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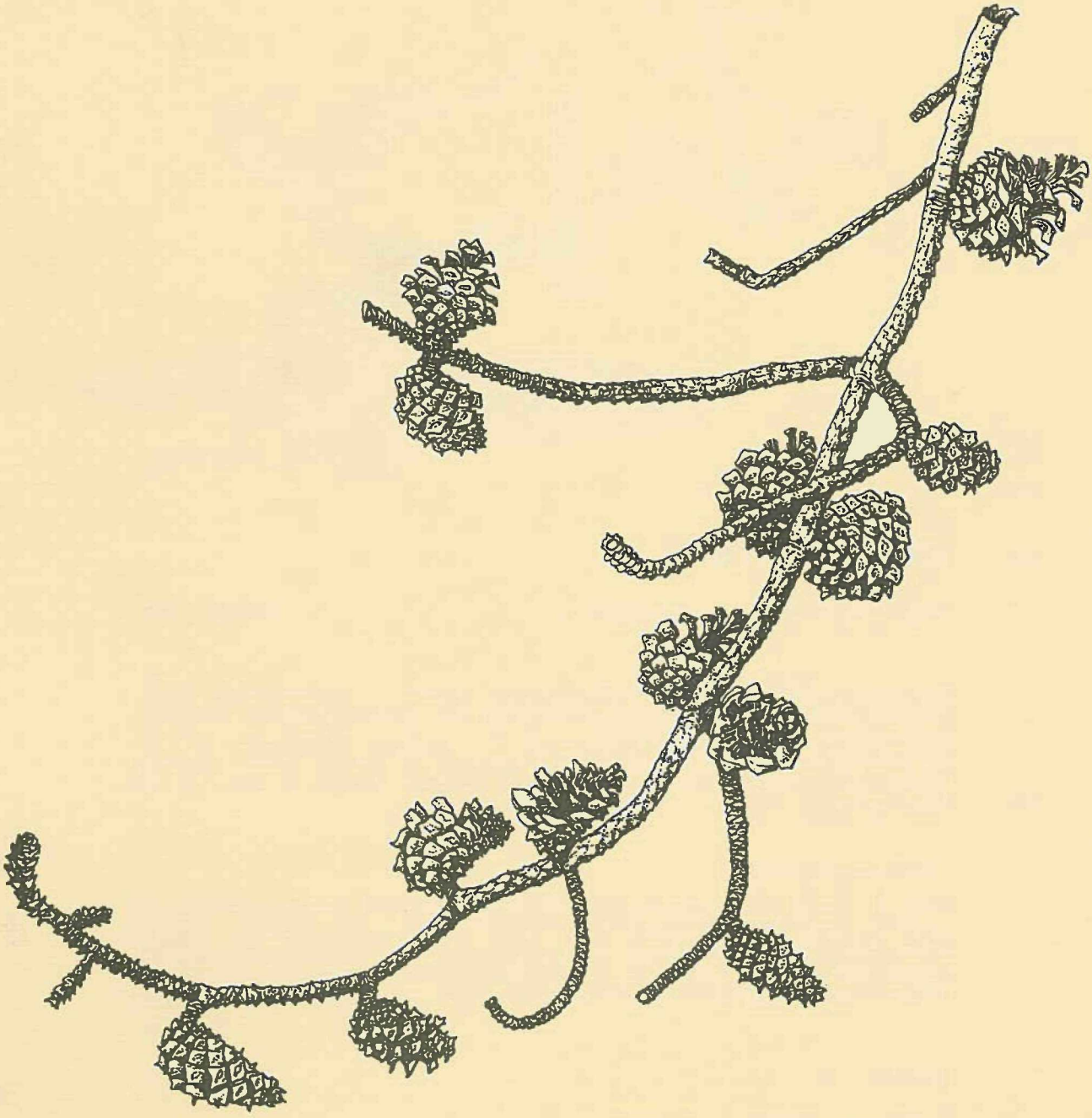

Cover:
Branch of *Pinus contorta* bearing cones.

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Dispersal by Falling Water Drops in Saxifragaceae

D. B. O. SAVILE*

It has long been recognized that fungal spores and bacteria oozing from cankers on plants are readily spread by splashing rainwater, and that raindrops may pump spores from a puffball; but there are more sophisticated dispersal devices powered by falling water drops that have been only recently elucidated. Such devices do not generally induce conspicuous geographic spread, but they are important in ensuring the removal of disseminules beyond the limits of the parent plant, where new plants may grow without severe competition.

A landmark in our understanding of these devices was the paper by Brodie (1951) on splash-cup dispersal. He described the process in detail for the Bird's Nest Fungus *Cyathus,* which has a geometrically perfect cup and a complex mechanism to attach the ejected peridioles ("bird's eggs") to vegetation with which they are eaten by herbivores; the spores being finally excreted and starting new colonies of the fungus. Brodie also demonstrated functional sclerotial splash-cups in a basidiomycete *Aleurodiscus minnsiae,* in gemma cups of the liverwort *Marchantia* and the moss *Lunaria,* and in the erect open capsules of *Sagina decumbens* (Pearlwort) and *Oenothera rosea* (Evening-primrose). A few other examples were soon added, including *Mitella* (Mitrewort, Figure 1) and *Chrysosplenium* (Golden Saxifrage) (Savile, 1953).

Brodie (1955) described and named the springboard mechanism for the dispersal of various parts of vascular plants. In these devices a falling drop hits and depresses a projecting lip. As the supporting organ snaps upward again either it or a contained projectile is thrown upward and outward. Brodie (1955, 1957) and Savile (1954) recorded the following examples, the actual disseminule being shown in parenthesis: *Lycopodium selago* and *L. lucidulum* (bulbils); *Kalanchoe tubiflora* (plantlets); *Ocimum basilicum* and *Salvia lyrata* (nutlets); and *Tiarella* spp. (seeds). Discharge to over 1 m laterally has been recorded in some of these plants. Brodie (1975) summarized our knowledge of various splash-operated mechanisms. Although these devices have obviously evolved repeatedly, and vary greatly in morphology and operational details, the term "springboard" is conveniently accepted for all of them. However, it is most appropriate for *Salvia* and *Ocimum* (and probably many other labiates) and for *Tiarella* (Figure 2). In these plants only a nutlet or seed is ejected and the apparatus remains in position.

Drop Size and Dispersal Efficiency

It is important to understand the effective power of falling water drops, regardless of the dispersing mechanism. Splash-cups and springboards are commonly described as being powered by raindrops. Raindrops generally fall slantingly, owing to wind, which causes them to strike the mechanism obliquely and also slows their velocity through turbulence, with inevitably reduced efficiency. More importantly, raindrops are seldom over 2.2 mm diam., for larger drops usually break up in a long fall; and they are often much smaller: ca. 2 mm in heavy rain, 1 mm in moderate rain, 0.5 mm in light rain, and 0.2 mm in drizzle (Humphries, 1940). Probably the only drops as large as 3 mm diam are those that fall as hail and melt just before reaching the ground (List, 1978). In regions where precipitation occurs as dew, fog or drizzle, droplets falling freely could not possibly power a splash-cup or springboard device. Yet we see *Chrysosplenium* and *Marchantia* growing freely in low-arctic marshes, where anything heavier than a drizzle is exceptional; and Brodie (1975) reported *Cyathus olla* growing below shrubs on arid slopes in western Peru where dew is the only recorded precipitation.

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I realized that large drops falling from a tree canopy must be effective in dispersal because their impact on leaves or an umbrella is loud; and their importance was emphasized when I stood in the forest at Cheam View in British Columbia on a drizzly day and saw the horizontal capsules of *Tiarella trifoliata* flicker under their impact. But what is the performance of drops falling very short distances? Meteorologists are mainly concerned with terminal velocities of (small) raindrops. However, we found some data for terminal velocities and drag coefficients of large drops, from which Dr. H. N. Hayhoe was able to derive an equation that allowed us to find the velocity, at any distance from the release point, of a drop of given size. The results (Savile and Hayhoe, 1978) were startling. A selection of figures for relative momentum are given in Table 1.

The size of drop released from foliage depends on the extent to which impurities reduce surface tension. In a test with tap water and a dusty, deliberately unwashed pipette, I found the drops to be 4.5 mm diam. (scarcely 20 drops/ml). Thus, drops in nature probably are generally over 4 mm diam. In contrast, raindrops are usually 2 mm or less and only rarely 3 mm diam. From the feeble momentum of a 2 mm drop even at terminal velocity (V_t), it is clear that we can forget about smaller drops. The table shows that even after 0.25 m (not quite 10 in.) a 4 mm drop has the momentum (mass x velocity) of a 2.5 mm drop at V_t and over twice that of a 2 mm drop at V_t. At 0.5 m the 4 mm drop has nearly the momentum of a 3 mm drop at V_t. The 4.5 mm drops have an even more impressive performance, with momentum after 0.25 m almost that of a 3 mm drop at V_t.

The momentum of large drops after very short falls is very revealing. Now we see why splash-cups of *Mitella* and *Chrysosplenium* functioned well with drops falling 1 m or less from a burette (Savile, 1953); why *Chrysosplenium rosendahlii* (Savile, 1959, as *C. iowense*) grew prolifically in marshes on Somerset Island where the "canopy" of nodding grasses and sedges provided a fall of only 0.3-0.4 m; and why *Cyathus olla* could grow under shrubs in the Peruvian desert. At the last site I suspect that a desert mouse emerges at dusk to collect leaves and twigs and incidentally transports *Cyathus* peridioles from shrub to shrub.

Although both splash mechanisms must occasionally be operated directly by raindrops, the figures for relative momentum emphatically suggest that they have always evolved under tree or shrub canopies. On truly open ground the infrequency of large, vertically falling drops must inevitably make incipient selection for wind- or animal-operated devices or explosive capsules overwhelmingly more valuable. I therefore regard the intermittent occurrence of *Lycopodium selago,* some *Cyathus* and a few *Chrysosplenium* species in unforested country to be secondary.

TABLE 1. Relative momentum of falling water drops after various distances.

Drop diam. (mm)	Distance of fall	Relative momentum (mass x velocity)
2.0	At V_t*	27
2.5	At V_t	60
3.0	At V_t	117
4.0	0.25 m	67
4.0	0.5 m	101
4.0	1.0 m	149
4.0	2.0 m	198
4.0	At V_t	296
4.5	0.25 m	111
4.5	0.5 m	153
4.5	1.0 m	207
4.5	2.0 m	280
4.5	At V_t	431

*V_t = terminal velocity, achieved at ca. 7-9 m according to drop size.

