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Guideline to Collecting Cones of B.C. Conifers

R.C. Dobbs, D.G.W. Edwards
Canadian Forestry Service

J. Konishi, D. Wallinger
British Columbia Forest Service

Résumé

Le progrès rapide d'un programme provincial de reboisement nécessite un approvisionnement continuel de semences de qualité et de provenance choisie. Est également de prime importance l'apprentissage par le personnel des procédés et des techniques nécessaires à la cueillette des cônes. A cet effet le B.C. Forest Service et le Centre de recherche forestière du Pacifique (Service canadien des forêts) ont formé un comité conjoint qui a préparé un manuel à jour concernant les aspects variés de la production, de la cueillette et de la préparation des semences.

Dans cette publication intitulée "Collecting Cones of B.C. Conifers", les auteurs s'adressent tout particulièrement au personnel du B.C. Forest Service. Cependant la majeure partie des renseignements fournis étant d'intérêt général, ce manuel peut également servir aux forestiers et aux techniciens en dehors de la région désignée.

Le guide est divisé en deux parties. La première partie donne un apercu des différentes opérations nécessaires à la cueillette des cônes; elle traite de la formation et du développement des cônes et des semences; des obstacles au développement des récoltes et à la périodicité; la détermination des besoins des cones et semences; les prévisions des récoltes et l'estimation de leur valeur; la préparation des zones de cueillette; l'équipement, les moyens de transport et la main-d'oeuvre; les méthodes de cueillette des cônes et la surveillance des récolteurs; et les procédés de manutention des cônes, ce qui comprend l'identification des lots des semences, l'enregistrement et l'étiquetage, les formulaires et l'expédition des cônes à la sècherie.

La deuxième partie donne des renseignements et recommendations specifiques sur le cueillette des cônes de 20 principales essences resineuse de la Colombie brittanique. Ils sont également inclus des appendices sur les reglements provinciaux de cueillette des cônes sur les permis de cueillette et les données physiques sur les cônes et semences des espèces resineuse les plus importantes. Une appendice donne quelques directives detaillées sur la prévision de récolte de cônes du sapin de Douglas et de l'épinette blanche.

Le guide est illustré à profusion de photos en blanc et noir et en couleur, de dessins lineaires et de cartes de repartition.

GUIDELINE TO COLLECTING CONES OF B.C. CONIFERS

by
R.C. Dobbs, D.G.W. Edwards

Canadian Forestry Service
Victoria, B.C.

and
J. Konishi, D. Wallinger

British Columbia Forest Service
Victoria, B.C.

Illustrator: J.C. Wiens
Canadian Forestry Service

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For their many hours spent in reviewing the manuscript, we thank Messrs. A.H. Bamford, R.C. Jones and Dr. A.L. Orr-Ewing of the B.C. Forest Service, and Messrs. J.T. Arnott, A. MacEwan, and R.F. Piesch of the Pacific Forest Research Centre (PFRC).

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Foreword

The B.C. Forest Service is rapidly expanding its seedling production program to meet growing reforestation needs throughout the province. Such expansion can only be sustained, however, if adequate amounts of good quality seed of the required species and provenances can be obtained. As requirements for seed grow, so too will the numerous biological and logistic problems which hamper a tree seed supply operation.

Training of field and laboratory personnel in the procedures and techniques required to provide the tree seed needed for reforestation is of major importance. Toward this end, the B.C. Forest Service and the Pacific Forest Research Centre, Canadian Forestry Service, formed a joint committee to bring together up-to-date information and prepare a series of guidelines relating to various aspects of producing, procuring and processing tree seed. While these guidelines will be worthwhile as references and training aids, they will not negate the need for clinics and workshops nor lessen the need for use of "common sense" by the many persons upon whom a successful seed supply operation must depend.

In 1974, an interim "Guideline to Collecting Cones" was given limited distribution among B.C. forestry personnel. Users of the interim version have provided comments and advice that have been incorporated into this revised guideline. While primarily addressed to B.C. Forest Service personnel, the guideline should also be useful to foresters and forest technicians over a wide geographical area. We trust that not only will it fulfill the need for such a guideline but that it will stand as a worthy example of what can result when two agencies co-operatively apply their resources toward a common goal.

E.L. Young, Chief Forester,
British Columbia Forest Service,
Victoria, B.C.

M.H. Drinkwater, Director,
Pacific Forest Research Centre,
Canadian Forestry Service,
Victoria, B.C.

Table of Contents

Page

Figures

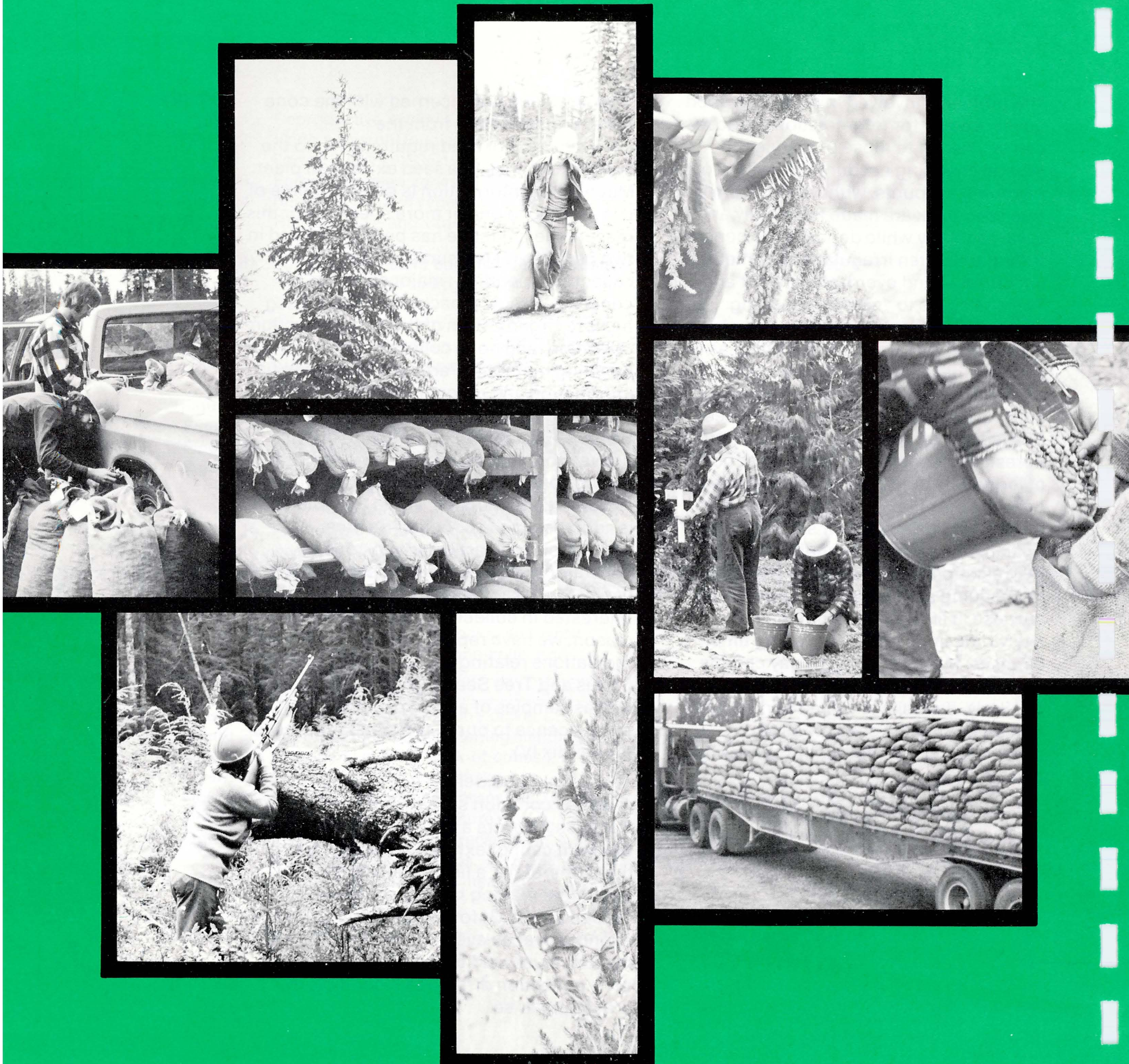
Introduction

The problems involved in providing good quality ***seed**** for reforestation purposes can be likened to those of managing several chequing accounts. As with most chequing accounts, withdrawals from a tree seed bank are made frequently and quite regularly while deposits are generally infrequent, often irregular and sometimes uncertain — and overdrafts are not allowed. The analogy is to "several chequing accounts" because a seed bank contains many ***seed lots*** carefully identified as to species, the zone and elevation from which the seed was collected, as well as other factors. For example, if Douglas-fir seed is needed for reforestation in the Sayward Forest, the fact that we have an abundance of lodgepole pine seed from the Williams Lake area is of no help. Neither, for that matter, would Douglas-fir seed from the Williams Lake area be suitable for reforestation in the Sayward. The analogy to chequing accounts serves one further purpose. It focuses attention on the overriding importance of making timely deposits. Many of us earn a pay cheque before we can add money to our accounts. Similarly, deposits to a seed bank depend first on getting the seed or, more specifically, on collecting the cones which bear the seed.

