juniper is one of the most widespread tree species in the Northern Hemisphere, ranging from Asia to Europe and North America.

The close-grained, aromatic, and durable wood of the larger junipers was once used for furniture, interior paneling, novelties, Christmas trees, posts, poles, fuel, and charcoal (Dealy 1990; Hemmerly 1970; Lawson 1990; Noble 1990; Wilhite 1990). The most important current uses are for firewood, furniture, paneling, and novelty products. Juniper Aberries@ are used for flavoring in cooking and in gin (the word Agin@ is derived from the Dutch word for juniper, *jenever).* Junipers are also valuable for watershed and windbreak plantings, wildlife habitat and food, and ornamental use (Dealy 1990; Johnsen and Alexander 1974; Lawson 1990; Noble 1990; Wilhite 1990). Their utility as ornamental plants has led to the selection and propagation of many horticultural varieties (Dirr and Heuser 1987; Vines 1960). Some junipers are sources for natural oil products. Cedarwood oil is extracted from the heartwood and foliage of Ashe=s juniper and eastern redcedar to produce fragrance in soaps, sprays, disinfectants, and cleaning agents. Rocky Mountain juniper oils have the potential for these uses also (Adams 1987). Because of the encroachment of junipers onto range and pasture lands, particularly in the West, considerable effort has been directed toward their control (Burkhardt and Tisdale 1976; Jameson 1966; Johnsen 1962; McPherson and Wright 1990).

Genetic variation and hybridization. Junipers exhibit considerable natural variation in their growth habit and appearance, and studies have established marked differences in color, crown form, growth rate, and disease resistance in eastern redcedar (Henderson and others 1979; Minckler and Ryker 1959; Seidel and Watt 1969; Tauer and others 1987; Van Deusen 1979), Rocky Mountain juniper (Tauer and others 1987), and western juniper (Matthews 1945). Where ranges of the junipers overlap, natural hybridization abounds. This condition probably explains the large number of reported varieties of North American junipers (Dealey 1990; Fassett 1945; Hall 1952; Hall and others 1961; Lawson 1990; Noble 1990; Ross and Duncan 1949; Vines 1960; Wilhite 1990).

Flowering and fruiting. The small, inconspicuous flowers are borne in the spring (table 2) on the ends of short branchlets or along the branchlets. The flowers are dioecious or occasionally monoecious in oneseed juniper and some sources of western juniper (Dealy 1990; Johnsen and

Alexander 1974). Pollen cones are yellow, terminal, and about 3 to 4 mm long; ovulate cones are composed of pointed scales, 3 to 8 in number, that fuse to form a fleshy cone 6 to 8 mm long (figure 1) (Brown and Kirkman 1990). The fleshy cones are commonly called berries. Cones are usually greenish in color when immature and change to a bluish black or reddish brown as they mature in the autumn (table 2). Most are covered with a conspicuous glaucous bloom. Cones of alligator, Utah, and common junipers require 2 years to reach full maturity, but those of common juniper may require 3 years in some parts of its range (Johnsen and Alexander 1974; Vines 1960). Cones of the other junipers mature in the fall of the first year (table 2). The outer skins of the cones may be thin and resinous as in Virginia redcedar and Rocky Mountain and oneseed junipers, or dry and leathery or mealy as in alligator and Utah junipers (Johnsen and Alexander 1974).

There may be 1 to 4 brownish seeds per juniper cone (table 3). The seeds are rounded or angled, often with longitudinal pits (figure 2) and have thick, bony seed coats (figure 3). Embedded within the fleshy, white- or cream-colored endosperm is a straight embryo with 2 to 6 cotyledons. Junipers begin bearing seeds when they are about 10 to 20 years old. Heavy seed crops are irregular, but some seeds are produced almost every year. Large numbers of empty seeds are common in juniper crops, a likely result of poor pollination. Seeds disperse during the autumn, but some ripe cones of most species will persist on the trees through the winter. Seeds are naturally dispersed, usually by birds that eat the cones (Chavez-Ramirez and Slack 1994; Holthuijzen and others 1987; Livingston 1972).