Implications of Splash Dispersal in Mitella and Tiarella

Mitella (Mitrewort) and *Tiarella* (False Mitrewort or Foamflower) deserve our attention because they are important elements in British Columbia forests. They are closely related members of the group of genera of Saxifragaceae with parietal placentation. Records of intergeneric hybrids, involving the eastern *T. cordifolia* with *M. diphylla* and *M. nuda,* are summarized by Spongberg (1972). How did they evolve such different capsules although both utilize the energy of falling water drops to disperse their seeds? Probably both genera sprang from a forest ancestor with an unspecialized thyrsoid inflorescence, somewhat like those of *Heuchera glabra* and *H. micrantha,* which are among the more primitive species of that genus. In such an inflorescence the flowers and capsules are randomly oriented, and many seeds land at the base of the plant; but, as *Heuchera* grows largely on open slopes, wind action throws seed from partly erect capsules a substantial distance. In dense forest a much higher percentage of seed would land under the plant, and there would be selection to utilize any helpful element in the environment. Drops from the canopy evidently shook some seeds clear of the parent plant. From this modestly advantageous start, selection in one population operated to produce capsules with the axis vertical and the valves flaring at maturity; and selection in a second population produced capsules with the axis horizontal at maturity and the lower valve projecting beyond the upper one. Thus *Mitella* and *Tiarella* originated, perhaps in adjacent valleys in the Cordillera and in about late Miocene time. Climatic fluctuations in late Pliocene and Pleistocene times fragmented the populations into today's species.

Details of Dispersal in Mitella

The details of splash-cup and springboard operation are not fully understood. Some points might be explained by the use of high-speed electronic flash photography triggered by the falling drop. The following notes are thus partly provisional.

If we look at maturing plants of *Mitella* we see that in most species the erect capsule has a pedicel only 1-2.5 mm long by 0.4-0.7 mm thick and attached directly to the scape. In Canadian species seen by me, the only exception is that in a few populations of *M. pentandra* the pedicels may be 3-7 mm long by 0.3-0.5 mm thick. The typically short thick pedicels hold the capsules firmly erect and close to the scape, minimizing the waste of energy of an impacting drop that resilience would cause. Most splash-cups are symmetrical, but in *Mitella* they are generally somewhat compressed in the axis through the scape. This modification probably ensures that most seeds are ejected along the long axis and thus do not hit the scape (Figure 1, inset).

In *Mitella,* as in *Chrysosplenium, Marchantia* and *Cyathus,* the flaring lip of the cup is usually at an angle of about 60-70° from the horizontal (Figure 1). The optimum angle of elevation for maximum range of a projectile is approximately 45° if it is discharged from ground level, and somewhat less if it starts from, let us say, the top of a 20 cm *Mitella* stem. If only one of these genera had such a steeply angled cup we might argue that this is as far as evolutionary refinement has progressed; but it is unrealistic to suppose that evolution has stopped equally far short of perfection in more than 100 species of these four genera. If the seeds are carried away with a water drop, as they seem to be, surface tension will tend to pull the drop into a lower trajectory as it leaves the cup. We may surmise that the elevation is commonly depressed approximately 20°, bringing it close to 45°.

The seeds of *M. trifida* are smooth, ca. 1.0 × 0.6 × 0.4 mm, and flattened-ellipsoidal in form. So small a seed, with a specific gravity only slightly above unity, would be a rather ineffective projectile; but if it is incorporated into a 2 mm drop (of which a 4 mm drop can make eight) it can be thrown much farther. Significantly, all the seeds recovered in my tests with *Mitella diphylla* and *Chrysosplenium americanum* (Savile, 1953) were found in a splash of water on the spread newsprint. I presumed that the seed would be enveloped by the drops; but, at the suggestion of Dr. F. W. Collins, I made a simple test. A drop of water was placed on a sheet of parafilm and rolled toward seeds of *M. trifida* from a herbarium specimen. The seeds were almost always picked up by, and reasonably firmly attached to, the drop, but did not penetrate the surface film. This position has accordingly been illustrated; but I cannot be certain that fresh seeds in the capsule always behave in the same way. The flattened-ellipsoidal seeds do, however, seem adapted to superficial attachment.

Details of Dispersal in Tiarella

In *Tiarella* each peduncle usually bears 2-3 flowers. The pedicels usually angle slightly upward in fruit, and are ca. 5-9 mm long by 0.2-0.3 mm thick (Figure 2). The peduncles are also usually slender. When a drop hits the horizontally projecting lower valve, not only is the lower valve depressed (allowing a seed to roll toward its tip), but the entire capsule is depressed on its flexuous pedicel and peduncle. In its recovery the capsule thus describes a substantial arc. In fact, it may be regarded as a miniature of the long curved basket on the wrist of a player in the Basque game *jai alai.*

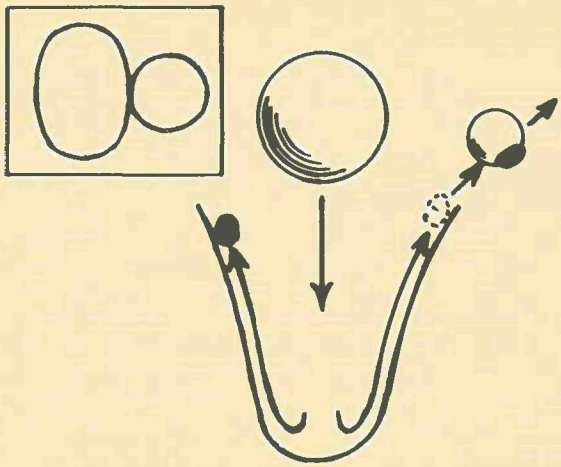

FIGURE 1. Diagrammatic vertical section through mature capsule of *Mitella* (Mitrewort), showing approximate track of splashed seeds and droplets, x ca. 3.75. Inset: cross-section through scape (right) and adjacent capsule (left).

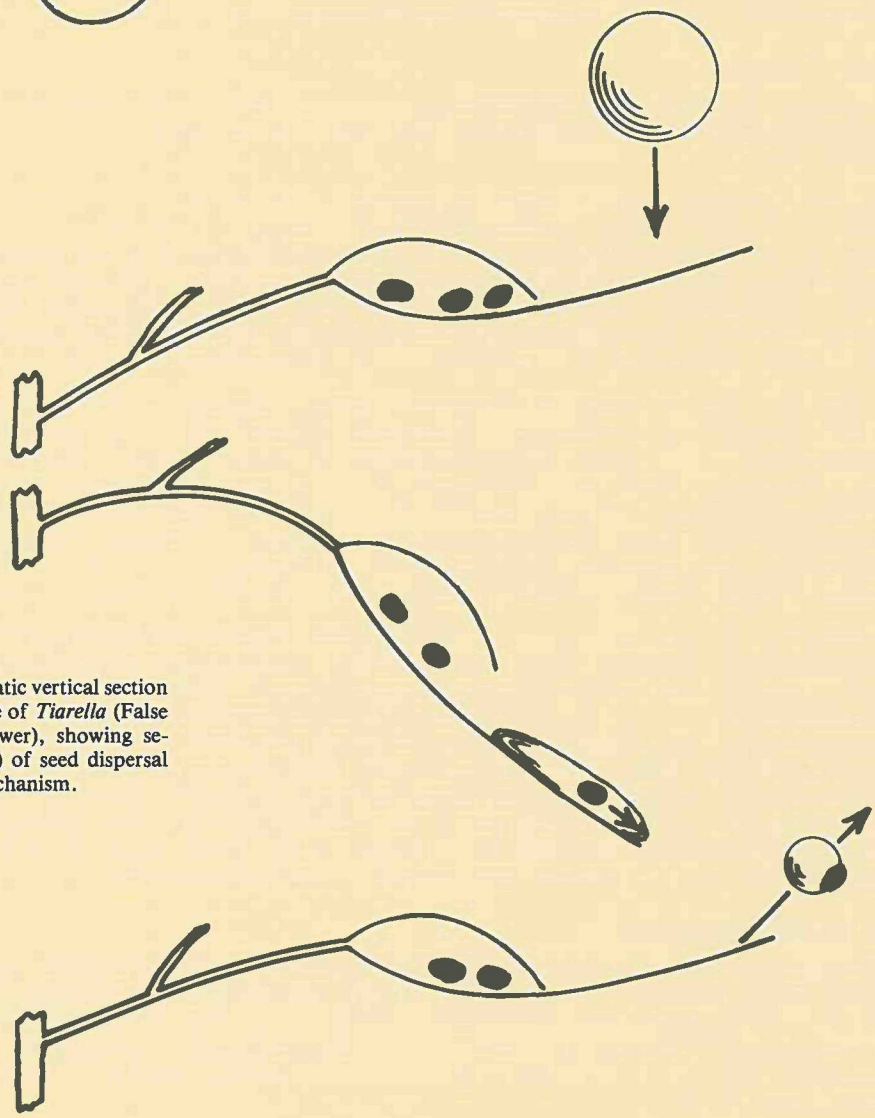

FIGURE 2. Diagrammatic vertical section through mature capsule of *Tiarella* (False Mitrewort or Foamflower), showing sequence (top to bottom) of seed dispersal by the springboard mechanism.

The seeds of *Tiarella trifoliata* are ca. 1.3 x 0.9 x 0.4 mm, slightly larger than, but similar in shape to, those of *Mitella trifida*. In the test on parafilm they behaved similarly, attaching to the surface of the drop. Again, it is not certain that fresh seeds in the field behave exactly as mine from herbarium specimens; but the seed shape suggests adaptation to carriage at the surface of the drop.

Acknowledgement

I am grateful to Dr. F. W. Collins for his interest and pertinent suggestions.

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An Introduction to Bird-watching*

PEGGY IRVING**

I would like to begin by offering definitions of a bird watcher and a birder. A bird watcher is frequently an amateur naturalist who is interested in learning about, and perhaps in preserving, the world of nature as a whole, but with a special emphasis on birds. A birder is usually a specialist who is mainly interested in getting as many species as possible during a lifetime, and in fact the compiled list is called a "lifer" list. A keen birder may only be aware of the surroundings insofar as they affect birds, and while spotting a Lazuli Bunting may tread on a *Dodecatheon hendersonii.* I have accomplished that description without the use of a pronoun to indicate the sex of either species, for this is one area where the males do not dominate, except perhaps there are more male "lifers" than female. In support of the fair sex, I must mention one lady who journeyed from Florida to Vancouver to see a Myna Bird. You will no doubt recall the event of the Spoon-billed Sandpiper in the summer of 1978 when Vancouver was flooded with visitors. Most of these people were birders. I am a bird watcher of the most basic type. I enjoy the outdoors; I leave the climbing of mountains because they are there to those younger and fitter than I; I am content to wander and observe, and one of my problems is to decide where to look if the wild flowers are plentiful. The binoculars get reversed to provide a lens and then there is confusion when I hear a twitter above me. I was lucky enough to have a mother who took me on what she called "nature walks" from a very young age. We lived in England near enough to fields and woods to wander through them and in the days before motorways my father took us in the car on Sundays through many delightful country lanes and byways.