This guideline is concerned with the cone collection operation from the determination of seed requirements to the delivery of cones to a seed extraction plant. Much of the information is general; some of it is specific to one or more species. For this reason, the guideline has been organized in two parts. Part I is a survey of the cone collection operation; major sections concern biological background, planning and pre-organization of the cone collection operation, and cone collection and handling methods. Part II provides specific information and recommendations for collecting cones of important conifers. Because Canada is committed to metric conversion, metric units are given priority throughout. The reader will find conversion factors in Appendix VII. While the guideline is addressed to B.C. Forest Service personnel, and particularly to cone collection supervisors, it should also be useful to personnel of other agencies interested in collecting tree seed. For this reason, we have reproduced the provincial regulations relating to the "Picking of Tree Cones and Tree Seeds" (Appendix III), as well as samples of a cone pickers permit and a licence to purchase cones and seeds (Appendix IV).

This is only a guideline; it is not meant to replace "common sense" or innovation. Because it covers a wide range of specific topics, it cannot exhaustively cover any of them; therefore, a list of suggested additional reading has been included (Appendix IX). Unfortunately, this guideline cannot cover all eventualities and, for this reason, must yield to B.C. Forest Service cone collection directives if conflicts in procedure arise.

*Terms in bold italics appear in glossary (Appendix 1).



Part I

Survey Of The Cone Collection Operation

Biological Background

The availability of cones for collection purposes — how many there will be, their quality and when they will be ready for picking — is determined by a series of biological processes and constraints which are generally beyond control of the forest manager. But understanding and monitoring these processes and constraints is an essential prerequisite to planning and implementing a successful cone collection operation.

Stages in cone and seed development

Conifer seeds develop through four principal stages which begin in the spring and, for most species, are completed in the fall **of the following year**. Only the pines and yellow cedar require an additional year to complete seed development. The following, sufficiently generalized to apply to all commercially-important B.C. conifers, is supplemented by the reproductive cycle diagram of Douglas-fir (Figure 1) and by color photographs of buds, flowers, and cones (Figures 4, 5, 8, 13, 16, 17, 19 and 21).

I. Formation and development of male and female reproductive buds.

This stage extends through spring, summer, and fall of the year previous to the cone crop year. (In the pines and yellow cedar, this stage occurs 2 years before the cone crop year). At some point, usually by midsummer, the male and female buds can be distinguished from each other and from the vegetative buds which are also developing during this period. (This distinction among types of buds is the basis for early forecasting of cone crops. See Appendix V.)

II. Bud opening and development of pollen cones and seed cones.

This stage occurs the following spring. Upon opening, the male buds develop into ***pollen cones*** (male flowers) and the female buds develop into ***seed cones*** (female flowers). Within the pollen cones, pollen grains are developing and within the seed cones, ***ovules,*** the structures destined to become seeds, are also developing.

III. Pollination and fertilization.

This stage usually occurs in April to June of the cone crop year. When the pollen cones are fully developed and the seed cones have developed enough to be receptive, pollen is released from the pollen cones and transported by air currents to the seed cones. This process is called ***pollination***. Upon reaching a receptive seed cone, the pollen grain produces a long tube which enters an ovule and introduces genetic material from the male parent. This process is termed ***fertilization***. (Exception: In pines, fertilization does not occur until spring of the third year).

IV. Final development of seed cones and seeds.

This final stage extends through the summer and, except for pines and yellow cedar, ends in late August to October with cone opening and seed dissemination. At this point, pine cones and yellow cedar seeds are only partially developed. Fertilization (in pines) and final development occurs during spring and summer of the following year, after which seeds are disseminated.

Cone and seed maturation

Seeds of most conifer species begin to disperse soon after the cones are fully mature. Therefore, the collection period is liable to be brief, and it is important to determine when cones are sufficiently ripe for collection. There are few rigid rules for determining this, since much depends on the varying environmental conditions under which they develop and upon inherent differences among species and individuals within a species. Consequently, cones on some trees in a stand may ripen 7 to 10 days ahead of others; ripeness also varies within a crown, depending upon aspect and height.

The most commonly used indicators of ripeness are physical conditions of the cones and seeds. Ripening is often accompanied by recognizable changes in size, color and texture of the cones and seeds. For example, cone color can be quite a useful index in Douglas-fir, the cones of which are generally considered ripe enough to collect when they begin to turn from green to yellowish-brown. Other indices have been developed for certain species. For instance, since cones lose water as they ripen, marked changes in specific gravity may be observed. Once the relationship between seed maturity and the specific gravity of the freshly-picked cone has been established, testing for ripeness is easily done by floating the cones in a liquid of the appropriate density. Measurable chemical changes also occur as the cones ripen and, in some instances, biochemical indices of ripeness have been established; the reducing sugar content of the seeds has been shown by Rediske (1961. For. Sci. 7: 204-213) to be a good maturity indicator for Douglas-fir. Such tests require laboratory facilities but may be of use when large seed collections are planned for a species in any one area.

Unfortunately, specific gravity or biochemical indicators have not been adequately tested to recommend them for use in B.C. The best available method for judging seed ripeness in this province is the seed cutting test (see page 22). As conifer seeds ripen, the seed contents, i.e. the ***embryo*** and ***endosperm***, change from a milky viscous condition to a firm consistency similar to the meat of a coconut. The embryo, which frequently becomes a straw-yellow color in most species, increases in length and this may be relied upon as a general ripeness index. In the cutting test, the seeds are sliced in half and the presence of an embryo, and its length, are observed. For most conifer species in British Columbia, cones cannot be considered mature enough to collect unless the majority of the embryos occupy at least 75% of the length of the cavity within the endosperm. This stage of development usually precedes seedfall by 2 to 4 weeks.

Seed dispersal usually begins soon after the cones are mature, and continues throughout the fall and early winter months and, sometimes, into the following spring. In amabilis fir, grand fir and alpine fir, the seeds are shed very soon after maturation as the cones disintegrate rapidly on the tree. For most of the pines, seeds are shed within a few days to a few weeks after cone maturation; the major exception is interior lodgepole pine, the cones of which usually remain closed on the tree for several years after the seeds are fully mature. Such cones are termed ***serotinous*** and their seeds are not released until the cones have been subjected to the high temperature of a fire or dried in a cone kiln. (This feature is of significant help to the forest manager because it removes the uncertainty as to whether cones will be available for collecting and enables collections to be conducted over an extended period.)

Impediments to cone and seed development

Just as biological processes may lead to a cone crop, biological agents or weather may intervene. The following is a brief consideration of impediments to cone and seed development.

Each spring, buds are laid down on the growing branches and twigs of conifers. Most of these buds are destined to open the following spring to produce more twigs or branch segments — or perhaps to produce pollen cones or seed cones. When first laid down, they are undetermined; that is, they may develop into either vegetative or reproductive buds. By midsummer, however, conditions have determined whether they will become vegetative buds or male or female reproductive buds. The factors that determine the type of bud that develops are not understood but weather patterns and tree nutrition are thought to be involved. Thus, adverse weather during the period of bud determination may be regarded as potentially the first impediment to cone and seed development. Should conditions favor the formation of reproductive buds, adverse weather such as drought, frosts or extensive rain during the pollination period may yet impede the development of a good cone crop. If ovules are not fertilized because of pollination failure or other impediment to fertilization, normal seeds will not develop.

Insects may also destroy or damage developing cone crops. Some insects lay their eggs within the reproductive buds; others attack the seed cones, and still others lay eggs in the fertilized ovules. Insects that attack reproductive buds and seed cones may cause cone abortion, whereas those that attack the developing

