Gaultheria L.

wintergreen

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Growth habit, occurrence, and uses. Of the 100 to 150 species of the genus *Gaultheria,* commonly called wintergreen, most are found in Asia, Australia, and South America. Only 6 species—creeping snowberry, alpine wintergreen (*G. humifusa* (Graham.) Rydb.), *G. miqueliana* Takeda, *G. ovatifolia* A. Gray, checkerberry, and salal—occur in North America north of Mexico (table 1) (Abrams 1951; Chou 1952; Hitchcock and others 1959; Viereck and Little 1972). The 3 species considered here (table 1) are evergreen shrubs. Both creeping snowberry and checkerberry have a prostrate or creeping form (Fernald 1950) and have been described as semi-herbaceous or almost herbaceous (Fernald 1950; Rosendahl 1955). Salal has a distinctly woody stem and grows 1 to 3 m tall.

Over its wide range in the United States and Canada, creeping snowberry is most common in bogs and wet forested conditions (Curtis 1959; Gleason 1952; MacKinnon and others 1992). Checkerberry tolerates site conditions ranging from dry to poorly drained and grows well on many acidic soil types, including peat, sand, sandy loam, and coal mine spoils (Robinette 1974). Salal also grows on a variety of sites, including shallow rocky soils, sand dunes, glacial till, and peat (Haeussler and Coates 1986). It is most common on well-drained slopes and ridges in coastal Oregon and Washington, on lowland sites in British Columbia, and on low-productivity timber sites in southeast Alaska (Fraser and others 1993; Hemstrom and Logan 1986; Minore and Weatherly 1994; Viereck and Little 1972).

Both creeping snowberry and checkerberry are low cover species valued for wildlife habitat and ornamental use (Dirr 1990; Hitchcock and others 1959; Robinette 1974; Stiles 1980; White and Stiles 1992). Animals known to feed on fruits, buds, or leaves of checkerberry include migratory birds; grouse, including blue (*Dendragapus obscurus*), spruce (*Canachitea canadensis*), and ruffed (*Bonasa umbellus*) grouse; bobwhite quail (*Colinus virginianus*); wild turkey (*Meleagris gallopavo*); ring-necked pheasant (*Phasianus colchicus*); as well as black bear (*Ursus americanus*); white-tailed deer (*Odocoileus virginianus*); and others. Checkerberry is a favorite food of the eastern chipmunk (*Tamias strictus*)(Martin and others 1951; Robinette 1974; Stiles 1980; Van Dersal 1938). Leaves of this species contain oil of wintergreen, which has been extracted for pharmaceutical use, and the edible fruits have been marketed (Dimock and others 1974).

Within the plant communities in which they grow, creeping snowberry and checkerberry occupy a far less prominent niche than their West Coast relative—salal. Common to the point of invasiveness, salal is a dominant shrub that lends watershed protection wherever it thrives. Because it rapidly forms dense rhizome mats (figure 1), salal is recommended for sand dune stabilization along the northern Pacific Coast (Brown and Hafenrichter 1962; Huffman and others 1994a,b). Under open canopied forests, salal often forms a dense, vigorous cover that dominates understory plant communities. Sala shoots bearing its glossy, evergreen leaves are highly prized nationwide by the floral industry and marketed as "lemon leaf" in the eastern United States (Sabhasri 1961; Schlosser and others 1991). Harvesters look for dark green sprays, free of discoloration and defect. These are sold as short-stemmed bunches ("tips") or regular bunches 60 to 75 cm long. Salal leaves range from 7 to 21 cm² in area, depending on light conditions (Huffman and others 1994b; Messier 1992) and persist on the plant from 2 to 4 years (Haeussler and Coates 1986). A handsome ornamental, salal responds well to cultivation, both domestically and abroad (Fraser and others 1993); wild transplants have been a commercial product (Douglas 1970).