I propose to draw your attention briefly to the incredible adaptability of birds to the environment. Man is always adapting the environment to suit his needs — we chop down trees to build houses while birds build their homes in trees of twigs and dried grass they gather from the ground. We live in a wet area but we do not grow webbed feet, contrary to popular belief — we use boots and umbrellas instead.

The feet of birds are adapted for terrain and for their feeding habits. The heron has long legs and good solid feet because it stands so much of the time in water, watching for food; the perching birds have comparatively short, slender legs with a foot that can almost form a circle round a twig and tiny claws to help the grip. Some perching birds are never seen on the ground, while others come down for drinking, dusting, bathing and feeding. The claws of birds of prey are long and sharp for killing and carrying food, and their legs and feet are strong and sturdy. The duck types nearly all have webbed feet for swimming and diving — hence the use of flippers by humans. Shorebirds have flattish feet, spread well apart and their legs are longer because they spend much time walking or running on the ground or standing in shallow water. Nuthatches, creepers and woodpeckers have feet adapted for gripping on to trees while remaining parallel to the trunks in their quest for food. Similarly, swallows and swifts have feet adapted for clinging to walls and swallows are often seen perched on wires, but they cannot really walk. When gathering mud for their nests they swoop and then shuffle and flutter, scooping the mud up into their beaks. Birds hop, walk, waddle, shuffle, run, swim, dive and fly; remember to note the means of locomotion when you are identifying them.

The beaks can tell you much about the bird's habitat and feeding. Long beaks indicate a probing for food. Hummingbirds have long beaks and even longer tongues for extracting nectar from blossoms. The woodpeckers use their beaks to chip away at tree trunks and to extract grubs. Brown creepers, nuthatches and wrens have longish, thin beaks for extracting grubs from the cracks in the tree bark. Shore birds have long, probing beaks for extracting small fish from the bottom mud or sand, for prying open shells and even for sifting. Robins and starlings have long, thin beaks for pulling grubs out of the earth. Bottom-feeding ducks have wide flat beaks for scooping up mud, and other ducks, such as mergansers, have serrated beaks for grasping fish. Flycatchers have long, thin beaks for doing just that, as do the tiny warblers that feed on small insects found in trees and bushes. Swifts have a small beak, but a wide, gaping mouth that remains open as they fly to trap flies. Finches have short, strong and heavy beaks for cracking open seeds. Birds of prey have strong sharp beaks for tearing their food into small pieces. Gulls and crows, which will eat anything, have large all-purpose bills.

*From a talk given to the Friends of the Garden, The UBC Botanical Garden.

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The many shapes and sizes of wings and feathers again demonstrate a fantastic adaptability. The birds that feed on the wing have well developed and versatile flights. Swifts and swallows can often be seen together in the summer gliding, fluttering and wheeling in a restless mob, feeding where insects are flying just above the trees. The hummingbird can hover almost like a helicopter; in flight its wings move from 50 to 200 times a second. In contrast, the birds that live mostly on the ground, such as pheasants, ptarmigan and herons, look almost clumsy as they noisily take to the air. Hawks and other birds of prey are able to hover or glide on large wings equipped with a braking system so that they can pounce on their prey with accuracy. They also seem to enjoy the thermal air currents for they often soar in circles. The Peregrine Falcon swoops or dives on its prey at speeds often in excess of 160 kph (100 mph). Migrating birds fly for hundreds of miles and sometimes do not even feed on the way. I am sure you have all thrilled to the sight and sound of hundreds of snow geese migrating. How they synchronize their take off and flight and how they pick their squadron leader is something of a mystery.

Feathers are a most useful form of clothing. In cold weather they are fluffed out to give a thicker blanket and in hot weather the outer feathers are opened up and ruffled to help heat loss. Remember this when you are bird watching because heat and cold can play havoc with sizes and silhouettes. All birds have a covering of inner down feathers, which provide a well insulated "undershirt". You all know the warmth of a down sleeping bag and the value of giving it a good shake as extra precaution against the cold. All clothing needs attention occasionally and the birds take special care of theirs. It has to last them a long time in between moults. Most birds carry feather-eating parasites at times and preening is used to help get rid of them. Feathers frequently need to be put in order and smoothed down to maintain good flying condition, and this is most important after bathing. Dampening of the feathers is thought to help the bird to spread preen oil more effectively. The oil, a secretion from the preen gland, is used to waterproof and insulate the feathers. Sunning and dusting are probably other forms of feather care, and anting — allowing ants to crawl over the bird — is also thought to be part of the grooming process. Adult birds share their clothing with the newly-hatched young by covering them in the nest, for many birds emerge from the egg in only their bare skin. Feathers are of help in identifying birds, especially in the spring during mating time. It is then that the males look gorgeous and the females look even worse than usual. One exception is the female Wilson's Phalarope, which is much larger and more colorful than her male counterpart. In the fall, when colors have faded and plumage is sometimes changing to a winter coat and juvenile birds abound, identification becomes a headache and one reverts to shape, size, habitat, etc.

The physical features of birds are closely linked to their choice of food. Many birds of prey kill their meal with their talons and beaks on the ground, but the Peregrine Falcon will kill in flight. Strangely enough, many large hawks feed on moles and mice, as do some owls. You may wonder what happens to the bones and fur of a mouse as a bird would probably get indigestion from such fare. This residue from the meal is regurgitated in the form of a pellet and you frequently see pellets in feeding areas. Swallows, martins and flycatchers feed on the wing and seem to expend far more energy in the process that the pheasants or herons who feed standing. The small birds, such as kinglets, chickadees and warblers, flit restlessly from branch to branch and tree to tree in their quest for food, while the shorebirds are content to move in groups, probing with their long bills. Starlings, robins and house sparrows feed mostly on the ground, but because their habitat is often in the city, they seem to expend a lot of energy avoiding disturbances in the form of dogs, cats, cars and people. Seed-eating finches and grosbeaks can feed in the comparative security of a tree or bush, with their food neatly laid out before them on a branch.

Now at last I come to bird watching and in discussing how to watch birds I will deal briefly with behavior. I would like to read a paragraph or two from the "Book of British Birds", which contains an excellent section about birds in general:

> *"Anyone can study birds, simply by taking a stroll through the park; for a city park often supports a bigger and more varied bird population than an equal area of the countryside . . . If you have an enquiring mind, a receptive and musical ear and a retentive visual and aural memory, you are off to a good start as a bird watcher. You will also need to learn (or to rediscover, for everybody as a child has played a game of hide-and-seek) how to move silently and unobtrusively through woods and fields. You will find, though, that most birds are not unduly concerned by your activities; they may stop feeding and study you for a while, but if you make no conspicuous movements they will usually resume feeding. The important thing is to avoid any action that might alarm them. Walk slowly and deliberately, making use of whatever cover is available, but taking care not to appear in their field of view or disappear from it suddenly. Raise and lower binoculars gently . . .*

If you are prepared to begin watching birds without the help of binoculars, or cannot afford a pair at first, so much the better; for you will end up by being a more proficient naturalist. Without binoculars, you may not be able to determine the colouring of birds in flight; but this simply means you will have to learn to recognise them by their silhouettes and their manner of flight . . . Above all, without binoculars, you will learn to identify birds from their songs and call-notes".

The book "Birds of North America" by Robbins *et al* is my field guide of choice for two reasons. One is that it contains maps showing habitat and breeding areas, which is valuable for the beginner as well as the more experienced. The other very important reason is the little set of silhouettes that appear at the top of some of the illustration pages. They show very accurately the size comparisons and how different birds perch. Remember that silhouettes are often all you have to go on because there are many lights, even direct sunlight, that make it impossible to see color. I would suggest that you pick a common medium-sized bird, such as the American Robin, and then use it as a benchmark when sizing the birds you are observing. A field notebook will help you in your quest for bird identification and to start with I suggest you use the following list. If you do not want to make notes, try to develop a sequential way of looking at birds because you may be faced with a long hunt through perhaps more than one book when it comes to identification.

Location — ground, bush, tree branch, tree top, building (roof, chimney, etc.), shoreline, rock, in the air.

Size — larger than a robin, smaller than a robin, very large, very small.

Position — perching, fluttering, flitting restlessly, making short flights and returning to perch, flying high, flying low, soaring, swooping, clinging to tree trunk, moving up or down tree trunk, running, walking, hopping on ground, standing in shallow water, swimming in pond, etc.

Distinguishing marks — these would be mostly the colors noted, e.g., white tail feathers; bright colors on parts of the body (such as yellow on the Pine Siskin, the Yellowrump, the Goldfinch, the Yellow Warbler; red on the Flicker, the Ruby-crowned Kinglet, the American Robin, the Red-winged Blackbird; blue on the bluebirds, Stellar's Jay, the kingfishers); light-colored breasts; light markings on the wings, either in the form of wingbars or on the underside of the wings. There are so many variations that you should note down everything you are able to see, but remember that light can play havoc with color.

Activities — feeding, flocking, singing, etc. Note down what the bird is feeding on and at the same time take a good look at the beak. Is it short and stubby (seed eater), long and thin (fly catchers, warblers, woodpeckers, shorebirds), hooked (birds of prey), fairly long (starlings, robins, etc, which feed on earthworms and crane flies)?

Singing — I expect you have all been wondering when I would mention this because birds are anything but silent, especially in the spring. But how can I begin to suggest a method of learning bird songs? The only thing to do is to go out and listen. Once in a while when you are bird watching, shut your eyes and listen. Birds have so many songs that only experience can help you. The mating songs are perhaps the sweetest of all, while the warning and scolding songs are often monotonous and unhappy. Claiming territory songs are often loud and rather raucous — robins frequently become a perfect nuisance at about 5 a.m. on a sunny spring morning. The early spring songs, which are often incomplete, are charming, as are the little trills of fall, but the most lovely song of all is what I call the undersong, which can be heard occasionally before the spring days arrive. It is a soft bubbly sound, full of melody, as though the bird is chattering to itself, but singing instead of chattering.

Flocking — refers particularly to the incredible gathering that takes place when birds prepare to migrate. You are only likely to see this in the spring and fall but it is a sight never to be forgotten, especially when the geese are gathering. There are other less exciting forms of flocking. Starlings gather in enormous numbers to roost at night in a warm spot. In Vancouver they roost under the bridges and can be seen early in the morning making their way to Richmond to visit the farmers' fields or the dump. Gulls gather in flocks at the dump to feed and can be frequently seen on the shore for the same purpose. Shore birds always seem to be in flocks and many ducks are the same. Birds seem to flock more in the winter but this may be due to food being scarce.