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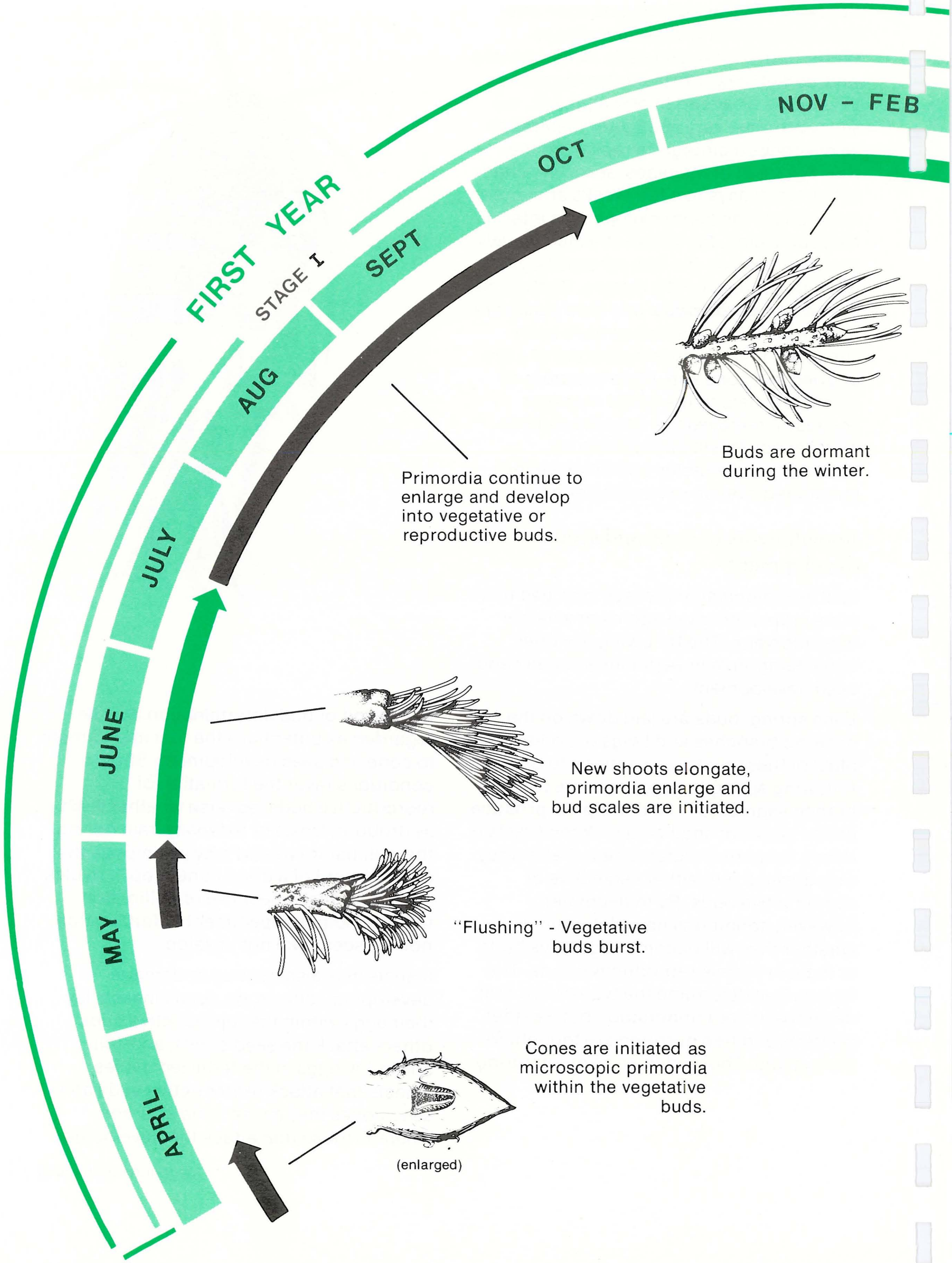
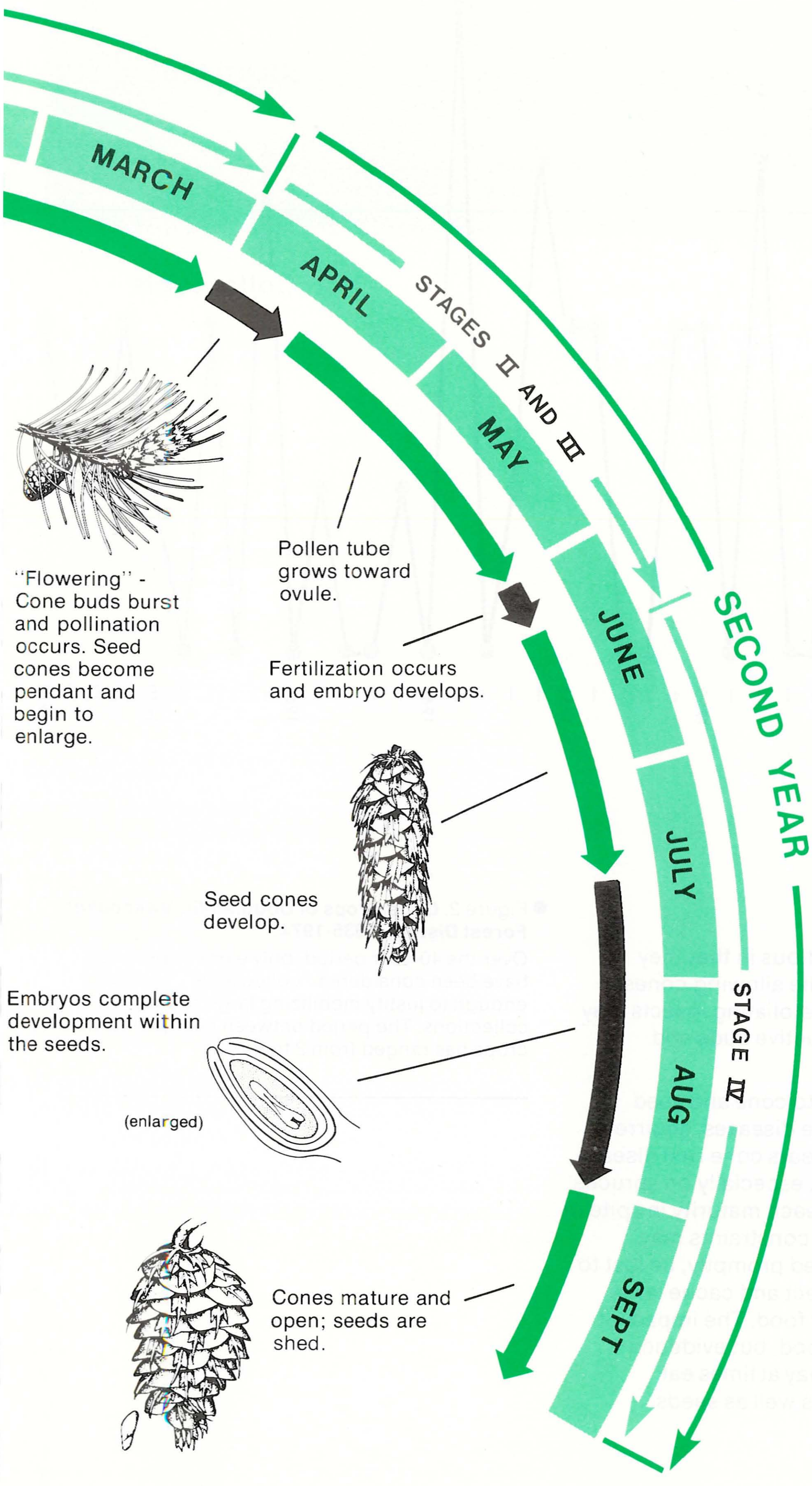
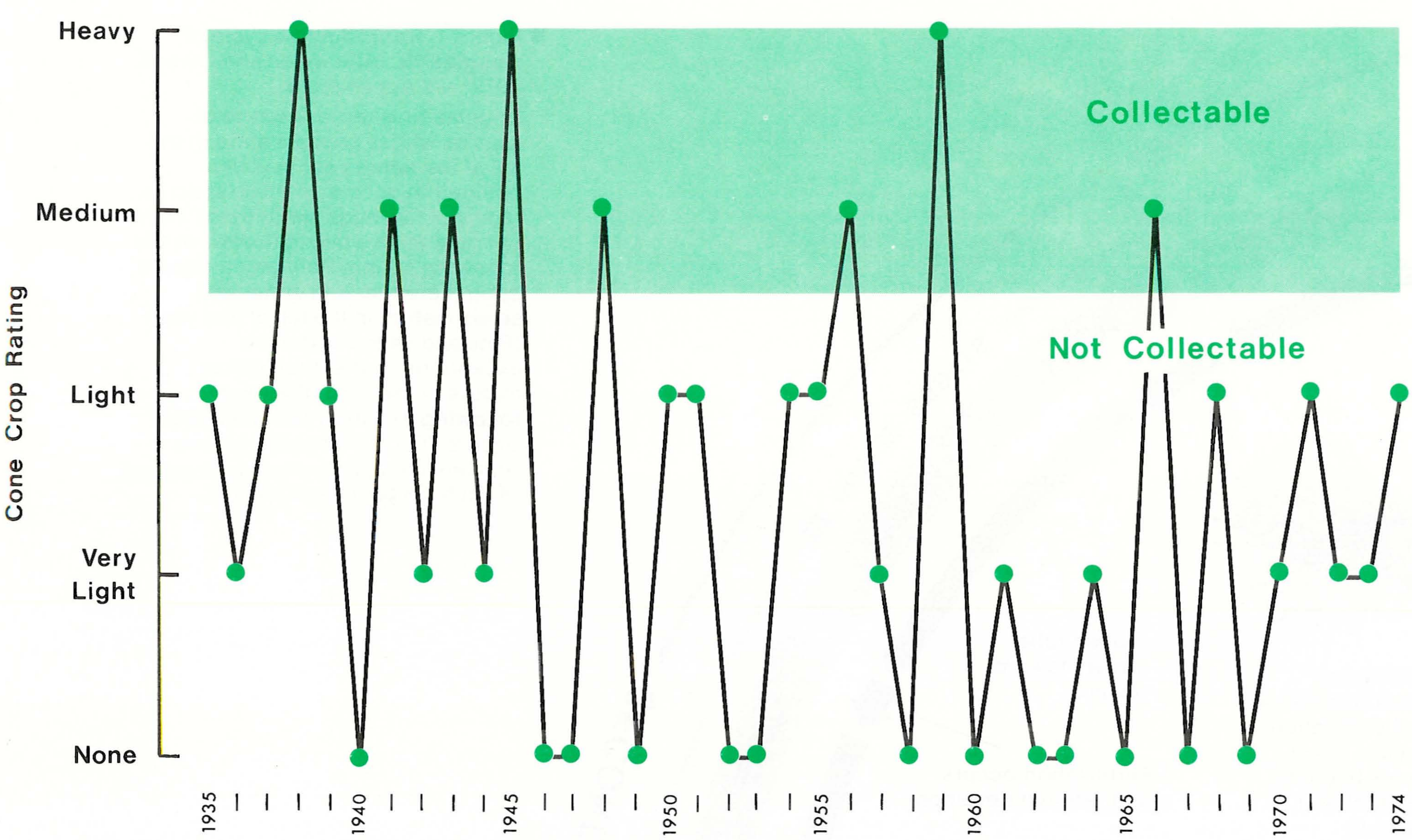

FIRST YEAR
STAGE I
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV - FEB
Buds are dormant during the winter.
Primordia continue to enlarge and develop into vegetative or reproductive buds.
New shoots elongate, primordia enlarge and bud scales are initiated.
"Flushing" - Vegetative buds burst.
Cones are initiated as microscopic primordia within the vegetative buds.
(enlarged)



● Figure 1. **Reproductive cycle of Douglas-fir.** (After Allen and Owens. 1972; see Appendix IX).