Not much is known about the insects that infest seeds of junipers, or how much damage they do to seed crops. Larvae of *Eurytoma juniperina* Marcovitch, a sawfly, have been found in seeds of Utah and western junipers and eastern redcedar. Larvae of *Periploca atrata* Hodges and another unnamed Cochylidae moth are known to feed on seeds of alligator and California junipers (Hedlin and others 1980).

Collection of cones. Juniper cones are usually collected in the fall by stripping them from the branches by hand directly into containers. Cones can also be collected by shaking or flailing the limbs to dislodge the cones onto netting or dropcloths on the ground. The larger fruits of alligator and Utah junipers may be picked up from the ground after dispersal (Johnsen and Alexander 1974). Care should be taken to avoid collecting from plants with large numbers of green immature cones because they are difficult to separate from the mature ones. It is always wise to perform cutting tests on samples from each tree or group of trees to determine the percentage of filled seeds. The number of filled seeds can vary widely from tree to tree, as noted above, and collections can be adjusted to allow for this condition. Although collection can be delayed over much of the winter for some species, it is desirable to collect the fruit as soon as possible after ripening to reduce losses to wildlife. Freshly collected cones should be spread to avoid heating but should not be dried enough to make the fleshy covering tough and difficult to remove.

Extraction and storage of seeds. Twigs, leaves, and other debris should be removed by winnowing, screening, or aspiration. Seeds can be easily extracted from the pulpy cones by maceration with water. Small lots can be cleaned with laboratory or kitchen blenders, and large lots can be cleaned in larger macerators. Full seeds should sink, and pulp and empty seeds can be floated off the top of the water (Johnsen 1959; Johnsen and Alexander 1974). For extraction of Rocky Mountain juniper and eastern redcedar seeds, a cone volume to water volume ratio of 1:2.5 is recommended. The pulp residue can then be removed from the filled seeds by adding a little liquid

detergent to warm water and agitating for about 5 minutes (Van Haverbeke and Barnhart 1978). Dried fruits should be soaked in water for several hours before macerating. After the seeds have been separated from the pulp and cleaned, they can be prepared for stratification or dried for storage. Intact cones can be stored also, but this is not usually done. Seed yields and weights are listed in table 4.

Juniper seeds are orthodox in storage behavior. They should be air-dried to a moisture content of about 10% and stored at temperatures of 5 to -18 °C (Johnsen and Alexander 1974; Jones 1962; Stoeckler and Slabaugh 1965). There have been no long-term studies to compare different storage temperatures and moisture contents for juniper, but results are available from several sources. Seeds of Ashe's juniper stored in a bag at about 5 °C and high humidity retained about half their original viability after 4 years, and seeds of Rocky Mountain juniper stored in sealed containers at 12 to 16 °C (both in dried cones and as cleaned seeds) showed about 30% germination after 3 2 years (Johnsen and Alexander 1974). The seeds of alligator, oneseed, and Utah junipers stored dry in sealed bags or jars at room temperature for 45, 21, and 9 years, respectively, yielded germination of 17, 51, and 16% (Johnsen 1959).

Pregermination treatments and germination tests. Juniper seeds germinate very slowly due to conditions of deep dormancy. Their dormancy appears to result from internal embryo dormancy, seed coat dormancy, germination inhibitors in the pulp of the cones, or a combination of all three (Johnsen and Alexander 1974). There is wide variation among species in degree of dormancy. The least dormant may be eastern and southern redcedars, whereas Rocky Mountain juniper is among the most dormant (Rietveld 1989). There is also considerable variation among sources and crop years; some seedlots from alligator and oneseed junipers germinated without any stratification (Johnsen 1959; Meagher 1943; Riffle and Springfield 1968).