Spring activities vary greatly from those at other times of the year, and the spring is a veritable bonanza for the bird watcher. The males are staking out territories with loud noises that one can hardly call singing, and even with fighting; then comes the calling and displaying to attract a mate. As I have mentioned, nearly all males are much better dressed than females during the spring mating season. Their attraction to the female is a mixture of song, color and display. I was watching a pair of Ruby-crowned Kinglets in the Native Garden of The UBC Botanical Garden in March and the red topknot of the male shone like a flower. It was almost opened up to display a large area of red to an obviously excited female. The robins were flying around frenziedly and their songs were hardly melodious. The Bewick's Wren had ascended to the tops of the smaller trees to declare himself. Once the display is over and the wedding has taken place, the nest-building activity takes over and the birds are all too busy gathering material to bother about a few humans who are watching them. Then comes the feeding of the young, when tiny helpless fledglings develop into flying birds in anything from 2 to 8 weeks. This is surely the easiest time of the year to observe birds in their natural habitat because I believe they are all too busy to worry about a few curious people with binoculars. They must be on the lookout for predators such as crows, hawks, and some of the smaller mammals when nests are near the ground. They have the constant vigil of feeding their young and keeping them warm. When you realize that many small birds have to feed nearly all day to keep themselves alive, it seems to me that spring is a time of all work and not much play. The actual mating may last for some days of intensive activity, but after that the honeymoon is definitely over. Most birds are monogamous, at least for part of the breeding season, but some males are promiscuous as are some females who walk around selecting likely candidates for their favors. But if we have prostitution, we also have at least one rapist in the bird world. The handsome Mallard has been known to drown a female while forcing his attentions upon her. Some females have no desire to bring up their offspring and deposit their eggs in another bird's nest. Such a bird is the Brown-headed Cowbird and she invariably chooses a nest of a bird much smaller than herself. Her offspring often gets rid of the host's babies while demanding an enormous amount of food that the harried parents provide, thinking that they have produced a monster. Once off the nest the young cowbird is on its own, and twice, when I have been camping with the Vancouver Natural History Society, we have been adopted by young cowbirds, who were rather lonely and delighted to have so many parents all at once who would catch flies for them and generally fuss over them.

The other time of the year when you may find bird watching easy is on a very cold winter's day when food is rather scarce. The small birds need even more food to counteract the long nights of chilling temperatures and they will be less cautious about us in their hunt for food. This brings me to a very important aspect of bird watching. If you have a garden then do by all means have a feeder put up in a spot where you can see it from, say, the kitchen window. It is one of the best ways to study birds because they will remain reasonable still while feeding. Children can be taught to watch them and to use binoculars this way and a bird feeder can be fascinating for anyone, young or old, who has to stay indoors. Birds can be an endless source of delight and many valuable observations of bird behavior have been made by amateurs. Few bird scientists will spurn the intelligent amateur's observations and, indeed, the annual bird count of North America is done almost entirely by amateurs and has proven a very valuable source of information regarding habitat. I can thoroughly recommend bird watching as a cure for the ills that stem from the pace of living with its inherent stresses and strains. Given a pair of binoculars, a little patience and good powers of observation it is richly rewarding.

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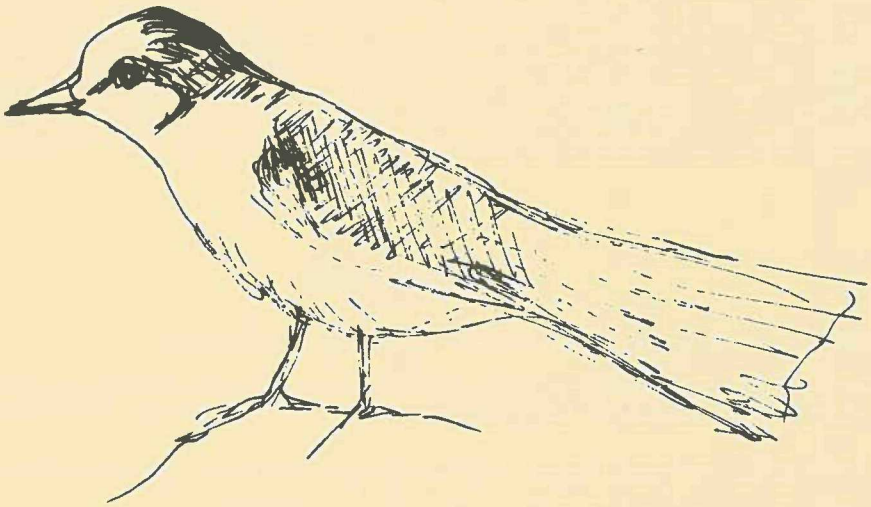
APPENDIX. Birds seen in The UBC Botanical Garden.

The following is a list of birds seen in the B.C. Native Garden, The E. H. Lohbrunner Alpine Garden and Asian Garden components of the Botanical Garden. It is extracted from 'Bird Checklist of UBC Botanical Gardens', which is available from the Office of the Botanical Garden.

Great Blue Heron
Mallard
Turkey Vulture
Sparrow Hawk
*Bald Eagle
*Ring-necked Pheasant
*Killdeer
*Glaucous-winged Gull
Mourning Dove
*Saw-whet Owl
Common Nighthawk
Black Swift
Rufous Hummingbird
*Belted Kingfisher
*Common Flicker
Pileated Woodpecker
*Yellow-bellied Sapsucker
*Downy Woodpecker
Violet-green Swallow
Tree Swallow
Rough-winged Swallow
Barn Swallow
*Common Raven
*Northwestern Crow
*Black-capped Chickadee
Boreal Chickadee
Chestnut-backed Chickadee
*Bushtit
Red-breasted Nuthatch
Brown Creeper
House Wren
*Winter Wren
*Bewick's Wren
Rock Wren
*American Robin
*Varied Thrush
Mountain Bluebird
Townsend's Solitaire
Golden-crowned Kinglet
Ruby-crowned Kinglet
Cedar Waxwing
*Starling
Townsend's Warbler
MacGillivray's Warbler
Wilson's Warbler
Audubon Warbler
Chestnut-sided Warbler
Yellow Warbler
*House Sparrow
Golden-crowned Sparrow
Evening Grosbeak
*House Finch
*Pine Siskin
American Goldfinch
*Rufous-sided Towhee
*Dark-eyed Junco
White-crowned Sparrow
*Fox Sparrow
*Song Sparrow

*Commonly seen throughout the year, and possibly resident, in the garden area.



Pinus contorta D. Douglas ex Loudon

Shore Pine, Lodgepole Pine

Member of the Family Pinaceae

Distribution and Natural Habitat

Pinus contorta occurs over a wide range of sites and soils from sea level to about 3900 m in western North America. It is present on coastal dunes and bogs to montane dry to moist areas from southern Alaska and central Yukon south along the coast to northern Baja California, east to Alberta and extreme southwestern Saskatchewan, northeastern Oregon, Idaho, northern Utah, western Nevada, the Black Hills of South Dakota, and Colorado. The northern limit of its distribution is about 64°N on the divide between the Klondike and McQuestern Rivers in the Yukon, and the southern limit is about 31°N in the northern part of the Sierra Pedro Martir in Baja California. Within its area of distribution the temperature shows extremes of —58°C to +38°C, and the precipitation ranges from less than 450 mm of rain per year to snowcover exceeding a depth of 635 cm. It shows its best growth on well-drained loam soils, but may also be found on gravelly and stony ridges to swamps and coastal dunes. The species may be found in association with other species, or in large dense pure stands. There are, in fact, 3 principal regions of distribution within the overall area — the Pacific Coast, the Cascade and Sierra Mountains, and the Rocky Mountains — and the species is divided into 3 principal varieties, each of which is present in one of these areas.

In British Columbia the coastal form of *Pinus contorta* is found in bogs and on sand dunes and rocky bluffs along the coast from the southern part of the Province north to Alaska, while the inland form is present on mountain slopes and meadows and the dry gravelly soil of the Interior plateau from the coast east to the Rocky Mountains. It often forms extensive forests on burns of the Interior plateau. *Pinus contorta* has the widest general climatic range of any conifer in British Columbia, but is lacking in all areas where limestone outcrop soils occur.

Description

Pinus contorta is an evergreen, resinous species showing great variation, ranging from a small contorted tree or shrub on the coast to a tall slender tree in the Interior, 3-15(-60) m tall, and 15-100(-180) cm DBH. The crown is either rounded and spreading or narrow-pointed, and the trunk is usually slender, straight and clear of branches in dense stands, although the branches may be retained close to the ground in open-grown trees. The tree is usually much smaller and contorted at the coast and in windswept conditions inland.

The root system initially consists of a taproot, which is maintained through life although it may be bent, stunted or atrophied at its extremity, or be obscured by the other roots in the system. Lateral roots develop horizontally, but may later develop short downward-growing side roots. The short roots almost always have a mycorrhizal association.

The bark is 0.6-2(-2.5) cm thick, reddish-brown to grayish-black and sometimes tinged with purple and orange, rough, and ridged and furrowed with closely appressed scales to not ridged and furrowed with loosely appressed scales.

The twigs are rather stout, dense, short and crooked. They are green or orange and glabrous when young, becoming reddish-brown to almost black with age.

The wood is resinous, generally with a straight to somewhat uneven grain, moderately light, and moderately soft. The heartwood is light yellow to yellowish-brown or pale reddish-brown, and the sapwood is nearly white and narrow. The split surfaces of boards often have numerous depressions giving a dimpled or pebbled appearance, leading to the common name of 'bird's eye pine'.

The winter buds are cylindrical with a short-pointed apex, 6-12(-25) mm long, dark brown to reddish-brown, and resinous. There are numerous scales with appressed points.

There are two kinds of mature leaves in *Pinus contorta* (as in all pines), both of which form on deciduous spurs on the branches. The first are scale-like leaves in the axils of the spurs. These are triangular-lanceolate, membraneous, 0.3-0.6 cm long at first but becoming shorter with age. The second type are needle-like leaves with the scale-like leaves forming a sheath around their base. These are in clusters of 2, and are 2.5-5(-8) cm long, 1-3 mm wide, dark green to yellowish-green, often spirally twisted, and densely clothe the branches. The apex is usually short horny-pointed, and there are numerous whitish stomatic lines on each surface. The margin has rudimentary teeth, although they are often difficult to distinguish. Each needle is semicircular in cross-section, and there are median resin canals, although these may be lacking in the coastal form. The leaves are persistent for (2-)3-8(-9) years, after which they fall, leaving the swollen base of the spur shoot on the branch. Like all pines, the needles emit a pungent odor when bruised due to the release of an oleo-resin rich in oil of turpentine. This is the only 2-needle pine native to British Columbia.