Douglas-fir is representative of species whose cones mature in the fall **of the same year** in which pollination occurs. In these species, reproductive buds are initiated in the spring and give rise to flowers in the following spring. Pollination occurs soon thereafter and cones and seeds mature in the fall of that year. (Pine and yellow cedar are exceptions, in that their cones mature in the fall **of the year following** that in which pollination occurs.) On the diagram, arrows indicate the approximate time period of each stage of development.



(continued from page 5)

seeds are more insidious in that they destroy the seed while allowing cones to develop normally. Defoliating insects may also destroy reproductive buds and developing cones.

Other impediments to cone and seed development include diseases, squirrels and birds. In some years cone rust disease may be quite severe, especially on spruces. Finally, cones that reach maturity in spite of the aforementioned constraints may, unless they are picked promptly, be lost to squirrels which collect and cache large quantities for winter food. The impact of birds is not understood, but evidence suggests that they may at times eat reproductive buds as well as seeds.

● Figure 2. **Cone Crops of Douglas-fir, Vancouver Forest District, 1935-1974.**
Over the 40-year period, only eight cone crops have been considered "collectable", i.e. heavy enough to justify mobilizing large scale collections. The period between collectable crops has ranged from 2 to 8 years.

Periodicity

We see then that trees do not produce bountiful cone crops every year and in some years produce no cones at all. This year-to-year variation in cone crops is termed ***periodicity***. Cone crop periodicity results from a combination of interacting factors, including weather conditions, damaging agents and internal mechanisms. Most trees exhibit this phenomenon, although its extent and "period" may vary considerably from one species to another. For example, over a 40-year period only eight Douglas-fir cone crops in the Vancouver Forest District have been considered collectable, i.e. heavy enough to justify mobilizing large-scale collections — and the period between them has varied from 2 to 8 years (Figure 2). Abundant spruce crops occur about once every 6 years in the interior of the province.

Periodicity also varies from one region to another and even within regions. In any year, the cone crop of a particular species may be heavy over a broad region — or it may be non-existent. But in either case, local exceptions may be found. It is not uncommon for moderate to heavy crops to occur in a given drainage or on a particular slope when there is generally a poor to nil crop.

Planning and Pre-organization

Planning

Reforestation planning must encompass tree seed procurement and ensure that adequate and continuous supplies of seed of appropriate species and ***provenances*** are available to sustain the reforestation program. Such overall planning is the responsibility of the Reforestation Division, although it depends on inputs from Forest Districts and the forest companies. At this level of planning, considerable attention is devoted to assessing potential cone crops throughout the province. When a potentially collectable crop materializes, planning at the District level is actuated to monitor and, later, to evaluate the crop. As the prospect of a collectable crop is confirmed the District establishes cone collection quotas and selects primary and alternate collection areas. Quotas, based on requirements derived from annual seed inventory data provided by the Reforestation Division, are established by species, ***seed zone***, elevation and intended use of seed (e.g. routine seedling production, direct seeding, research, etc.). At this stage, planning passes to the Ranger District level and merges with pre-organization activities (see page 27).

Determination of seed and cone requirements

Since seed must be collected to provide for planting or direct seeding, it follows that reforestation projections are the first step in determining seed requirements. For each seed zone and elevation (Figure 3), the planner must have reliable projections of the area to be planted or seeded annually to each species. He may then determine his annual seed requirements by species and provenance. Consider the following computations for a single provenance of, say, white spruce:

Metric	Imperial
1) Area to be planted annually 1000 hectares	1) Area to be planted annually 2500 acres

The area to be planted derives from reforestation projections which take account of backlog N.S.R. (Not Sufficiently Restocked) and area cut annually. In planting this area, the silvicultural prescription may call for a spacing of

Metric	Imperial
2.5 metres, which requires 1680 trees per hectare. Thus,	8 feet, which requires 680 trees per acre. Thus,
2) Trees per hectare = 1680	2) Trees per acre = 680
3) Annual seedling requirement (1000 x 1680) = 1 680 000	3) Annual seedling requirement (2500 x 680) = 1,700,000

Nursery experience has indicated that, on the average, 3 ***viable*** seeds are required to produce a plantable white spruce seedling. So,

Metric	Imperial
4) Number of viable seeds required annually (3 x 1 680 000) = 5 040 000	4) Number of viable seeds required annually (3 x 1,700,000) = 5,100,000

The number of viable seeds in a specified volume of cone varies greatly according to species and, within a species, from crop to crop. Average yields (see Tables 8 and 9) are

Metric	Imperial
183 900 viable seeds per hectolitre of white spruce cones. Therefore,	66,900 viable seeds per bushel of white spruce cones. Therefore,
5) Volume of cones required annually (5 040 000 ÷ 183 900) = 27.4 hl	5) Volume of cones required annually (5,100,000 ÷ 66,900) = 76.2 bu

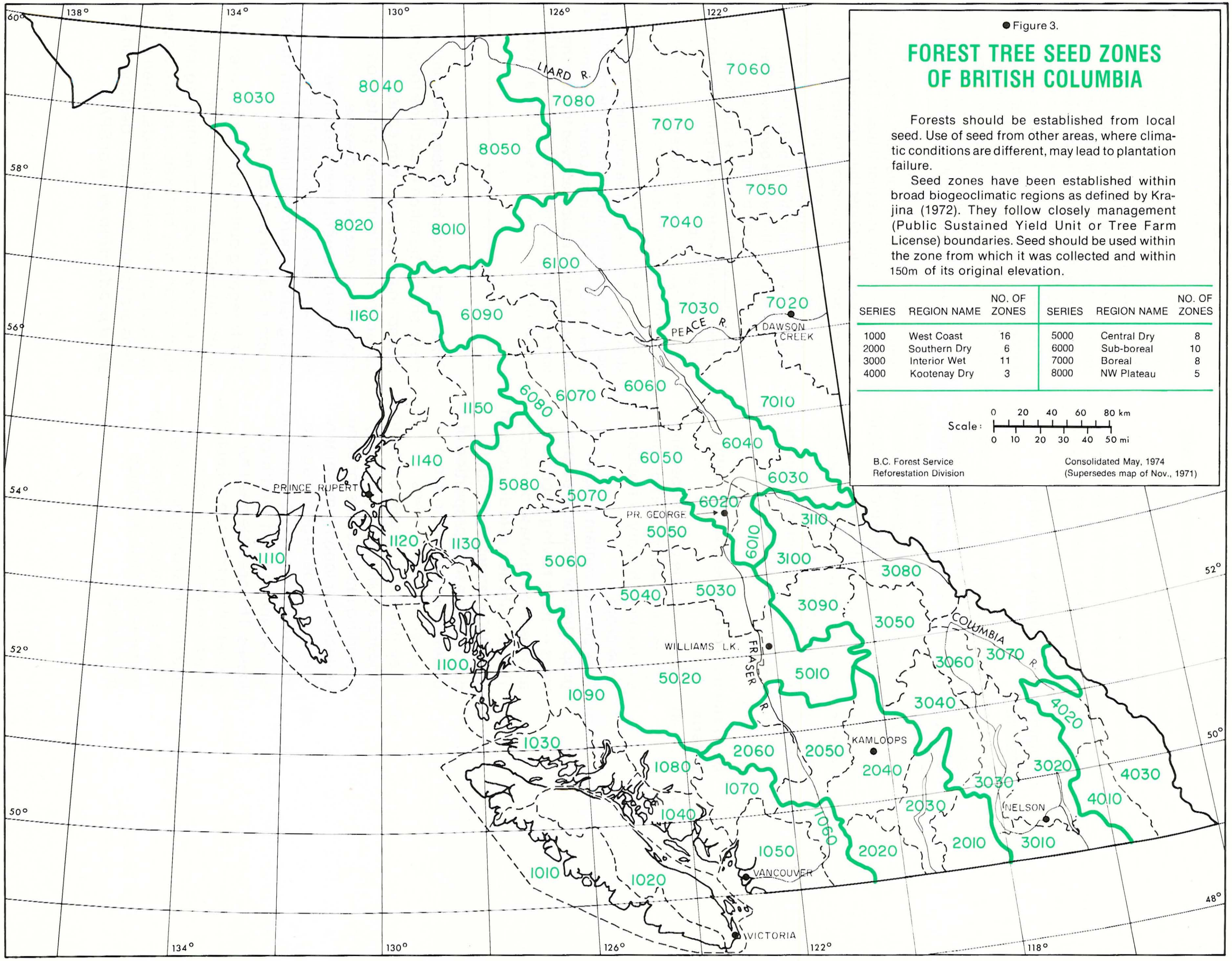
Thus, given our previous assumptions, we have determined that about