The leaves, buds, and fruits of salal are dietary staples for several game bird species, including blue, ruffed, and spruce grouse and band-tailed pigeons (Dimock and others 1974; Martin and others 1951; Van Dersal 1938). Mammals that use its leaves or fruit include black bear, black-tailed deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), Douglas squirrel (*Tamiasciurus douglasi*), Townsend chipmunk (*Tamias* spp.), and mountain beaver (*Aplodontia rufa*) (Hayes and others 1995; Martin 1971; Martin and others 1951; Van Dersal 1938). Salal berries were eaten either fresh or dried by Native Americans; leaves were smoked with bearberry (kinnikinnick)—*Arctostaphylos uva-ursi* (L.) Spreng.—and used in various medicinal preparations (Gunther 1945; Pojar and Mackinnon 1994). The fruit can also be used for jam or preserves (Brown and Hafenrichter 1962; Pojar and Mackinnon 1994).

Flowering and fruiting. The perfect, white to pinkish flowers are borne either solitary and axillary, or in axillary (creeping snowberry) or terminal racemes (figures 2 and 3). The number of flowers per inflorescence is 1 to 4 for checkerberry and 5 to 15 for salal (Fraser and others 1993; Reader 1977). Stamens number either 8 (creeping snowberry) or 10 (checkerberry and salal), and ovaries are either 4- or 5-celled, with many ovules (Abrams 1951; Hitchcock and others 1959; Rehder 1940). Flowering dates range from early spring to late summer (table 2). In forest conditions, flowering shoots of salal over 4 years old had greater growth and leaf production than non-flowering shoots the year preceding flowering (Bunnell 1990). Shoot growth and leaf production the same year as flowering was less for flowering shoots than for others. Stems less than 4 years old and those under overstory canopies greater than 33% mean crown cover did not flower (Bunnell 1990). In the nursery, 2nd-year stems produced from rhizome cuttings flowered under light levels as low as 20%, whereas seedlings did not flower under the same conditions (Huffman and others 1994b). Bumble bees (*Bombus* spp.) are important pollinators of wintergreen (Pojar 1974; Reader 1977). Autogamy also occurs; all 3 species appear self-compatible.

The fruit of wintergreen is a many-seeded capsule surrounded by a persistent, thickened and pulpy calyx that forms a fleshy pseudoberry (Hitchcock and others 1959) (figures 2 and 3). The distinctly colored fruits of the 3 species range from 3 to 10 mm in diameter (table 3). Fruits ripen from mid-summer on and are persistent on the plants into winter, thus providing food for birds and mammals, the main dispersers (Stiles 1980; Van Dersal 1938). Checkerberry fruits remain on the plant throughout the winter and are present after snowmelt. Good seed crops are frequent.

Collection of fruits. Fruits of wintergreen are sufficiently persistent after ripening to permit collection over an extended period (table 2). Depending upon species, they may be combed, stripped, or picked individually from the plant. Refrigeration at temperatures just above freezing minimizes molding if fruits must be stored before processing. Dried fruits of checkerberry vary from 6,250 to 6,600/kg (2,835 to 3,000/lb) (Dimock and others 1974; Swingle 1939) and contain 35 to 81 seeds each (Mirick and Quinn 1981). Dried fruits of salal vary from 8,333 to 1,1494/kg (3,750 to 5,180/lb) (Huffman and others 1994b), averaging 8.5/cluster (Sabhasri 1961) and containing from 80 to 140 seeds each (Huffman and others 1994b; Zasada 1996). Seeds per fruit averaged 98.7 (range, 79.0 to 125.9) in samples of 20 to 25 fruits collected from widely separated sources (Sabhasri 1961; Zasada 1996). In a nursery study, seed production (seeds per fruit) and fruit dry weight (0.89 to 0.12 g/fruit) were highest for plants growing under 70% light (Huffman and others 1994b).