The strobili ("flowers") appear in April to July over the range, and from April to June in British Columbia. They are formed the previous year on branchlets of that year's growth. Male and female strobili are on separate parts of the same tree (monoecious). The male or staminate strobili are single, numerous, and clustered at the base of shoots in the lower part of the crown. They are cylindrical, 8-10 mm long, orange-red to reddish-green, and contain numerous spirally arranged sporophylls, each bearing 2 pollen-sacs at its apex. Each strobilus is subtended by an involucre of 3-6 scale-like bracts, and disintegrates soon after pollen release leaving a distinct naked zone on the branch. The ovulate or female strobili are paired or in clusters, and usually somewhat upright at or near the ends of branches in the upper part of the crown. They are ovoid, usually lop-sided or slightly curved, and reddish to greenish. There are numerous thin scales, each bearing 2 inverted ovules on the upper surface although only the ones in the upper part of the strobilus are fertile. The extreme basal and apical scales are usually barren. The bracts are small, adnate to the scales, and hidden by them. Open-grown trees begin to bear reproductive structures at 5-10 years of age, while trees in dense stands usually begin to bear them at about 15-20 years of age. Several abnormalities in the reproductive system have been reported, especially on the inland forms. These include the replacement of male strobili by female, the occurrence of bisexual strobili, and atypical positioning of cones along the branches.

The mature cones are woody, lustrous light yellowish-brown to dark brown, 2-6(-7.6) cm long, and 2-3 cm broad. They are ovoid or conical, usually asymmetrical or even slightly curved, and have very short stalks. The cones are subterminal on the branches, often occurring in clusters of 1-6 or more, and are reflexed (pointing backwards) or more or less at right angles to the branch. The scales are thin, slightly concave, 12-19 mm long, (3-)6-9 mm broad, and brown or purplish-brown on the covered portion. The apophysis or exposed part of the scale is thickened, and the umbo (the terminal protruberance) may be light brown to black, and bears a small, slender, more or less recurved prickle that soon wears away. The cone is mature in the fall of the second, or even third, year, either opening and releasing the seed almost immediately, or remaining closed for many years. In the latter case, fire is usually needed to open the cones (serotinous). The open cones may persist on the branch for many years before falling.

The seeds are 3-5 mm long, reddish-brown with darker black-brown spots, usually obovoid, and often ridged on one side. The testa (outer seed coat) is expanded at one end to form a thin membraneous wing that is 8-12 mm long and often red-streaked. The apex of the wing is pointed. Trees begin to bear cones when very young (4-10 years), and fertile cones are borne nearly every year after about 15 years of age. Heavy cone crops are usually produced every year, although there is some tendency for especially heavy fruiting every third or fourth year.

Varieties and Ornamental Cultivars

Pinus contorta is a variable species occurring over a wide climatic and geographic range. Intermediate forms exist between the extremes, leading to suggestions that it is a polymorphic species differentiated into a series of ecotypes. It has, in fact, been shown that *Pinus contorta* of the California coast is genetically different from trees in Alaska or in the High Sierra of California. As many as four varieties have been described, but these are themselves variable, and obviously more research is needed to determine the exact status of trees in various parts of the range.

Taylor and MacBryde (1977) accept two varieties as occurring in British Columbia. *Pinus contorta* var. *contorta,* Shore Pine, is the coastal form, occurring from Alaska south to Mendocino County in California. In British Columbia it is found on poor soil in bogs, on sand dunes and rocky bluffs close to the coast. It is a small, poorly formed tree, 3-12(-15) m tall, which is frequently gnarled and contorted, with twisted branches. The crown is dense and globose, and the needles are dark green and about 5 cm long. The bark is usually 2-2.5 cm thick. The cones are more or less at right angles to the branches, light yellowish-brown to yellow-brown, and

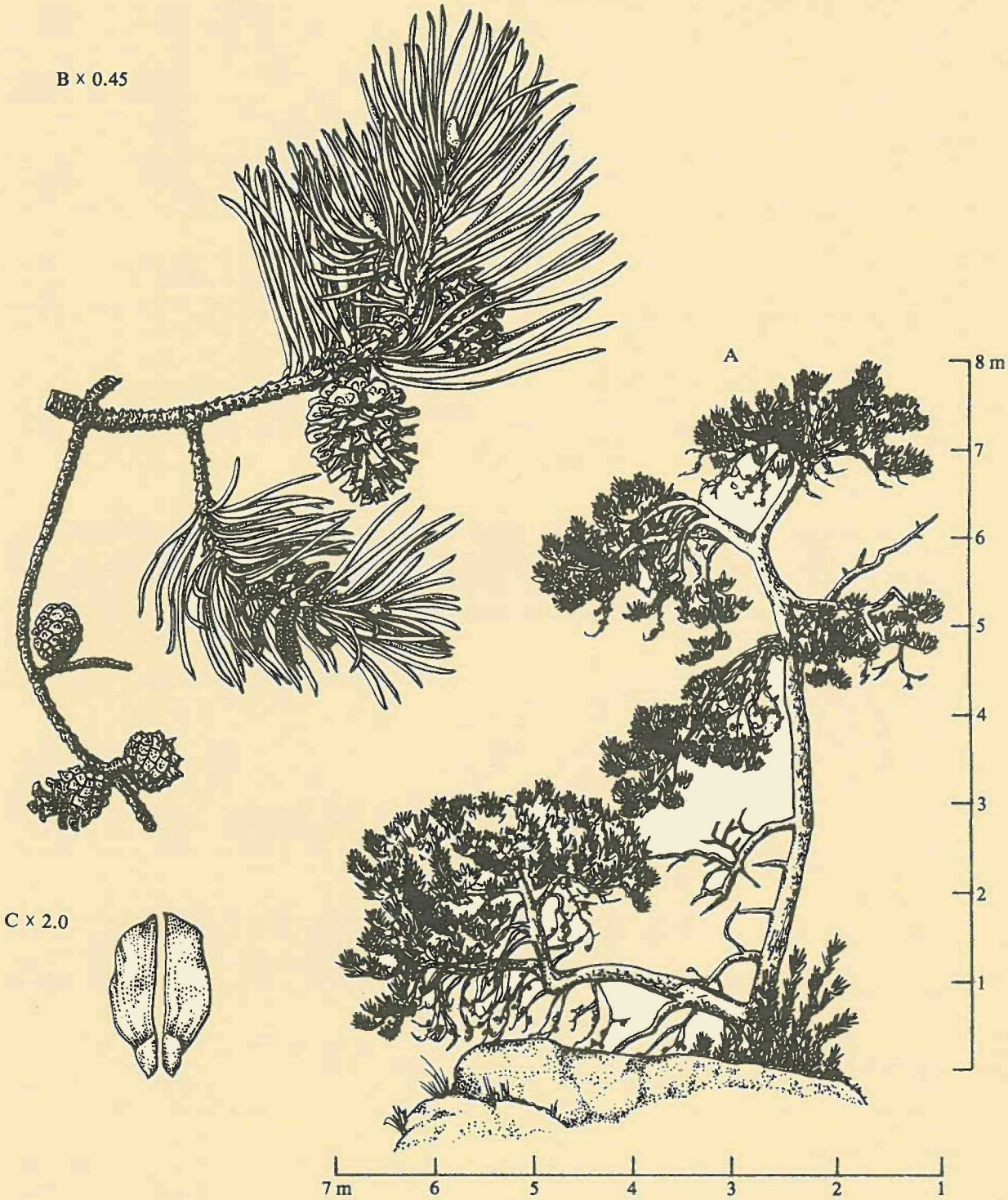


FIGURE 3. *Pinus contorta* var. *contorta*. A. Habit, B. branch bearing cones in various stages of development, C. seeds.

usually open at maturity. *Pinus contorta* var. *latifolia* Engelmann in S. Watson, Lodgepole Pine, is the inland or mountain form, occurring in the range of the species except along the coast. In British Columbia it occurs on sandy plains and the dry gravelly soil of the Interior plateaux as far east as the Rockies, and extending as far north as latitude 64°N. It is a tall slender tree, 15-60 m high, with a straight trunk and conical crown. The needles are yellowish-green and 4-8 cm long. The bark is usually less than 1 cm thick. The cones are light brown, point backward (reflexed) on the branches, and the majority remain closed for many years. This variety has been described as the most common pine of the northern Rockies, and often forms pure even-aged forests covering large areas. *Pinus contorta* var. *bolanderi* (Parlatore) Lemmon is a much dwarfed form, 60-150 cm tall, with very small cones, which is found in Mendocino County, California. *Pinus contorta* var. *murrayana* (Greville & Balfour) Engelmann is the name often given to the form occurring from the Columbia River south in the mountains to the San Pedro Martir of Baja California.

Hybridization between *Pinus contorta* var. *latifolia* and *P. banksiana* Lambert is relatively common in central and northwestern Alberta, where the ranges overlap. The hybrid, *P.* x *murraybanksiana* Righter & Stockwell, is fertile, and forms hybrid swarms in the vicinity of Edmonton. It is named after the two parent species — *Pinus contorta* var. *latifolia* was once known as *P. murrayana* Greville & Balfour.

There are no cultivars listed for the species.

A bonsai form, found on Chieftain Mountain at Squamish in British Columbia and now growing in The E. H. Lohbrunner Alpine Garden at UBC, has been estimated to be 400 years old. It is presently about 1.25 m tall.

Propagation

There is variation in the germination of seeds of the coastal and inland forms, with the inland form germinating twice as fast as the coastal one at 10-20°C. There is also variation between sources within the forms — seeds from a high elevation in British Columbia have been shown to germinate faster at 20°C, while seeds from a low elevation in the Province germinate faster at temperatures above 20°C. Seeds retain their viability for long periods, with high germination rates reported for 25-year old seeds, and there have been reports of seed germinating from 150-year old cones.

The cones must be dried slowly as soon as they are collected to prevent the development of mold, but may then be stored temporarily in well-ventilated bags or trays. Open cones may be shaken to remove the seeds, the seeds should be rubbed to remove the wings, and then can be sown or stored at −15 to −18°C or 0-5°C for up to 7 years (inland forms) or 17 years (coastal form). Serotinous cones may be opened by dipping in boiling water for 30-60 seconds. Fresh seeds need no pretreatment and may be sown immediately. Stored seeds should be stratified at 0-5°C for 28 days (coastal form) or 28-35(-36) days (inland forms). Sow the seeds in fall if fresh or in spring if pretreated, pressing firmly into the soil, and cover with 3 mm soil. Provide temperatures of 30°C for 8 hours and 20°C for 16 hours per day for 28-62 days. This regime should give 65-80% germination. Alternatively, the seeds may be sown outside from the middle of March to the middle of April in light well-drained soil and covered with 3-6 mm fine sandy soil, or in pots or boxes in a greenhouse or frame.

The young seedlings require protection from the sun under lath screens or brush, and plenty of moisture. Care must be taken to prevent damping off. The young plants can be transplanted after 1 year for the coastal form or 2 years for the inland forms. If the plants cannot be transplanted to their permanent position and have to be kept in frames or nursery bed, frequent transplanting at two-year intervals should be done to ensure effective fibrous root development.