Metric	Imperial
27 hectolitres	76 bushels

of cones of our particular provenance will be required annually. However, since the planner cannot expect to collect cones year by year as they are needed, he must collect enough cones and store seeds when they are available to meet his needs until another collectable crop materializes. The number of years' supply to be acquired in the anticipated collection will depend on such factors as the periodicity of the species, the seed storage life and seed stocks on hand. If we suppose that a 15-year supply of seed is required of our hypothetical collection, we can carry our computations one step further:

Metric	Imperial
6) Total volume of cones required (15 x 27) = 405 hl	6) Total volume of cones required (15 x 76) = 1140 bu

In the above computations, the 3 viable seeds required to produce a plantable seedling and the number of viable seeds in a volume of cones (183 900 per hectolitre or 66,900 per bushel) are current averages. These data are revised as additional information becomes available. Also, more accurate data may be available for particular provenances and seed zones. It is important that the planner apply the most applicable data available in determining seed and cone requirements. The same computational steps should be followed to determine the annual seed and cone requirements for planting smaller or larger areas, at closer or wider tree spacings.
To determine seed and cone requirements for direct seeding, the planner must first establish the area to be seeded and the amount of seed to be applied per hectare; cone requirements may then be calculated on the basis of data in tables 8 and 9. (For guidance in determining amount of seed to be applied to an area, see 1) Clark, M.B. 1971. Direct seeding experiments on an operational scale. BCFS Research Div. 17 pp. and 2) Reforestation handbook for Region No. 6. USDA Forest Service, Portland, Oregon.



● Figure 3.

FOREST TREE SEED ZONES OF BRITISH COLUMBIA

Forests should be established from local seed. Use of seed from other areas, where climatic conditions are different, may lead to plantation failure.

Seed zones have been established within broad biogeoclimatic regions as defined by Krajina (1972). They follow closely management (Public Sustained Yield Unit or Tree Farm License) boundaries. Seed should be used within the zone from which it was collected and within 150m of its original elevation.

SERIES	REGION NAME	NO. OF ZONES	SERIES	REGION NAME	NO. OF ZONES
1000	West Coast	16	5000	Central Dry	8
2000	Southern Dry	6	6000	Sub-boreal	10
3000	Interior Wet	11	7000	Boreal	8
4000	Kootenay Dry	3	8000	NW Plateau	5

Scale: 0 20 40 60 80 km; 0 10 20 30 40 50 mi

B.C. Forest Service
Reforestation Division

Consolidated May, 1974
(Supersedes map of Nov., 1971)

Reserving seed stands

Current tree improvement programs will not contribute substantially to seed requirements within the next 20 years. Therefore, the bulk of seed required for reforestation over the next two decades must be obtained from natural stands. To ensure that the best quality seed is obtained, ***seed stands*** should be reserved.

The size and number of seed stands, their species and general locations depend on seed production estimates and projected reforestation needs. As a general rule, seed stands of locally important species should be established at appropriate elevations in every seed zone where substantial reforestation is expected over the next 20 years. Alternative stands should be reserved to ensure collection areas in the event of local variation in cone crop intensity.

Seed stands should meet the following criteria:

a) They should be of cone-bearing age and located on a productive site having a history of frequent cone crops.

b) They should contain a high proportion of desirable parent trees — trees having good form and free from disease or insects.

c) They should be a safe distance (at least 300 metres) from stands containing a high proportion of undesirable parents to avoid pollination by such trees.

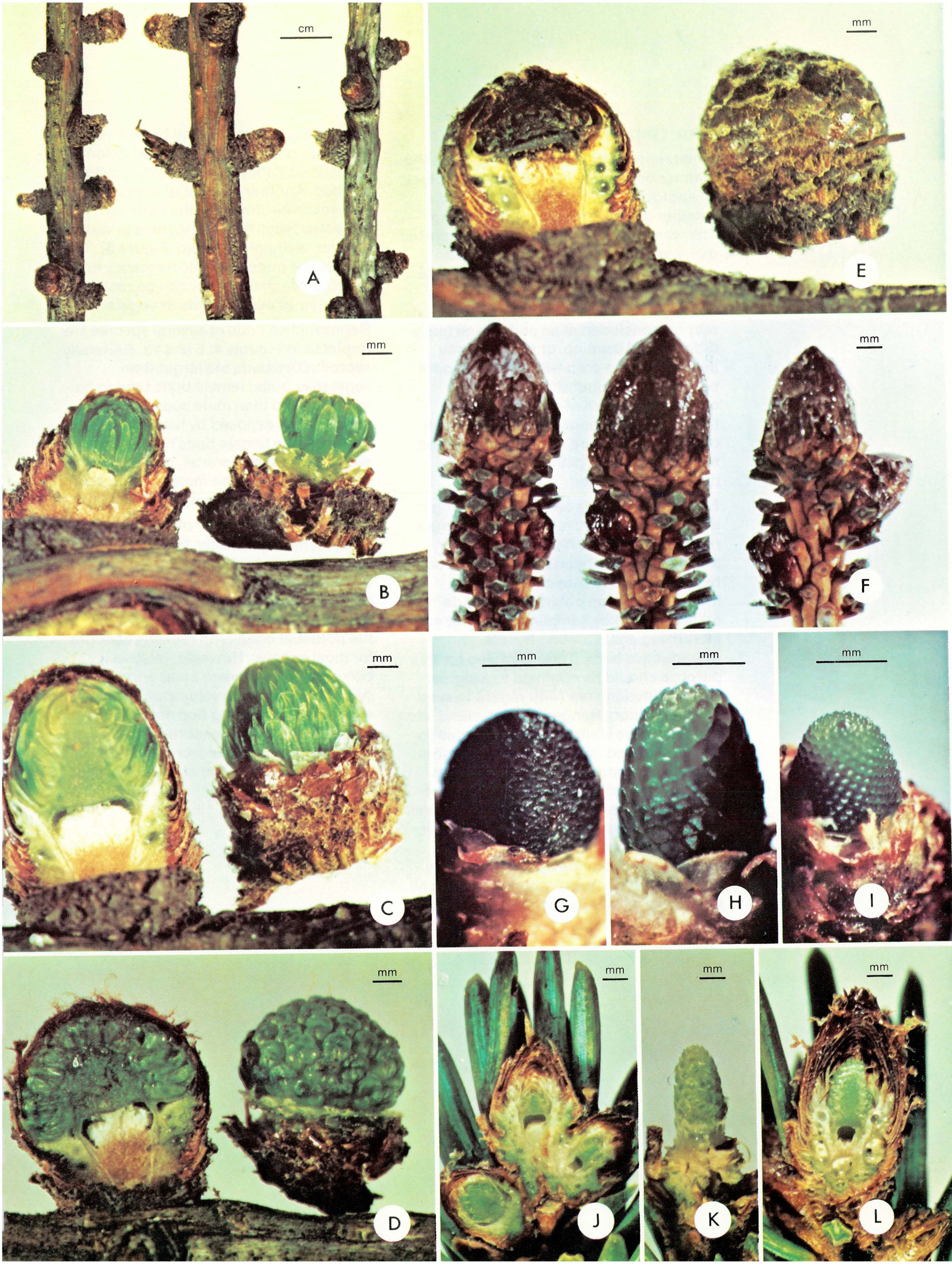
d) They should be located on flat to moderately sloping topography providing ready access for cone collection or logging machinery.

e) They should be large enough to meet anticipated cone collection quotas and to resist windthrow losses. The possible need for partial felling for cone collections must also be considered in establishing stand size. In any event, they should be at least two hectares in size to minimize inbreeding.

● Figure 4. **Reproductive and vegetative buds.**
A-E. *Larix occidentalis* (western larch) buds in January. A. Twigs showing winter buds: left, male; middle, female; right, vegetative. The vegetative bud is small and rounded; the female is the largest bud and is football-shaped, while the male is intermediate in size and is dome-shaped. B-D. Buds sliced vertically in half to show internal structure (left); bud scales have been removed from the sliced-off portions (right). B. Vegetative bud, with its artichoke-like appearance. C. Female bud, with its conical core and long overlapping bracts. D. Male bud, with its raspberry-like appearance. E. Male bud destroyed by an insect; intact bud scales on the sliced-off portion give no indication of the internal condition of the bud.
F-I. *Picea sitchensis* (Sitka spruce) buds in January. F. Exterior of male (left), female (center) and vegetative (right) buds. The male bud, only slightly longer than the vegetative bud, is wider and more rounded. The female bud is the longest, widest, and most pointed. G-I. Bud scales removed to show structure of male (G), female (H) and vegetative (I) buds. The male bud is dome-shaped; the female bud resembles a miniature cone, with its spirally-arranged cone scale primordia; the vegetative bud shows smaller, spirally arranged leaf primordia and the shoot apex at its tip.
J-L. *Picea glauca* (white spruce) buds in April. J. A terminal vegetative bud (center) and two sub-terminal male buds, sliced to show internal structure. In the vegetative bud, the primordia occupy a relatively small volume; the male buds show the characteristic raspberry-like form. K. A female bud with scales removed to show the spirally-arranged cone scale primordia and its overall football shape. L. A sliced female bud.