The most common treatment for overcoming dormancy is long periods of moist stratification at 3 to 5 °C. Periods of 30 to 180 days have been used for seeds of Ashe's, alligator, and oneseed junipers and eastern redcedar (Barton 1951; Benson 1976; Johnsen and Alexander 1974; Taylor 1941). Early reports suggested freezing juniper seeds during stratification, but this method has generally been unsuccessful (Johnsen and Alexander 1974). Seeds of common, Utah, and Rocky Mountain junipers, eastern redcedar, and possibly western juniper often respond positively to warm stratification at room temperature (around 25 °C) or alternating temperatures of 20 °C (night) and 30 °C (day) for 45 to 240 days, followed by cold stratification for similar periods (Johnsen and Alexander 1974; Rietveld 1989; Van Haverbeke and Comer 1985). Young and others (1988), however, reported no response by western and Utah junipers to the 2-temperature pretreatment. The best treatment for eastern redcedar was to first soak the seeds for 96 hours in a 10,000 ppm solution of citric acid, followed by warm stratification for 6 weeks and cold stratification for 10 weeks (Van Haverbeke and Comer 1985). The use of citric acid was suggested by Cotrufo (1963), and although the nature of the stimulation is unknown, some lots respond with faster germination rates. Faster germination has also been reported for seeds of Pinchot's and Rocky Mountain junipers and eastern redcedar that were soaked in concentrated sulfuric acid for periods of 35 to 120 minutes (Djavanshir and Fechner 1976; Johnsen and Alexander 1974), although stimulation for the latter 2 species occurred only when the carbonized layer was removed from the surface of the seeds (Djavanshir and Fechner 1976). Washing seeds of oneseed juniper in running water for 48 hours,

followed by 30 minutes in 30% hydrogen peroxide, stimulated germination to 79% from 47% for untreated controls (Riffle and Springfield 1968). Another promising method reported for western and Utah junipers is a 12-week soak in aerated water at 5 ˚C; germination percentages of around 50% were recorded for both species. If gibberellin (GA_3 at 0.289 mmol/L) was added to the aerated solution, germination increased to 84% for western juniper and to 64% for Utah juniper (Young and others 1988).

Prescriptions for official germination tests have been established for 3 species: common juniper, eastern redcedar, and Rocky mountain juniper (ISTA 1993). Tetrazolium staining is the recommended method for these species, but alternative stratification directions are also suggested. Common juniper should be stratified for 90 days at 3 to 5 ˚C, whereas eastern redcedar and Rocky Mountain juniper seeds should receive 60 days at 20 ˚C, followed by 45 and 40 days, respectively, at 3 to 5 ˚C. Recommended germination temperatures are 20 ˚C for common juniper and 15 ˚C for eastern redcedar and Rocky Mountain juniper. Germination of Pinchot's juniper is reported to be best at 18 ˚C (Smith and others 1975), but no data exist for the other junipers. There is obviously much to learn about stimulation of germination for the junipers, and more research is called for. Germination capacities for various pretreatments and test conditions are given in table 5. Germination is epigeal.

Nursery practices. Juniper seeds are usually sown in the late summer or fall, but may be sown in the spring or early summer. All seed should usually be stratified, no matter when they are sown, but untreated seeds can be used in some circumstances. Untreated fresh seeds may be sown in the fall within a week after collection and extraction if they are not dried (Meines 1965). Stratified seeds sown in the spring should be in the ground early enough to insure complete germination before the air temperatures go higher than 21 ˚C. If stratification is successful, germination should begin 6 to 10 days after sowing and be completed in 4 to 5 weeks (Johnsen and Alexander 1974; Stoeckler and Slabaugh 1965).

Juniper seeds are usually drilled in rows 15 to 20 cm (6 to 8 in) apart, and covered with about 6 mm (¼ in) of firmed soil or sand (Stoeckler and Slabaugh 1965). The seeds are occasionally broadcast by hand onto the seedbed and covered with sand. The beds should be mulched with straw, sawdust, burlap, or plastic film to prevent winter drying, alternate freezing and thawing, and premature germination in the spring. The mulch normally must be held in place to prevent blowing (Stoeckler and Slabaugh 1965). The seedbeds should be kept moist, and as soon as germination begins, burlap or plastic film mulches should be removed. Light shade should then be provided by slatwire snow fence or plastic screening materials; young seedlings of eastern redcedar and Ashe-s, oneseed, and Rocky Mountain junipers should be shaded throughout the first growing season. Seedlings of alligator juniper (figure 4) should be shaded only during the germination period (Johnsen and Alexander 1974). Burlap may be used over snow-fence shade structures to conserve moisture and to protect against early spring freezing (Stoeckler and Slabaugh 1965). During the autumn, the seedlings may change color due to freezing weather, reduced watering, or increased light intensity resulting from removal of the half-shades. Seedlings of eastern redcedar change from green to purple, most markedly with the 1+0 seedlings. The normal green color returns the next spring.