Cuttings from all pines should be taken late in the season, using one-year old firm tip shoots with a two-year old (woody) base. Remove all leaves from the bottom third to one-half of the cutting, and set it firmly in clean sand or peat in flats. It is best to provide mild bottom heat at first, raising the temperature to about 21°C later. Rooting should occur in 4-8 months. Alternatively, the cuttings may be rooted outside in frames during the summer.

Grafting is used for propagating special forms. Pines in general are usually grafted in spring onto stocks of the same genus, although Lodgepole Pine has been successfully grafted onto mature Ponderosa Pine *(Pinus ponderosa)* and Scotch Pine *(P. sylvestris)*.

Pines, including *Pinus contorta,* do not generally reproduce vegetatively.

Transplanting

All pines dislike root disturbance, and should be transplanted to their pemanent place when no more than 30 cm tall. It is possible to transplant specimens up to 60 cm tall if they have received individual attention by regular transplanting until that time. The use of modern tree-moving equipment allows the transporting and transplanting of trees up to 30.5 cm diameter with a root-ball 2 m diameter, provided that great care is used and the tree is well-guyed after replanting, but it is not recommended unless absolutely necessary. It is best to transplant the trees in spring just before active new growth starts. The top is usually not pruned, therefore the roots must be kept as intact as possible during the move. Trees must not be transplanted from a shady position into full sun. Pines do not like to be planted deeply, the top roots should be just covered with soil, and they should be well-guyed until established. The best results are obtained from well-handled nursery-grown materials, rather than by transplanting from the wild.

There are regulations against the movement of pines in British Columbia because of the presence of the European Pine Shoot Moth (see the section on *Diseases and Problems of Cultivation*).

Conditions for Cultivation

The growth rate varies from rather slow for the coastal form to fairly fast for the inland forms, but in all cases slows down after about 40 years of age. The species is considered to be mature at 140 years when the trees are 18-24 m tall, and can attain 200-300 years of age in nature. One individual tree has been reported to have reached 600 years, but this is unusual. The species is shade intolerant in nature, and the lifespan is often determined by the shade produced by other fast-growing trees. *Pinus contorta* often occurs in dense pure even-aged stands, resulting from establishment after a forest fire. The serotinous cones open only after heat has melted the resin which glues together the scales. Large amounts of seed are released after such a fire onto an area that is free from competition.

The recommended hardiness zone for Canada is Zone 6 for Shore Pine and Zone 1 for Lodgepole Pine.

The species thrives in a variety of soils, preferring moist, well-drained, sandy or gravelly ones. It also does well on dry soils, but will not grow in soils rich in calcium. The tree prefers full sunlight and at least 530 mm precipitation per year, with the Shore Pine growing better in a cooler climate than the inland forms. Pines in general require little if any fertilizing.

Pines in general require a minimum of pruning, although they may be pruned when necessary. It is best to remove a branch entirely rather than shortening it. If the lower branches of an exposed tree need to be removed, it must be done gradually to prevent the sudden exposure to the sun of a large expanse of trunk. The dense foliage of *Pinus contorta* var. *contorta* will take training well.

Landscape Value

Pinus contorta is considered to be an excellent tree for small gardens, wild gardens, or even a large rock garden, and deserves to be more widely grown that it is at present. The Shore Pine is one of the best small pines for small gardens, and also does well in containers. It often has a dwarfed or contorted outline, especially when collected from the wild. Lodgepole Pine has great frost resistance, and is ideal for gardens in the cold areas of Canada, as well as in the Rocky Mountain States of America. This form has been introduced near Fairbanks in Alaska as a fast-growing, hardy, shade tree, and is doing well.

Pinus contorta var. *contorta* is used in the Nitobe Memorial Garden at UBC, where it is pruned in the Tokyo style to show the form of the tree. The candles of the tree are reduced each year, and only two years' growth of needles is left on. This contrasts with the dense foliage encouraged by western gardeners.

Availability

Pinus contorta var. *contorta* and *P. contorta* var. *latifolia* are available from local nurseries, although it may be necessary to place a special order for specimens, particularly if wanted in large quantities.

Other Uses

The wood is easy to work and glues well, but holds nails and screws poorly, and is not durable under conditions favorable to decay. Newly worked wood has a resinous odor and is very inflammable. *Pinus contorta* var. *contorta* is generally too small and misformed for commercial use, although it is used locally for rough construction and for fuel, as well as for pulpwood. *Pinus contorta* var. *latifolia* is valuable commercially for

general construction, siding, loghouses, interior finish, boat-building, cooperage and box-making, as well as for fuel. Lodgepole Pine can also be used for railway ties, poles, mine timbers and fences after treatment with a preservative such as creosote. Many fences in the Interior of British Columbia were constructed of Lodgepole Pine.

Both varieties are being developed for use as Christmas trees, particularly in Washington.

Pinus contorta var. *contorta* has important uses in watershed and forest management, and is of great value in fixing and protecting exposed sand dunes because it is salt-resistant and establishes quickly. *Pinus contorta* var. *latifolia* has important uses in watershed and shelterbelt plantings, and also provides habitat and food for wildlife, since many birds and rodents eat the seeds. It is often used in Great Britain as a pioneer species on poor peaty soils, where it seems better suited than any other conifer, and has also been planted on a large scale in Sweden to replace *Pinus sylvestris,* Scotch Pine.

The cambium or inner bark is edible, especially in the spring, and can be a valuable source of food in an emergency. However, the removal of the outer bark is involved, and this can be detrimental to the tree, so the cambium should only be harvested in a real emergency.

Ethnobotany

The Indian tribes of British Columbia and Washington had many uses for the species, mainly medicinal, although it is sometimes difficult to tell from the literature which variety was used.

The gum exuded by the bark and cones of *Pinus contorta* var. *contorta* was used by the Bella Coola Indians of British Columbia as the base of several medicines. It was applied directly to cuts, or chewed and applied to broken skin. Gum collected in November to December from the ends of branches was boiled and the decoction taken internally for "consumption". It was mixed with the baked stems and leaves, or the dried and pulverized bulb, of False Hellebore *(Veratrum viride)* and applied as a poultice (sometimes spread on Red Cedar bark) to the chest for heart trouble, or to the arms for rheumatism. The poultice burned the skin within two or three days, but was sometimes left on for as long as two weeks. The Sikani Indians chewed the gum and swallowed the saliva for a cough. The Sechelt tribe rubbed the pitch on canvas and baskets to waterproof them, and onto their skin for sunburn, cuts, boils, and other infections. They also chewed it as a gum because it has a good flavor, and used it to make a hot fire. The Thompson Indians boiled the gum exuded by the cones and bark of *Pinus contorta* var. *latifolia* and mixed it with melted deer fat, then applied the ointment to the body for rheumatic and other pains. They also made another ointment by melting the gum with the best animal fat, thoroughly mixing the two, and then applied it to the body to relieve aches and pains of all kinds, as well as soreness in muscles and joints. The ointment was applied to the throat, sides of the neck, and, sometimes, to the back and chest to relieve "congestion". It was often applied after a sweat bath or in front of a hot fire, being rubbed in with the hands. They also mixed pitch from the trunk with grease and then used this with Horsetail stems (*Equisetum* sp.) to smooth and polish steatite pipes.

The inner bark or cambium was a favorite food of many tribes, particularly in the Interior of British Columbia. The cambium is at its prime for harvesting for a very short time in the spring, varying with elevation and local climatic conditions. The bark was removed and the cambium scraped from the wood in long fleshy ribbons about 2.5 cm wide and 60 cm long. The scrapers were made out of caribou antler, deer ulna, or black bear shoulder blade bones. A basket was held at the base of the tree and the cambium scraped off upwards so that none of the "juice" was lost. The cambium was usually eaten fresh, although some tribes sometimes dried it for use later in the year. The Kootenay Indians thought that it was especially good for "consumption", while the Gitksan tribe thought it useful as a blood purifier, purging the body in from 30 to 60 minutes. The Haida Indians boiled the inner bark and drank the juice for "lung troubles", colds and tuberculosis, sometimes adding Waterlily root *(Nuphar polysepalum).* They also applied the cambium as a poultice to sores.

The Northern Carrier Indians of British Columbia mixed the needle tips of *P. contorta* var. *latifolia* with the large needle tips of the "British Columbia Pine" (*Pinus* sp.?), the inside bark of Wild Gooseberry (*Ribes* sp.), the bark of Red-osier Dogwood (*Cornus sericea*), the inside pulp of Raspberry canes (*Rubus* sp.), the stems of the "Bearberry" (*Arctostaphylos uva-ursi* or *Lonicera involucrata*), and the inner bark of the wild Rose (*Rosa* sp.). The ingredients were placed in four gallons of water in a vessel, boiled down to a thick concoction, strained, and bottled. About two tablespoons of the mixture was taken at sunrise and sunset for "constitutional weakness" or paralysis, or if the body was covered with sores. The Gitksan tribe picked young needles in June and ate them as a purgative and diuretic.

The Gitksan tribe removed the bark, took shavings from the resinous timber, and boiled them. The decoction was placed in oil, and taken internally as a purgative and diuretic for many serious ailments, including gonorrhoea. It was also said to be beneficial in "consumption".

The wood is tough and fire-resistant, and was used by the Southern Kwakiutl Indians on Vancouver Island for making implements such as fire tongs for lifting red-hot rocks into steaming boxes, as board protectors used for bending boards of other woods in box-making, and as cedar-bark peelers, digging sticks, and harpoon shafts.

Trees of *Pinus contorta* var. *latifolia* with unbroken slender trunks were used as centre poles in huts and wigwams, hence the common name of Lodgepole Pine, and were also used to make the travois, the litter or drag-sled used by many Plains Indians. The Lillooet Indians have used the wood in recent times to build log cabins.

The Thompson Indians mixed the gum with the best animal fat and smeared the mixture on the body after a sweat bath as a purification rite.

Diseases and Problems of Cultivation

Pinus contorta has been damaged by sulfur dioxide from ore smelting, and is injured by an impure atmosphere, so that it is unsuitable for planting in the vicinity of manufacturing towns. The species is shallow-rooted, and is therefore generally considered to be susceptible to windfall. Trees planted too deeply are susceptible to attack by fungi such as *Fomes annosus* and *Armillaria mellea,* but good drainage and shallow planting will prevent such attacks.

Like all pines, *Pinus contorta* is subject to a number of pests, but healthy, well-grown plants need comparatively little attention. Well-drained soil and shallow planting will help to maintain the health and vigor of the plants.

In certain areas porcupines will gnaw the bark off many trees, and birds and rodents such as squirrels eat large amounts of the seed.