Once seed stands have been selected, steps should be taken to exclude logging (except in conjunction with cone collecting) and to intensify protection against fire, insects and disease. Undesirable parent trees should be removed. Seed stands should be designated in pertinent files and on status maps in Ranger District offices.

The foregoing outlines the procedures for reserving seed stands. Additional silvicultural steps, such as thinning and fertilization, may be taken to enhance cone production in reserved stands. When such steps are taken, the stand is designated as a ***seed production area*** or SPA.


cm
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Cone crop forecasting

When reproductive buds have formed, the planner or cone collection supervisor may, by appropriate sampling, determine whether a **potential** crop is developing. The word potential is stressed because the many impediments to cone and seed development may at any stage cause the reproductive structures to abort or may destroy the maturing seeds. As a result, it may be concluded at an early stage that a crop will **not** develop, or that one **may** develop. That a crop **will** develop cannot be determined until shortly before collection. Nevertheless, early crop forecasting and periodic evaluation of a developing crop are of great value to the forest manager in planning the cone collection operation.

Early forecasting is based on sampling to determine the relative numbers of female reproductive buds. Although specific procedures have been developed for only two B.C. conifers (Appendix V), an indication of crop potential can be derived for any conifer by sampling branches and identifying and counting female reproductive buds. Trees sampled for this purpose should be confined to a logical cone collection area (with regard to seed zone, elevation, Ranger District, stand, etc.) and should be limited to those eligible for cone collection (see page 30). Until more specific procedures are developed, ten well-distributed, representative trees are considered a minimum sample for a stand. Three branches should be collected from each tree; depending on species, these should come from the upper crown only (e.g. as in spruces and true firs) or from all levels (e.g. as in Douglas-fir, hemlocks and cedars).

Depending on species and time of year, female buds may be recognized externally; sometimes it may be necessary to section the bud. Another method of identifying bud type involves "forcing" the buds on collected twigs by placing them in water in a warm, well-lighted room (Figure 6). This causes the buds to break dormancy and open, at which time they can be readily identified as male, female or vegetative.

Reproductive buds of several species are depicted in Figures 4, 5 and 13. Generally, reproductive buds are larger than vegetative buds; female buds tend to be more pointed than male buds. When sectioned or exposed by having scales removed, the female buds have a structure suggestive of the cone as, indeed, they are primordial cones; the male buds more typically resemble miniature raspberries.

The greater the number of reproductive buds or, more precisely, the greater the ratio of female buds to vegetative buds, the better the potential cone crop. Unfortunately, the quantitative relationship between female bud counts and "size" of the potential cone crop remains obscure for most species. However, relative comparisons (between areas and years) can have immediate value and, with experience in relating bud counts to cone crop ratings, the procedure described may be honed into a useful technique for forecasting cone crops of any important B.C. conifer.

Table 1. Cone crop ratings and criteria.

Crop rating		Criteria
None	1	No cones on seed trees*
Very light	2	Few cones on less than 25% of seed trees
Light	3	Few cones on more than 25% of seed trees
Medium	4	Many cones on 25-50% of seed trees
Heavy	5	Many cones on more than 50% of seed trees

* Seed trees are upper story (dominant and co-dominant) trees.

Cone crop rating

There is no point in forecasting or assessing cone crops unless a reliable method exists to express the "size" of the crop. The system used for rating crops is a numerical classification developed in California; it is based on visual observations of tree crowns and subjective assessments of the relative amount of cones in the crowns. This system is now commonly used throughout the Pacific Northwest. The person carrying out the examination merely walks through the stand observing the volume of the **current year's** cones on a number of well-distributed, representative dominant and co-dominant trees. To ensure best possible visibility, the observer should stand with the sun to his back. Findings are interpreted according to Table 1.

"Few cones" and "many cones" are subjective determinations based on species and local experience. For example, 80-100 cones on a white pine or true fir would probably be classed as "many", while this number of cones on a mature spruce or Douglas-fir might go unnoticed. While thousands of cones might constitute "many" on a spruce tree, the same numbers might be classed as "few" on a mature cedar. In developing judgments of few and many cones, attention should be confined to that part of the crown which might be expected to bear cones. In white pine and true firs, this is limited to the top 4 or 5 whorls of branches; in spruce and Douglas-fir, the upper two-thirds of the crown should be considered potentially cone-bearing, and in cedars and lodgepole pine, cones may be found over the entire crown. As a general rule, the fewer the cones, the more likely they are to be confined to the upper crown. Finally, an experienced observer might note that in crowns bearing numerous cones, the branches often seem to sag under the unaccustomed weight.

Generally, medium and heavy crops (rating 4 and 5) are collectable. Obviously, the more trees observed, the greater will be the reliability of the rating. Two common errors in rating cone crops are 1) taking account of old cones that have shed their seeds, and 2) evaluating roadside trees which, because of their increased exposure to sunshine, often bear more cones than those within the stand.

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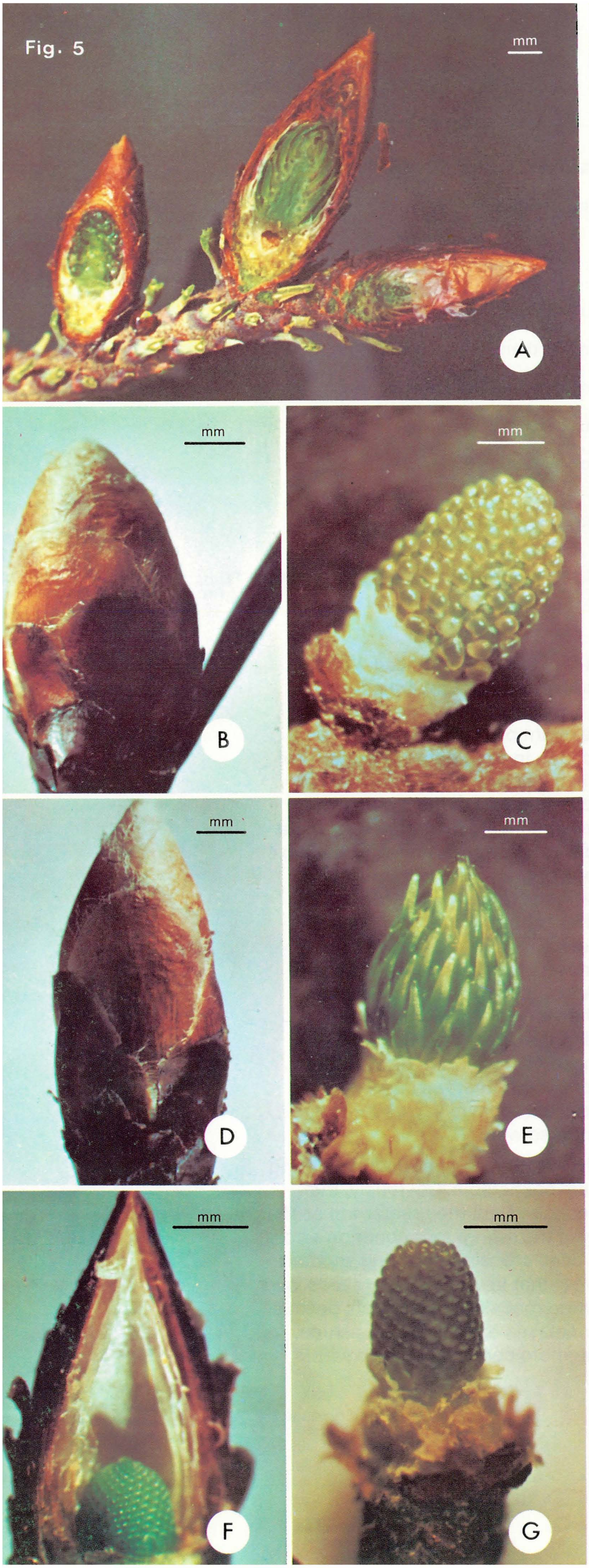
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● Figure 5. **Reproductive and vegetative buds of Douglas-fir.**

A. Twig bearing male (left), female (center) and vegetative (right) buds in January. Half of each bud has been sliced off to reveal the internal structure. The male bud, located well below the terminal, shows the characteristic raspberry-like form. The large, pointed female bud in the subterminal position, shows the conical core and prominent bracts. B. An intact male bud with typical egg-shaped appearance. C. A male bud with scales removed. D. An intact female bud. E. A female bud with scales removed to show the long, pointed bracts. F. A vegetative bud (in April) with half the bud scales removed to show the vegetative shoot tip with its spirally-arranged leaf primordia. The primordia occupy a relatively small portion of the volume enclosed by the bud scales. G. A vegetative bud with all scales removed.