In the West, juniper seedlings are usually transplanted in the nursery after the first or second

year. Early lifting in the spring gives the best survival. Roots must be kept moist during lifting, and the seedlings can be stored as long as a week before transplanting with little damage if kept cool and moist (Afanasiev and others 1959). Spacing in the transplant bed ranges from 15 by 2.5 cm (6 by 1 in) to 20 by 5 cm (8 by 2 in) for eastern redcedar and Rocky Mountain juniper (Johnsen and Alexander 1974; Stoeckler and Slabaugh 1965). Undercutting of third-year transplants of Rocky Mountain juniper seems to stimulate strong lateral root development (Stoeckler and Slabaugh 1965).

The most serious nursery disease that affects junipers is the cedar blight, which is caused by *Phomopsis juniperovora* Hahn (Otta and others 1980; Peterson 1973; Stoeckler and Slabaugh 1965). Good sanitation practices in the nursery and chemical control measures are needed to keep this disease in check. Once established in a nursery site, it is very difficult to eradicate (Stoeckler and Slabaugh 1965). Other diseases that cause problems for junipers are cercospora blight, caused by *Cercospora sequoiae* Ellis & Everh. var. *juniperi* Ellis & Everh. (Peterson 1977; Peterson and Wysong 1968) and cedar apple rust, cuased by *Gymnosporangium juniperi-virginianae* Schwein. (Stoeckler and Slabaugh 1965). Application regulations and chemical recommendations change frequently, so local extension experts should be consulted for the current chemical control measures for these diseases in the nursery.

Other nursery pests that affect junipers are nematodes, grubs, and red spiders—*Pentamerismus erythrens* Ewing. Foliage may be damaged by winter injury and drying out, even in second-year beds and transplant beds. The plants usually recover during the spring. Small juniper seedlings are also subject to frost heaving, which can be reduced by heavy mulching or overhead sprinklers (Stoeckler and Slabaugh 1965).

Many junipers can be propagated vegetatively with cuttings (Dirr and Heuser 1987). There is evidence of wide variation in rooting ability among populations of common juniper (Houle and Babeux 1994). Rooting success as high as 82% has been reported for Rocky Mountain juniper (Edson and others 1996). Treatment of the 12-cm-long (5-in-long) cuttings with 1.6 or 3.0% indole-butyric acid (IBA) accelerated rooting by several months and increased overall succes by up to 36%. Two years after transplanting to containers, 92% of the stecklings survived.

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Figure 1—*Juniperus,* juniper: strobili (berries), × 3.

Figure 2—*Juniperus,* juniper: seeds, × 3.

Figure 3—*Juniperus scopulorum,* Rocky Mountain juniper: longitudinal section through a seed, × 12.

Figure 4—*Juniperus deppeana,* alligator juniper: seedling development at 2, 17, 43, and 96 days after germination.