The most serious insect pest in British Columbia is *Rhyacionia bouliana* Schiffermüller, European Pine Shoot Moth, which is common in the Vancouver Forest District. The adult is a moth with light orange forewings with silvery lines on them, dark brown hindwings, and a wingspan of about 2 cm. The larvae bore into the buds and shoots, distorting or killing them. The British Columbia Department of Agriculture recommends the pruning and burning of infected growing tips during the period from September until the end of May. If this is not possible, they recommend spraying with a Diazinon and Insecticidal Soap mix once during the last 10 days in June, repeating the spray about July 10 and July 24. The spray must be applied thoroughly to the point of run-off, and will kill any emerging larvae. Provincial regulations prohibit the movement of all pine trees from the Vancouver Forest District unless they have been found free of infestation for two consecutive years. Trees showing less than 3% infestation have to be treated and may then be sold within the Vancouver Forest District. Trees with a larger infestation may not be moved. This is to prevent the possible spread of the moth to the large commercial stands of native pines in other parts of the Province. Any pine tree bought or sold should have a provincial certification tag attached to it by the grower. Private individuals wishing to sell pine trees from their properties should apply to the British Columbia Department of Agriculture for inspection and certification of the trees. In addition, Federal law requires that pine trees imported from other Provinces or countries must be fumigated on entry.

Halisidota argentata Packard, Silver-spotted Tiger Moth or Douglas Fir Webworm, is common in coastal British Columbia, on Vancouver Island, and the Gulf Islands. In nature, *Dendroctonus ponderosae,* Mountain Pine Beetle, is the most serious enemy of mature pines (including *P. contorta*) in western Canada, and probably occurs throughout British Columbia.

Pinus contorta is subject to a number of rust diseases caused by fungi, and some may occur on garden specimens, particularly if the alternate host is nearby. The most important one is probably *Cronartium comandrae* Peck, Comandra Rust, which causes widespread mortality of trees of all ages in the wild. The alternate hosts are species of *Comandra. Cronartium coleosporioides* Arth. f. *coleosporioides,* Orange Stalactiform Blister Rust, has *Castilleja,* the Indian Paintbrush, as the alternate host. *Endocronartium harknessii* (J. P. Moore) Y. Hirat, Western Gall Rust, occurs in nature throughout the range to about 58°N, and may occur on cultivated trees. This is the most common, most conspicuous, and most destructive stem rust in western Canada. There are very

obvious woody, perennial, globose or hemispherical galls on the branches or so-called "hip cankers" on the trunks of affected trees.

Mistletoe is a serious pest of *Pinus contorta,* causing thin crowns, sickly pale short needles, and slow growth. *Arceuthobium americanum,* Dwarf Mistletoe, is probably the most common, and often causes Witch's-brooms on infected trees.

Origin of the Name

The generic name *Pinus* is the classical Latin name for the pine tree, and was used by Virgil and others. The specific and varietal epithet *contorta* is from the Latin meaning 'twisted', 'contorted', or 'bent irregularly', referring to the twisted branches of the typical scrubby Shore Pine of the coast. The varietal epithet *latifolia* is derived from two Latin words, *latus* meaning 'broad' or 'wide' and *folius* or 'leaves', meaning 'broad-leaved' or 'with broad leaves'.

The type locality for *Pinus contorta* is "Northwest America, in swampy ground near the sea coast, and abundantly near Cape Disappointment and Cape Lookout" [near the mouth of the Columbia River on the border of Washington and Oregon]. It was collected in 1825 by David Douglas (1798-1834), the great Scottish botanist and collector. The description was published in 1838 by John Claudius Loudon (1783-1843), a Scottish botanist and landscape gardener. The tree was apparently introduced to cultivation in Britain about 1855 when it appeared in a catalogue as *P. macintoshiana.* The type locality for *P. contorta* var. *latifolia* is "Uinta Mts., Utah" where it was collected by Sereno Watson (1826-1892). *Pinus contorta* var. *murrayana* was collected "on the Siskiyou Mountains" and in the "high Sierras, California" by John Jeffrey (1836-?1854) in 1851 and 1852. Jeffrey was a Scottish plant collector hired in 1850 by the Oregon Committee of Men (based in Edinburgh, Scotland) and sent to the west coast to collect plants for introduction into cultivation in Scotland. He mysteriously disappeared in San Francisco in 1854. This name is considered to be in synonymy with the variety *latifolia* in British Columbia. It was introduced to cultivation in Great Britain shortly before 1855.

There is evidence that Lodgepole Pine was first collected on Sitka Island in Alaska by Franz Carl Mertens (1796-1831), a medical doctor and botanist-zoologist on Captain Lutke's around-the-world expedition sponsored by the Russian Government. He gave the specimen to Henri Gustave Bongard (1786-1839), professor of botany at the University of St. Petersburg, who misidentified it in 1828 as *P. inops* Aiton (= *P. virginiana*).

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Index Seminum

The Index Seminum, or Seed List, is published annually in mid-winter and is the means by which The Botanical Garden offers seed for exchange with other botanical gardens and research institutions. Many botanical gardens, including ourselves, confine their Index Semina mainly to the seeds of native plants, most of which are collected in the wild during the previous summer and fall.

The Index Seminum for the 1978 collection year was distributed to a total of 511 institutions or individuals engaged in research projects in 46 different countries. The list contained 197 taxa in 52 families. We received requests for 5372 seed packets from 302 institutions in 36 countries of which we were able to supply 4249 packets (79%). The ten most frequently requested taxa were: *Douglasia nivalis* var. *dentata* (107 requests), *Abies lasiocarpa* var. *lasiocarpa* (106), *Erythronium grandiflorum* var. *grandiflorum* (104), *Abies grandis* (93), *Pinus monticola* (90), *Fritillaria pudica* (79), *Dodecatheon jeffreyi* (76), *Lewisia cotyledon* (74), *Mahonia repens* (74), and *Larix occidentalis* (73). The following are the ten countries in which our seed was in most demand: U.S.S.R. (including Estonia, Latvia and Lithuania, formerly recorded separately) (33 requests), West Germany (30), United Kingdom (29), Czechoslovakia (22), U.S.A. (22), France (17), East Germany (15), Hungary (12), Poland (11), and Switzerland (11).

We acknowledge with gratitude the assistance received from members of the 'Friends of the Garden' who spent many long hours cleaning seed and dispatching orders.

During 1979 we received Index Semina from 314 sources in 46 countries. We requested 766 packets of seed from these lists and have received 535 packets.

Repotting House Plants

DAVID TARRANT

January and February are ideal months for repotting house plants, because new top and root growth usually starts during late February to early March. Repotting is a very basic and simple operation, although beginners often make one or two common mistakes that may be fatal to the plant.

How does one determine whether a plant needs repotting? The best way is to examine the root system. To remove the plant from the pot with minimum root damage, first water well the previous evening. Place a hand across the top of the pot so that the plant stem is between the middle fingers, turn the pot upside down, and give the rim a sharp tap on a wooden surface. The plant and soil should now slide out of the pot and rest on your hand (Figure 4). If the ball is all root with little soil showing, the plant is pot-bound and definitely needs repotting. The ideal stage for repotting is when the soil is approximately 50 per cent covered with roots. If less, replace the plant in its pot and leave it to develop.

The most common mistake is to break up the root-ball, especially on a pot-bound plant, supposedly "to relieve the pressure". This breaks most of the tiny feeder roots and results in severe die-back or leaf-drop. Always leave the root-ball intact.

The second common mistake is to repot the plant in a pot that is much too large for it, with the intention of avoiding several repottings. For example, many people will buy a *Fatsia japonica* in a 10 cm pot and will immediately repot it into a 30-35 cm pot because "it will eventually need that size". Unfortunately, the plant does not develop normally under such conditions as the soil is either too wet or too dry so that the feeder roots quickly die. Repot only into pots 5 cm larger than the old ones for best growth.

Place some broken crocks or pebbles over the drainage hole, put some fresh potting soil in the pot, and position the plant so that it is in the centre of the pot with the soil level about 1.25 cm below the rim. This may need some trial and error at first, but experience will soon tell you approximately how much soil to put in the base of the pot. Handling the plant carefully without breaking up the root ball will cause little damage during this learning stage. Fill in the space between the root ball and the side of the pot with soil, using the forefingers to push it gently down (Figure 5). Be sure that the crown of the plant is about the same level as previously (Figure 6). To help the soil settle, tap the base of the pot sharply on a wooden surface. Water well and stand the plant away from direct sunlight for two or three weeks, misting lightly each day.

FIGURE 4. Plant pot inverted and tapped on the bench. Note how the fingers of the right hand are supporting the plant and soil. The surface of the soil is approximately 50 per cent covered with white roots.

FIGURE 5 (left). The plant is placed in the new pot, the space between the root ball and the side of the pot filled with soil, and the soil firmed gently with the forefingers.

FIGURE 6 (right). The repotted plant, showing the crown at about the same level as previously and the soil level about 1.25 cm below the rim of the pot.

The pots may be either clay or plastic, depending on your personal choice. Clay pots, however, should be soaked in water for at least 30 minutes before using as they are so porous that large amounts of moisture will be absorbed from the soil and plants will be put under moisture stress. Plastic pots do not "breathe", therefore a fairly open soil mix should be used so that it will drain fairly quickly. Otherwise a very wet soil condition will develop, often drowning the plant.

Many kinds of potting soil are available from supermarkets and garden shops. They all claim to be ready to use, but in fact many of them leave much to be desired. It is probably quite safe to say that few types contain any fertilizer, because it does not store well after mixing. Many may be considered as "soil-less" mixes, consisting of a large quantity of peat with a little vermiculite and perlite added. Peat holds moisture and does not drain well, yet many people tell me that they add more peat to a bought mix. I would suggest using 2 parts purchased potting soil to 1 part coarse river sand or perlite, mixing well. Add 1 tablespoon of a time-release fertilizer, such as Osmocote 14-14-14, to each 3.8 L (use a large ice-cream bucket as a convenient measure). People who have access to soil and facilities for mixing may prefer to make their own potting soil using the following "recipe": 3 parts (by bulk) sterilized soil, 2 parts coarse peat and 1 part coarse sand. Add 1 tablespoon time-release fertilizer per 3.8 L mix. The fertilizer releases food slowly over a 3-6 month period, so that the plants should not need further fertilizer until late June.

Just before using moisten the soil so that a handful just sticks together when squeezed.

The soil may be sterilized in an oven by using a plastic roasting bag to eliminate the odor. Fill the bag with moist soil, seal and place in the oven at 110°C. When the temperature in the centre of the soil reaches 82°C (use a meat thermometer to check), remove and spread the soil over a flat area so that it will cool quickly. Store until required in a covered container such as a garbage bag or pail.

Botanical Garden News and Notes

Publications — The Botanical Garden is pleased to announce that the following publications will be available shortly:

The Young Grower by Margaret Coxon is a beautifully illustrated manual of indoor and outdoor garden activities for teachers and parents. The 'green thumb mystique' is removed by a very practical yet sensitive approach to the plant world. Both inexperienced and experienced gardeners can enjoy learning through growing, to enable them to share with young people the wonder and joy of growing their own plants. A handy seasonal calendar of planting dates will ensure added growing success and allow a choice of activities for any time of the year. The expected publication date is summer 1980, interested persons should contact the Office of The Botanical Garden for further information.