● Figure 6. **Forcing Douglas-fir buds for identification.**

A. Twigs placed in water in a warm, well-lighted room to hasten bud development. B. Swollen buds after 2 weeks of forcing. C. Pollen cones just after bud burst. D. Seed cone just after bud burst; the long, pointed bracts give it a feathery appearance. E. Close-up of pollen cone showing sac-like structures (microsporangia) containing the pollen. F. Close-up of a receptive seed cone.

Crop rating is done early in the summer (July) when cones are readily visible on tree branches. All areas in which good female flower crops were previously reported should be re-visited with the objective of determining the extent of the cone crop and the anticipated yield. By doing so, primary and alternate collection areas can be selected on the basis of stand quality, quotas to be met, location with regard to future needs and other factors.

Rating will, of course, refer only to one species; separate ratings should be made for additional species. Cones may be examined for evidence of insects and disease, but the main objective at this time is to rate the size of the crop and compare potential collecting areas.

In addition to rating the intensity of the cone crop, the observer may wish to estimate the yield to determine if a collection quota can be met. A technique devised in Great Britain for true firs, Douglas-fir, spruce and pine (Seal, Matthews and Wheeler. 1962. Gt. Brit. Forest. Comm., For. Record 39) may be used:

> From the base of the tree, pace out a distance on the ground, roughly equal to the height of the tree. Use 6X (or 8X) binoculars to count visible cones, then multiply by 4 to estimate number of cones on the tree.

Or, for Douglas-fir, a system developed by Winjum and Johnson (1962. Weyerhaeuser Co., Forest. Res. Note 46) may be employed:

> Locate a position on the south side of the tree affording a clear view of the crown. Using binoculars, count the cones on one branch in each whorl, then determine estimated number of cones using the following equation:
>
> $$y = 7.76x - 253$$
>
> where y = total number of cones per tree (± 300)
> and x = sum of branch counts.

Knowing the number of cones per tree and the number of acceptable cone-bearing trees per hectare, the observer can estimate cone yield. Not all cone-bearing trees are acceptable (see sub-section on pre-selection of trees, page 30). In applying these methods, results should be averaged for at least 20 trees.

The Cone Crop Survey and Evaluation Form (F.S. 727) used by the Forest Service provides a good record of this rating examination and of the follow-up evaluation which is done in more detail (see page 18). Examples of a completed form are shown in Appendix VIII. At the time of crop rating, only the headings and the right-hand table are completed.

Once cone crop ratings have been applied to possible collection areas for the desired species, the planner will be able to assign collection priorities subject to the following evaluation of seed content (i.e. yield) from the cone crop.

Seed crop evaluation

While the rating of the crop tells us how many cones we can expect to get from one stand or area compared to another, the evaluation of the crop is meant to disclose how many seeds the cones contain, how good they will be and their progress toward maturity. The increasing costs of collecting cones, and the difficulty of recruiting collectors, make it imperative to verify that the developing crop will yield adequate amounts of high quality seed.

The seed crop evaluation involves observing the inside of seeds by slicing cones longitudinally, and by cutting extracted seeds. The importance of observing seed contents is demonstrated in Figure 7. No meaningful distinctions can be made among the seeds shown in Figure 7A, but an x-ray radiograph of the same seeds (Figure 7B) reveals crucial differences. Radiographic equipment is not normally available; therefore, a seed cutting test must be performed to determine seed quality (see page 22).

The evaluation for most conifer species should take place between the end of July and mid-August, after collecting priorities have been established. It involves the sampling of cones from a minimum of six seed trees well distributed throughout the stand and a detailed examination of nine cones from each tree. **The sample cones should be obtained from various aspects and levels throughout the cone-bearing portions of the crowns.** They may be sampled by climbing, by shooting branches off with a small-bore rifle, or from felled trees in an active logging area.

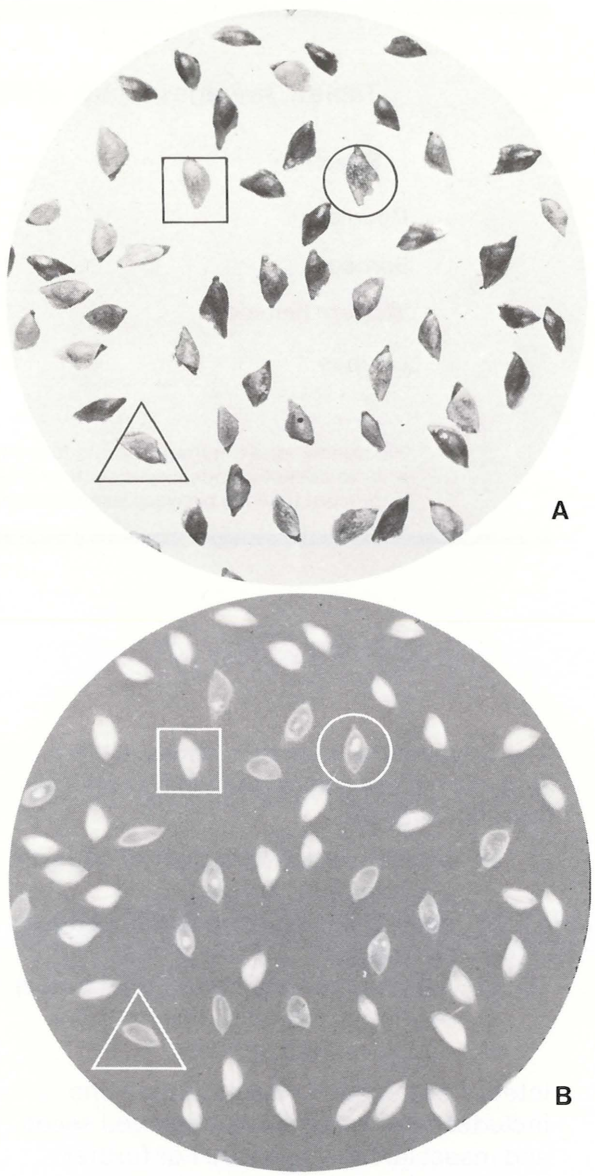
Seed crop evaluation and crop rating are jobs that can be done in conjunction with other field work; they need not require a special trip.

Sampled cones may be examined in the field or brought back to the office (provided they are carefully identified); they are sliced in half longitudinally along the cone axis with a sharp knife or cone cutting tool and a count is made of the exposed **filled seeds** in one half-section (Figure 8). The other half-section of each cone should be discarded and not counted. The half-section seed count provides a measure of the number of filled seeds in the cone. For example, Douglas-fir cones contain about three filled seeds for each filled seed revealed in the half-section. The average of the 54 half-cone seed counts indicates the potential seed yield from the stand and determines whether or not the cones are worth collecting. Table 2 shows average seed-count levels for medium and heavy cone crop ratings.

A different procedure is recommended for lodgepole pine cones. As these are very hard and difficult to section, it is easier to extract the seeds by dipping the cones in boiling water for 10 seconds, then placing them in an oven at 65°C for 3 to 4 hours. A minimum of 20 filled seeds per entire cone indicates a collectable crop. Filled seeds may be identified by crushing with the fingernail or with the point of a knife to reveal a firm, white endosperm (Figure 11). For lodgepole pine, average filled seed count per **entire** cone should be entered on Form F.S. 727.

In most cases, the seed crop evaluation will be the basis on which a final decision will be made regarding selection of collection areas. Therefore, it is important that some idea of the degree of seed maturity is acquired in order that a possible date may be set for collections to begin. A cutting test should be carried out on a sample of 20 to 30 seeds taken from several trees.

Insect damage to cones or seeds, as well as the presence of any cone diseases (mainly rusts), should also be assessed as part of the seed crop evaluation. Since these organisms affect the ability of the cone to produce good seeds, they affect yield and, therefore, become a factor in selecting areas from which to collect. If over 50% of seeds are damaged, collection is not worthwhile.



● Figure 7. **Photograph (A) and radiograph (B) of Douglas-fir seeds.**

Seed quality cannot be assessed from the photograph. However, the radiograph (or x-ray photograph) reveals filled seeds (white appearance □), empty seeds (white outline, grey center △), and seeds with insect larvae (○).

Table 2. Average number of filled seeds exposed per half-cone.

Species	Medium Crop*	Heavy Crop
Douglas-fir	5	7
Spruces	7	10
Western hemlock	3	4
Larches	6	8

*Recommended minimum counts for collectable crops. These figures are only applicable just prior to collection because insects or disease may further decrease counts if there is a significant time lag between examination and collection.

The presence of insects in cones is often (but not necessarily) signalled by external features such as:

a) premature browning of the cone as a whole or in patches
b) small holes on cone scales caused by boring
c) accumulation of boring dust (frass)
d) exudations of pitch-like material
e) disfigurement of cone

Interior evidence of insects in the cone includes bore holes, frass, damaged seeds and insect larvae (Figure 9). For further details regarding identification and significance of insects, the reader is referred to "Cone and Seed Insects of British Columbia" by A.F. Hedlin (1974. Canadian Forestry Service, Report BC-X-90).