Extraction and storage of seeds. Either dry or wet seed extraction is possible. Fruits of checkerberry and salal can be dried until they are brittle and powdery, then rubbed through a 30-mesh screen to separate the seeds from the pulp (Dimock and others 1974; Zasada 1996). Seeds of salal can also be separated from dry pulp fragments by using a South Dakota–type seed cleaner (Zasada 1996). Maceration of fresh salal fruits followed by repeated washings to separate seeds and pulp also is effective (Dimock and others 1974). Wintergreen seeds are very small (table 4) (figures 5 and 6). Seed weight is a small fraction of fresh fruit weight; for example, 100 lbs of fresh salal fruits produced 2.3 to 4.0 lbs of cleaned seeds (Dimock and others 1972).

Based on limited evidence, viability of wintergreen seeds may be maintained for 5 years or longer in cool, dry storage; storing seeds at temperatures below freezing has not been studied. Untested seeds of checkerberry stored for 2 years at 5 °C in sealed bottles showed 16% germination (Dimock and others 1974). McKeever (1938) obtained as high as 83% germination of salal seeds stored dry in paper bags at 21 °C for 159 days and 49% for seeds stored at the same conditions for 525 days. Salal seeds declined in germinative capacity from 31 to 21% after 1 year of storage at 4 °C (Sabhasri 1961). Another seedlot showed 73 and 27% germination, respectively, after 3 years of storage at 4 °C or room temperature (Mirov and Kraebel 1937). Some seedlots stored for 3 to 4 years at 1 °C showed 70 to 80% germination and did not differ in germination characteristics from fresh seedlots (Zasada 1996).

Pregermination treatments and germination tests. Very limited data indicate that creeping snowberry and checkerberry require cold stratification to substantially improve seed germination; however, salal does not (table 5). For seeds of creeping snowberry collected in New Hampshire, germination was completed after 98 days in a greenhouse when preceded by winter stratification outdoors for 83 days; unstratified seeds kept in a greenhouse did not germinate (Nichols 1934). Low germination of checkerberry was doubled with stratification (table 5). Salal seeds germinate as well without stratification as with it, but stratification tends to increase the rate and widen the range of temperatures at which germination can occur (table 5). Seeds stratified for 120 days began to germinate in 4 to 12 days at temperatures of 21 to 10 °C, respectively (Zasada 1996). Germination was complete in 18 days at 10 °C; germination was complete in 27 days at 21 °C. Seeds stratified for 150 days began to germinate during stratification. Germination is epigeal (figure 5).

Nursery practice and natural regeneration. Untreated seeds of checkerberry, and perhaps of creeping snowberry, can be sown from fall through early winter, or stratified and sown in the spring (Dimock and others 1974; Rogers 1994). Salal seeds can be sown in the fall or spring without stratification, but stratification will increase germination at lower temperatures.

Surface-sowing is recommended in either glass- or poly-covered flats, in open beds under tacked down loose-weave cheesecloth or muslin (which seedlings penetrate after germination), or under shade cloth (Huffman and others

1994b; McKeever 1938; Rogers 1994). Even without such measures, up to 73% germination has been obtained in soil-filled flats (Mirov and Kraebel 1939). Light for 8 hours/day is recommended. Some propagators expose seeds to an additional 2 hours of light during the dark period (Rogers 1994). A potted plant of checkerberry can be propagated from seed in 4 months (Rogers 1994). Salal seedlings raised in outdoor nursery beds grew 11 to 17 cm (4.3 to 6.7 in) tall in 2 years (Huffman and others 1994b). They exhibited poor apical dominance, however, developing 6 to 12 aerial stems. Light shade (70% light) produced seedlings with greater biomass, greater canopy size, and more aerial stems compared to those under 20 or 50% or full sun. Under all light intensities, some seedlings produced rhizomes in 2 years.

All 3 species are readily propagated vegetatively from layers, suckers, division of plants, stem or root cuttings, stolons, or rooting at the nodes (Brown and Hafenrichter 1962; Dimock and others 1974; Huffman and others 1994b; Rogers 1994; Sabhasri 1961; Van Dersal 1938). In the Northwest, salal is presently propagated almost entirely by rhizome cuttings (Dimock and others 1974). Cultured rhizome cuttings can produce 5 or more new rhizomes and over 7 aerial shoots/year under light shade during the first 2 years after planting (Huffman and others 1994b). Moist, acid conditions under partial shade are beneficial for young plants of all 3 species raised from either cuttings or seed.