1979 Annual Report from The Botanical Garden is expected to be published in March 1980. Copies of the Report will be available on request by writing to the Office of The Botanical Garden.

Rare Plants in British Columbia — Work has been completed on the development of the manuscript on the rare plants of British Columbia. It is anticipated that this information will serve as a basis for the discussion of rare plants at a forthcoming symposium sponsored by the British Columbia Federation of Naturalists. Information on the availability of this publication may be obtained by writing to the Office of The Botanical Garden.

New Cooperative Programs in Research — The Botanical Garden, in cooperation with the Department of Botany and the Faculty of Forestry at UBC, has developed cooperative research programs using the new Nursery Propagation Facility in the Garden. A number of research programs are now in progress, and it is anticipated that other Departments on Campus will also make use of the facility. Under the program, The Botanical Garden has responsibility for the maintenance and operation of the plant material in the projects. This provides additional service programs to the academic and research community on Campus.

New Television Program — The Canadian Broadcasting Corporation has taped a series of half-hour programs about gardens and gardening in British Columbia over the last year. The Botanical Garden serves as the anchor point for each program, with David Tarrant providing the gardening information. It is anticipated that these programs will be aired by the CBC in prime time during 1980. Details of times and dates of these programs may be obtained by writing directly to CBC Broadcasting, Vancouver.

Spring Educational Programs — Eleven separate instructional programs on a wide range of topics are being offered by The Botanical Garden in cooperation with The Centre for Continuing Education during the spring of 1980. In addition, there are three travel programs: a horticultural tour of Southern England is planned for May 1980; a look at the Spring Flowers of Cape Province in South Africa is proposed for October 1980; and a West Indies Garden Tour (including St. Vincent, Dominica, Granada, and Barbados) is being developed for February 1981. During the summer of 1980 there will be a biological field study program in the Queen Charlotte Islands. Information on programs operated by The Botanical Garden may be obtained by writing to the Office of The Botanical Garden.

Vancouver Home and Garden Show — The Botanical Garden will again participate as a major exhibitor and demonstration unit at the Vancouver Home and Garden Show to be held at the Pacific National Exhibition Grounds on February 22 to March 2, 1980. The theme of the Garden program will be "Easy Access Gardening", and will feature special displays of hanging baskets, hanging box planters, and provisions for easy access gardening by handicapped people. A series of demonstrations and lectures will be given during the course of the Show. About 80,000 people visited the Show in 1979 and learned of the activities of The Botanical Garden.

The Friends of The Botanical Garden Program — This continues to be an active project-oriented program. Of special interest is the art exhibition entitled *Plantae Occidentalis: 200 Years of Botanical Art in British Columbia,* which has been on a national tour. This exhibition, developed and operated by the Friends of the Garden with support from the National Museums Assistance Program, will complete its national tour at the end of August 1980 after being displayed for the summer at the British Columbia Provincial Museum in Victoria.

A second FOG program on the phenology of British Columbia plants in the B.C. Native Garden is now well underway, providing both illustrated and written information on the flowering times of the plants in the area. This program has provided considerable interest and information for people touring the B.C. Native Garden area.

The 1979 Student Plant Sale, operated by the FOGs, was a great success. More than 3600 UBC students participated in the sale, buying 7701 house plants. The sale was held over a three-day period, on the temporarily 'revamped' tennis court at the Garden Office. The sale provides good quality indoor plant material for students to use in their residence rooms, and has led to the development by staff members of evening workshops in the residences on the care and maintenance of indoor plants. During the sale care cards were provided for each plant sold, and expert advice was given by members of the Botanical Garden staff and Friends of the Garden. The sale also provided an opportunity for staff and students of the University to see the activities of the Garden, as displays of Garden programs were shown during the period.

Development at The Garden — The basic landscaping of the Main Garden will be completed this year when the underpass connecting the Main Garden with the Asian Garden is completed under contract with the British Columbia Department of Highways, which is upgrading road access to the University. With the completion of the underpass, all parts of the Main Garden area will be accessible to pedestrians. The anticipated completion of the new Public Service Centre will enhance the public's appreciation and utilization of the Garden during the coming summer.

Staff Activities — Sylvia Taylor, Librarian and Research Assistant in the Garden, has been appointed Editor of the Canadian Botanical Association Bulletin. She will commence her duties with the July 1980 issue.

Charles Tubesing, a graduate of Purdue University and presently in charge of propagation at the Missouri Botanical Garden, has been appointed Nursery Manager effective March 1, 1980.

Donations to The Botanical Garden

The following people or organizations have donated money or gifts in kind to The Botanical Garden during 1979. We are very grateful to them, and take pleasure in listing their names here.

Alpine Garden Club of B.C., Vancouver, B.C.
Vancouver Chapter, American Rhododendron Society, Vancouver, B.C.
Mr. David Bar-Zvi, Vancouver, B.C.
Dr. Kay Beamish, Vancouver, B.C.
Mr. Gordon Bentham, Victoria, B.C.
Mr. and Mrs. Ken Berube, Vancouver, B.C.
Mrs. Linda Blain, Victoria, B.C.
Mrs. J. Bottrell, North Vancouver, B.C.
Dr. Claire M. Buckland, Vancouver, B.C.
Mr. James A. Calder, Victoria, B.C.
Mrs. Edna Davidson, Vancouver, B.C.
Mr. A. Demezey, Victoria, B.C.
Mrs. Barbara Durrant, Vancouver, B.C.
Friends of the Garden, UBC, Vancouver, B.C.
Mr. Meinhart Harbeck, Hamburg, Germany
Mrs. J. Carlson Kerr, Vancouver, B.C.
Mr. and Mrs. E. H. Lohbrunner, Victoria, B.C.
Mrs. Maureen Macken, Vancouver, B.C.
Mr. Brian O. Mulligan, Seattle, Washington
Mrs. Joan Mulligan, Vancouver, B.C.
Mrs. Mary Pearson, West Vancouver, B.C.
Mrs. Phyllis Peck, Vancouver, B.C.
Mr. and Mrs. M. Sharzer, Vancouver, B.C.
Mr. and Mrs. Y. Tachi, Vancouver, B.C.
Dr. A. R. Taylor, Boulder, Colorado
VanDusen Botanical Display Garden, Vancouver, B.C.
Mrs. Doris Walton, West Vancouver, B.C.
Mr. R. S. Woodward, North Vancouver, B.C.
Finning Tractor and Equipment Co. Ltd., Vancouver, B.C.

Climatological Summary for 1979*

The weather in 1979 can be best described as about normal for the area with one or two minor exceptions. Perhaps the most significant item is that the total rainfall for the year is again below average, following the pattern of the last few years. However, December was particularly wet with 303.5 mm of rain falling during 28 of the 31 days. The temperatures, however, were normal for the month.

Although the total hours of bright sunshine for the year was higher than for the last few years, only March showed any significant increase, about 60 hours more than normal.

For the gardener who likes to gamble with spring bedding plants and vegetables, 1979 had to be a dream come true, with the last frost occurring on April 11 and the first on October 29. More than six months without any fear of frost damage! But who could predict such an event with any degree of certainty, and how many of us would take a chance on that prediction? Oh, the fun and frustration of gardening.

Data 1979	OCTOBER	NOVEMBER	DECEMBER
Average maximum temperature	13.5°C	8.9°C	8.2°C
Average minimum temperature	8.2°C	2.7°C	3.6°C
Highest maximum temperature	19.1°C	14.0°C	11.7°C
Lowest minimum temperature	4.4°C	−2.8°C	−1.2°C
Lowest grass minimum temperature	−0.8°C	−6.5°C	−5.5°C
Rainfall/no. days with rain	84.9 mm/17	79.5 mm/18	303.5 mm/28
Total rainfall since January 1, 1979	595.8 mm	675.3 mm	978.8 mm
Snowfall/no. days with snowfall	0	0	0
Total snowfall since October 1, 1979	0	0	0
Hours bright sunshine/possible	117.9/318.4	97.0/268.2	35.2/253.1
Ave. daily sunshine/no. days total overcast	3.8 hr/7	3.2 hr/3	1.1 hr/20

**Site: The University of British Columbia, Vancouver, B.C., Canada V6T 1W5*
Position: lat. 49° 15′ 29″ N; long. 123° 14′ 58″ W. Elevation: 104.4 m

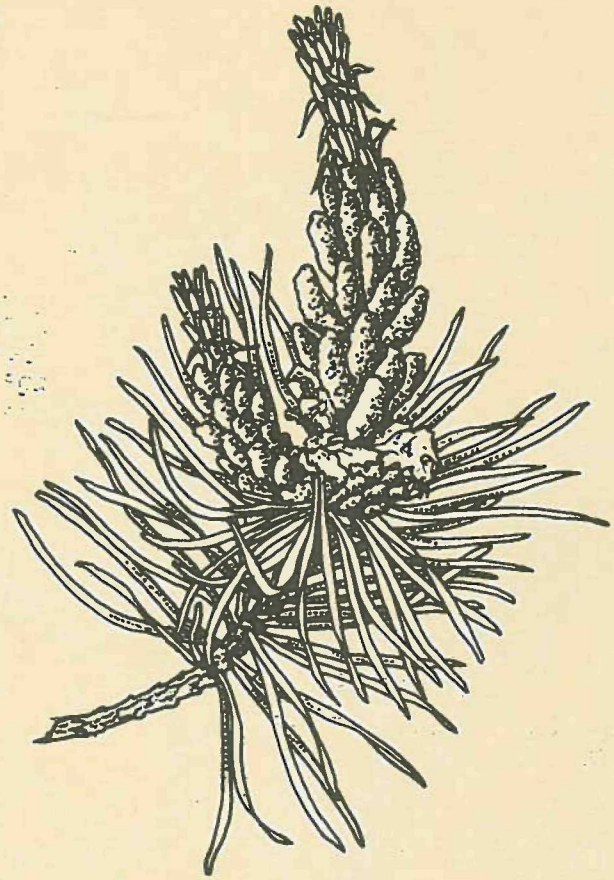
Cumulative Index and Colophon Notes for Volumes 6-10

An Index to Davidsonia Volumes 6-10 is in preparation and will be mailed to subscribers later.

The last five volumes of Davidsonia have been printed in English Times Roman type on Donegal Linen Text paper stock by Alpine Press Ltd., Vancouver, British Columbia. The ink used is deep brown.

Quercus rubra, Red Oak, in the garden of the Office and Educational Centre, following one of Vancouver's rare snowstorms.

Lateral branch of *Pinus contorta* bearing male strobili, x 0.9.



DAVIDSONIA

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