Table 1C*Juniperus,* juniper: nomenclature and occurrences

Scientific name & synonym(s)	Common names	Occurrence
***J. ashei* Buchh.** *J. sabinoides* (H.B.K.) Nees *J. mexicana* Spreng. *J. monticola* Martinez	**Ashe=s juniper,** mountain cedar, rock cedar, Mexican juniper	S Missouri, N Arkansas, NE & S Oklahoma, central & trans-Pecos Texas, & Mexico
***J. californica* Carr.**	**California juniper,** desert white-cedar	SW Oregon, N California to Baja California & Mexico
***J. communis* L.** *J. sibirica* Burgsd.	**common juniper,** dwarf juniper, prostrate juniper	Greenland, Newfoundland, & Labrador to NW Alaska, S in US from Washington, Montana, North Dakota, & Minnesota to California, Arizona, New Mexico, Georgia, & South Carolina; also in Europe & Asia
***J. deppeana* Steud.** *J. mexicana* Schlecht. & Cham. *J. pachyphlaea* Torr. *J. deppeana* var. *pachyphlaea* (Torr.) Martinez	**alligator juniper,** checkered-bark juniper, western juniper (lumber)	Trans-Pecos Texas to W New Mexico & central Arizona; S to N & central Mexico
***J. monosperma* (Engelm.) Sarg.** *J. occidentalis* var. *monosperma* Engelm. *J. mexicana* var. *monosperma* (Engelm.) Cory	**oneseed juniper,** cherrystone juniper, redberry juniper, west Texas juniper, sabina	Colorado, Utah, & Nevada S to SE Arizona, S New Mexico, central Texas, & Mexico
***J. occidentalis* Hook**	**western juniper,** Sierra juniper	W Montana, Idaho, & Washington to Oregon, S California & W Nevada
***J. osteosperma* (Torr.) Little** *J. californica* var. *utahensis* Engelm. *J. utahensis* (Engelm.) Lemmon	**Utah juniper,** bigberry juniper, western juniper (lumber), sabina	S Idaho & Nevada & SW Wyoming S to E & SE California, central Arizona, & W New Mexico
***J. pinchotii* Sudworth** *J. monosperma* var. *pinchotii* (Sudworth) Van Melle *J. texensis* Van Melle	**Pinchot=s juniper,** redberry juniper	Central to NW & trans-Pecos Texas, SW Oklahoma & SE New Mexico
***J. scopulorum* Sarg.** *J. scopulorum* var. *columnaris* Fassett	**Rocky Mountain juniper,** Rocky Mountain redcedar, redcedar, river juniper	NW to SE Alberta, E & S British Columbia, S to W North Dakota & Montana, Washington, E Oregon, Nevada, Colorado, South Dakota, Nebraska, to S Arizona, New Mexico, & trans-Pecos & NW Texas

J. virginiana L. *J. viriginiana* var. *crebra* Fern. & Grisc.	**eastern redcedar,** red juniper, savin	SW Maine, W to N New York, S Quebec, Ontario, Michigan, Wisconsin, Minnesota to SW North Dakota, to W Kansas, Oklahoma, to central Texas & E to Georgia
J. virginiana* var. *silicicola **(Small) J. Silboa** *J. silicicola* (Small) Bailey	**southern redcedar,** eastern redcedar	SE North & South Carolina & S & central Florida, W to S Mississippi & SE Texas

Sources: Johnsen and Alexander (1974), Little (1971), Little (1979).

Table 2C*Juniperus,* juniper: phenology of flowering and fruiting

Species	Location	Flowering dates	Fruit ripening dates	Seed dispersal dates
J. ashei	C	JanBApr	SeptBNov	Fall-winter
J. communis	C	AprBMay	AugBOct	Persists for 2 yrs (2ndB3rd yr)
J. deppeana	C	FebBMar	AugBOct	Persists for 2 seasons (2nd yr)
J. monosperma	Arizona	MarCApr	AugBSept	OctBNov (persists 1-2 yrs)
J. occidentalis	Oregon	Mid-AprBmid-May	Mid-Sept	Persists for 2 yrs
J. osteosperma	Arizona	MarchBApr	Sept (2nd year)	Persists for 2 yrs
J. pinchotii	Texas	Spring	OctBNov	Year round
J. scopulorum	C	Mid-AprBmid-June	Mid-SeptBmid-Dec	October (persists 2 to 3 yrs)
J. virginiana	Nebraska	Mid-MarBmid-May	SeptBNov	FebBMar (1st yr)
J. virginiana var. *silicicola*	South Carolina	JanBFeb	OctBNov	C

Sources: Johnsen and Alexander (1974), Rehder (1956), Vines (1960).