Seeds of wintergreen appear to have little innate dormancy under field conditions. No evidence of delayed emergence of salal was observed in 2 replicated studies subsequent to sowing test plots (Huffman and others 1994a; Tappeiner and Zasada 1993). Salal seedlings establish most readily on rotten logs and stumps under partial shade (Huffman and others 1994a; Huffman and Tappeiner 1997). There is evidence that this is also true for checkerberry (Matlack and Good 1989). Forest floor disturbance that exposes mineral soil enhances survival of salal seedlings (Huffman and others 1994a; Tappeiner and Zasada 1993). Predation of seeds did not appear to be a significant factor in a seedling establishment study in the Oregon Coastal Range (Tappeiner and Zasada 1993). Under field conditions, growth of salal seedlings is slow; they attained average heights of 2 to 4 cm (.8 to 1.6 in) in 2 years but can grow to 20 cm (7.9 in) (Huffman and others 1994a). Seedlings begin vegetative expansion in 4 to 6 years (Huffman and others 1994a). Young seedlings are susceptible to late spring frost (Sabhasri 1961).

Most field regeneration of wntergreen is vegetative (Bunnell 1990; Huffman and others 1994a; Huffman and Tappeiner 1997; Matlack and Good 1990; Matlack and others 1993; Sabhasri 1961). Checkerberry expands by growth of rhizomes and layering of creeping stems where conditions permit (Matlack and others 1993; Robinette 1974). Maximum expansion rates can be 10 cm (3.9 in) per year or more (Sobey and Barkhouse 1977). Clones of creeping snowberry develop as a result of layering of prostrate stems; maximum expansion rates range from 2 to 7 cm (.8 to 2.8 in) per year (Sobey and Barkhouse 1977). Rhizome expansion rates of 44 cm (17 in) per year have been reported for salal; the maximum observed was 93 cm (37 in)/yr (Huffman and others 1994a). Individual clones of salal can occupy areas up to 29 m^2 (312 ft^2)with up to 218 m (715 ft) of interconnected rhizomes (figures 1 and 7) (Huffman and others 1994a). Salal populations rapidly recover after logging (Halpern 1988; Messier 1992; Messier and Kimmins 1991; Stein 1995) and can severely compete with commercially important tree species (Price and others 1986; Weetman and others 1990; Messier and Kimmins 1990). Clonal assemblages persist by vegetative regeneration of aerial shoots that replace older, dying stems (Huffman and others 1994a). Although shade-tolerant, salal loses vigor with increasing overstory density and clones disintegrate into smaller fragments (Huffman and others 1994a). An estimated minimum light requirement for salal survival ranges from 0.3 to 3.3% of full sunlight (Messier and others 1989).

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Figure 1—*Gaultheria shallon,* salal: diagram of a typical clone comprised of 78 aerial stems and 91 m of interconnected rhizomes growing under an open canopied forest (Huffman and others 1994a).

Figure 2—*Gaultheria shallon,* salal: racemes bear pinkish white flowers, × 1.

Figure 3—*Gaultheria procumbens,* checkerberry: fruits present following snowmelt; plant is 5 cm tall.

Figure 4—*Gaultheria shallon,* salal: the ripe fruit is a purplish black, somewhat-fuzzy pseudoberry, × 3.

Figure 5—*Gaultheria shallon,* salal: the seeds are very small, × 20.

Figure 6—*Gaultheria procumbens,* checkerberry: longitudinal section through a seed, × 50.

Figure 7—*Gaultheria shallon,* salal: seedling development 2, 8, 15, and 33 days after germination.