Table 3C*Juniperus,* juniper: height, seed crop frequency, and fruit color

Species	Height at maturity (m)	Year first cultivated	Seeds/ cone	Interval between large seed crops (yr)	Fruit ripeness criteria	
					Preripe color	Ripe color
J. ashei	3B6	1925	1B2	C	Green	Deep blue
J. californica	1B5	C	1B2	C	Bluish w/dense bloom	Reddish brown
J. communis	1B15	1560	1B3	Irregular	Red	Bluish to black, glaucous
J. deppeana	3B20	1873	2B4	C	Green	Bluish to reddish brown, glaucous
J. monosperma	3B8	1900	1B2	2B5	Green with waxy bloom	Copper to dark blue with white waxy bloom
J. occidentalis	5B9	1840	2B3	C	Green-blue	Bluish black, glaucous
J. osteosperma	5B12	1900	1B2	2	Green glaucous	Reddish brown,
J. pinchotii	1B5	C	1	C	Green with light bloom to reddish brown	Copper to red
J. scopulorum	6B15	1936	1B2	2B5	Green with	Blue w/white waxy bloom
J. virginiana	9B30	1664	1B2	2B3	Green	Blue
J. virginiana var. *silicicola*	7	C	1B2	C	Green	Dark blue

Sources: Johnson and Alexander (1974), Sargent (1965), Vines (1960).

Table 4C*Juniperus,* juniper: seed yield data

Species	Place collected	No. of cleaned seeds Range /kg	Range /lb	Average /kg	Average /lb	Samples
J. ashei	C	C		22,270	10,100	1
J. communis	C	56,120B120,170	25,450B54,500	80,480	36,500	8
J. deppeana	Arizona	19,840B34,400	9,000B15,600	28,270	12,820	5
J. monosperma	Arizona, New Mexico	33,650B44,100	15,260B20,000	40,350	18,300	10
J. occidentalis	Oregon	17,640B34,970	8,000B15,860	27,120	12,300	C
J. osteosperma	Arizona	7,940B15,660	3,600B7,100	10,910	4,950	15
J. pinchotii	Sonora & Texas	21,280B30,650	9,650B13,900	24,230	10,990	2
J. scopulorum	Arizona	39,360B92,830	17,850B42,100	59,760	27,100	36
J. virginiana	Great Plains	81,580B121,270	37,000B55,000	96,140	43,600	34

Sources: Johnsen and Alexander (1974), Stoeckler and Slabaugh (1965), Vines (1960).

Table 5C*Juniperus,* juniper: germination test conditions and results

	Germination test conditions										
	Stratification period (days)		Daily light period (hr)		Temp (°C)		Germination rate		Germination percentage		
Species	Warm*	Cold[H]		Medium	Day	Night	Days	%	Days	%	No.
J. ashei	0	120	[C]	Sand	86	68	60	30	10	33	1
	0	120	[C]	Sand	50	50	60	27	29	36	1
J. communis	60[B]90	90+	8	Paper, sand	86	68	20[B]30	[C]	[C]	7[B]75	10+
J. deppeana	0	0	[C]	Paper, sand	86	68	40	[C]	[C]	16-30	2
	0	30[B]60	[C]	Sand, peat	86	68	30[B]40	[C]	[C]	45	1
J. monosperma	0	0	[C]	Sand, peat, soil	86	68	30[B]70	[C]	[C]	20[B]75	34
J. osteosperma	120	120	[C]	Sand, soil	86	68	70	[C]	[C]	8[B]49	8
J. pinchotii[I]	0	0	8	Perlite	60	60	36+	[C]	[C]	63	4
	30	60	8	Perlite	60	60	[C]	[C]	[C]	53	4
J. scopulorum	120	120	[C]	Paper, sand	86	68	20[B]30	5[B]31	8[B]15	22	7
J. virginiana	0	30[B]120	[C]	Paper, sand	50	77	20[B]30	6[B]74	9[B]24	76	16
	4[']	90	0	Perlite	58	58	60	84	30	87	3
	0	45	[C]	Kimpak	60	60	66	70	43	78	2

Sources: Cotrufo (1963), Johnsen (1959), Johnsen and Alexander (1974), Meagher (1943), Riffle and Springfield (1968).

* 30 to 20 °C alternated diurnally.

[H] 5 °C.

[I] Seeds soaked in sulfuric acid 45 minutes.

['] Seeds soaked in 1% citric acid for 4 days.