Table 1—*Gaultheria,* wintergreen: nomenclature, occurrence, and uses

Scientific name & synonym	Common name	Occurrence
***G. hispidula* (L.) Muhl. ex Bigelow** *Chiogenes hispidula* (L.) Torr. & Gray	**creeping snowberry,** creeping pearlberry, moxieplum	Labrador to British Columbia; S to Newfoundland, Nova Scotia & Pennsylvania; higher elevations to North Carolina; W through Michigan, Wisconsin & Minnesota; Idaho
***G. procumbens* L.**	**checkerberry,** wintergreen, mountain-tea	Newfoundland to Manitoba; S through Minnesota & Wisconsin, to Alabama & Georgia
***G. shallon* Pursh**	**salal,** Oregon wintergreen	Pacific Coast from S Alaska to S California inland into the Cascades & Sierra Nevada

Sources: Abrams (1951), Fernald (1950), Gleason (1952), Hitchcock and others (1959).

Figure 1—*Gaultheria shallon*, salal: diagram of a typical clone comprised of 78 aerial stems and 91 m of interconnected rhizomes growing under an open-canopied forest (Huffman and others 1994a).

Table 2—*Gaultheria,* wintergreen: phenology of flowering and fruiting

Species	Flowering	Fruit ripening and dispersal
G. hispidula	Apr–Aug	Aug–Oct*
G. procumbens	May–Sept	Aug–June†
G. shallon	Mar–July	July–Dec

Sources: Fernald (1950), Gleason (1952), Hitchcock and others (1959), McMinn (1951), Robinette (1974), Rosendahl (1955), Van Dersal (1938).
* Actual ripening time uncertain.
† Fruit of this species notably persistent and reportedly increase slightly in size during winter (Van Dersal 1938).

Table 3—*Gaultheria,* wintergreen: Growth form, height at maturity, and fruit characteristics

Species	Growth habit	Height at maturity (cm)	Fruit diameter (mm)	Color of ripe fruit
G. hispidula	Prostrate*	20–40*	3–10	Clear–white
G. procumbens	Creeping	5–20	5–10	Scarlet–bright red
G. shallon	Tall shrub	25–300	6–10	Dark purple to bluish black

Sources: Fernald (1952), Gleason (1952), Hitchcock and others (1959), Rehder (1940), Rosendahl (1955), Stein (1995).
* Length.

Table 4—*Gaultheria,* wintergreen: seed yield data

	Cleaned seeds (millions)/weight			
	Range		Average	
Species	/kg	/lb	/kg	/lb
G. hispidula	6.75–6.89	3.06–3.13	6.82	3.09
G. procumbens	6.33–10.67	2.87–4.84	8.50	3.86
G. shallon	5.67–8.33	2.57–3.78	7.14	3.24

Sources: Dimock and others (1974), McKeever (1938), Sabhasri (1961).

Table 5—*Gaultheria,* wintergreen: stratification, germination test conditions, and results

Species	Cold stratification (days*)	Germination test conditions: Moist medium	Temp. (°C) Day	Temp. (°C) Night	Germination rate Days	Germination rate %	Total germination Days	Total germination (%)
G. hispidula†	83	Soil	—	—	98	—	—	—
G. procumbens	0	Peat 30	20	213	7	59	8	
G. shallon	60	Peat 30	20	56	16	15	16	
	0	Paper	30	20	61	28	27	38
	30–120	Paper	30	20	55	26	37	31
	0	Sand/soil	21	21	28	74	22	76
	0	Paper/pads	21	16	60	42	30	51
	0‡	Paper/pads	16	10	60	28	30	51
	0‡	Paper/pads	10	4	60	0	30	41
	60‡	Paper/pads	21	16	60	39	30	45
	60‡	Paper/pads	16	10	60	31	30	40
	60‡	Paper/pads	10	4	60	23	30	50
	150‡	Paper/pads	21	16	60	55	30	59
	150‡	Paper/pads	10	4	60	32	30	40

Sources: Dimock and others (1974), Zasada (1996).

* Stratification temperature was 5 °C for *G. procumbens* and 3 °C for *G. shallon.*

† An unknown number of seeds were stratified outdoors during the winter and 147 seeds subsequently germinated in a greenhouse.

‡ Data are for 1 western Oregon seed source; 2 other seed sources had similar responses (Zasada 1996).