All native spruces are subject to infection by cone rusts, fungi which derive their name from their characteristic orange-yellow spores produced in masses on the cone scales (Figure 10). Infected cones usually open prematurely and development of seeds ceases before they

(continued on page 24)

● Figure 8. **Counting filled seeds in sections of Douglas-fir cones.**
Cones have been sliced longitudinally and the numbers of sliced, filled seeds are being counted. Seeds that are empty, contain insect larvae or that have not been sliced, are not counted. In the half-cone being examined, at least six filled seeds are visible. Note the difference in color between the green cones in the upper left hand corner and the cone with the brown bracts and scale margins at lower right; this cone probably has reached a more advanced state of maturity.

● Figure 9. **Cut section of insect-damaged Douglas-fir cone.**
The Douglas-fir cone moth, *Barbara colfaxiana,* is responsible for the seeds missing from the dark-brown areas and the accumulation of frass and dust. Despite the damage, 5 or 6 filled seeds are visible at this stage.

● Figure 10. **White spruce cones infected by rust.**
Spruce cone rust *(Chrysomyxa* spp.) destroys seeds and causes premature opening of cones. Note the orange-brown masses of spores on the cone scales.

● Figure 11. **Crushing test for lodgepole pine seeds.**
Since lodgepole pine cones are difficult to slice in half, seeds must be removed from the cone and examined by crushing with the fingernail or with the point of a knife. Filled seeds (to right of knifepoint) are easily distinguished by their firm white endosperm tissue; empty seeds are hollow.

Fig. 8

Fig. 9

Fig. 10

Fig. 11

The seed cutting test

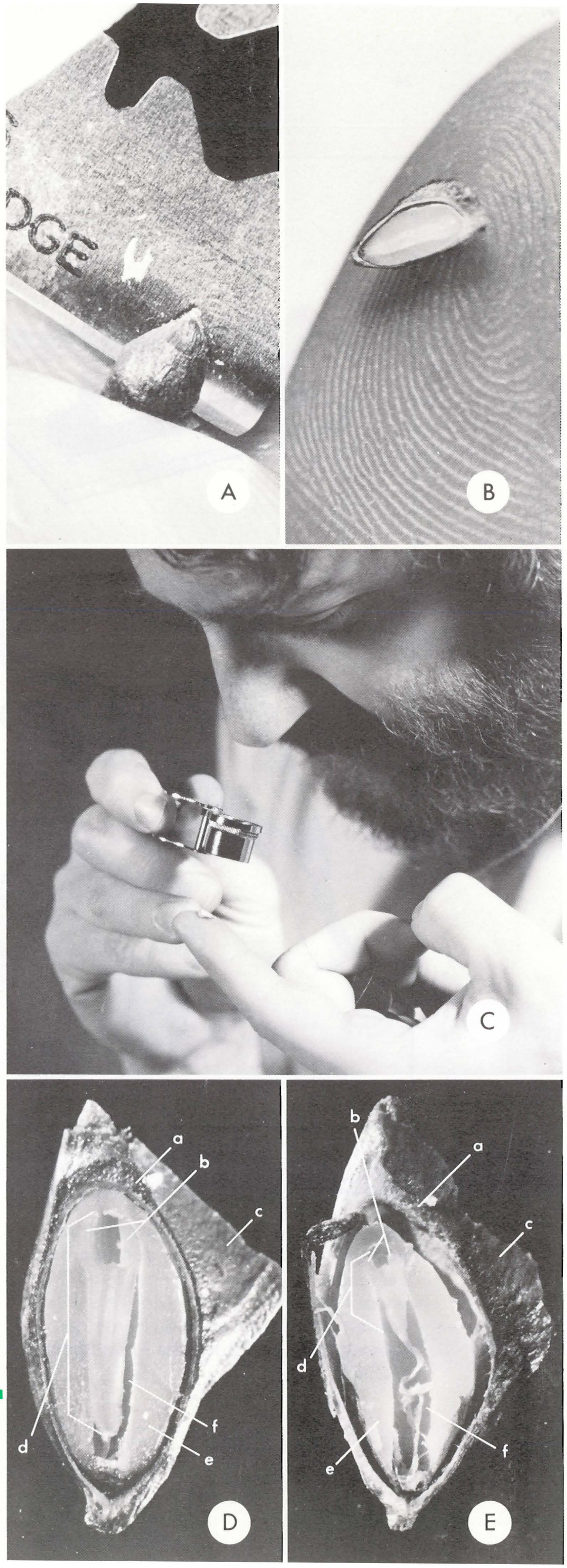
This test should be used with other indices of maturity to arrive at a tentative date to begin cone collection. (The cutting test should not be confused with the less exact procedure described on page 19 for evaluating lodgepole pine cone crops.)

In the cutting test, each seed is sliced **exactly** in half longitudinally with a razor blade or scalpel (Figure 12A, B). The contents of 20 to 30 filled seeds are then examined with a 10X hand lens (Figure 12C). Generally, as conifer seeds mature, their embryos elongate and become yellow in color, while the endosperm changes from a viscous milky condition to a firm consistency (similar to the meat of a coconut); the seedcoat and seed wing also darken in color. In most cases, embryos must have elongated to 75% of their potential length to assure seed viability. An embryo's potential length is the length of its cavity within the endosperm (Figure 12D, E). After picking, some further development, called "after-ripening", may occur.

The cutting test should not be made earlier than the final week of July, because up to this time unfertilized ovules may appear to be developing normally, i.e. they will contain endosperm and will appear to be filled. However, because they have not been fertilized, they lack embryos and cannot become viable seeds. Between late June and mid-July, most of these unfertilized ovules cease development and their endosperm tissue will shrivel. Therefore, by delaying the cutting test until after this period, the danger of inflating seed yield estimates by counting these unfertilized ovules will be avoided. The extent to which embryos in fertilized ovules have developed will also depend, in part, on the date at which the cutting test is made. At the beginning of August, embryos may not exceed 50% of their potential length and further checks are advised. Once the embryos begin to elongate past this stage, they usually do so rapidly and may reach 90% or more of full size within 2 to 3 weeks.

For most species, collection of cones can begin when the majority of embryos exceed 75% of the length of the cavity within the endosperm, and the endosperm is firm. A further check on seed ripeness can be obtained by leaving the sliced seeds uncovered overnight at room temperature. If the seeds are sufficiently developed, the embryo and endosperm will show little shrinkage and curling and will retain a relatively firm, fresh appearance. Considerable shrivelling and shrinkage away from the seedcoat indicates that the moisture content of the seed is still too high and that collection should be delayed. Mature and immature Douglas-fir seeds are illustrated in Figure 12D, E.

The duration of the collection operation must be considered when proposing the date to begin. A large collection that may require 10 days or more to complete should begin as soon as embryos achieve 75% development. This allows maximum time for the collection to be completed before natural seedfall begins. A smaller operation of 2 or 3 days' duration may be delayed for a week or so after embryos reach the 75% development stage.



● Figure 12. **The seed cutting test.**

A. Seeds must be sliced in half longitudinally with a sharp razor blade or scalpel. A pair of fine-pointed forceps may help in holding small seeds. B. A properly sectioned seed. C. The cut seed is carefully examined with a 10X handlens. D. A mature Douglas-fir seed with an embryo filling 90% of the length of its cavity; the endosperm is firm and shows no sign of separating from the seedcoat. E. An immature seed with an embryo occupying only 30% of its cavity. Only a short time after sectioning, the endosperm, although no longer in a viscous milky state, has begun to separate from the seedcoat.

Legend: a - ***seedcoat***; b - ***cotyledons***; c - seed wing (remnant of); d - embryo; e - endosperm tissue; f - cavity within the endosperm.

(continued from page 20)

become viable. Should cone and seed insects or disease show up during crop evaluation, the damaging agent and its impact should be determined. This is best carried out by the Canadian Forestry Service (506 West Burnside Road, Victoria, B.C. V8Z 1M5).

The information collected during the evaluation can be used to judge whether or not an area is suitable for collection and to compare probable collection efficiency and set priorities among a number of possible areas. The Forest Service Form F.S. 727 (Appendix VIII) illustrates how the information from the evaluation should be recorded. Data recorded on this form are also used to establish crop periodicity patterns.

Selection of collection areas

The distribution of collection areas must be based on requirements for seed of particular species and provenances. Within this constraint, selection of primary and alternate areas depends on seed crop evaluation data and other stand characteristics. If seed stands have been reserved (see page 12) and if an adequate crop is developing within them, they will be the likely choices for collection areas. In any case, the same criteria for selecting seed stands generally apply to choosing collection areas for a particular crop:

a) the areas must have an adequate density of well-formed trees of the required species bearing an acceptable seed crop
b) the trees must be climbable, or it must be feasible to fell the stand or selected trees
c) the prospective area should be accessible and should have flat to moderate topography

> Permission of the landowner is an absolute requirement in selecting cone collection areas; for Crown lands, a Forest Service permit is required (see Appendix IV).

> Collectors are warned that trees are not to be felled solely for the purpose of obtaining cones unless prior approval is obtained from the Chief Forester (see Division III of "Regulations" in Appendix III).

Cooperation and coordination between agencies

Bi-lateral cooperation between the Forest Service and other agencies planning cone collections is important and should be developed during assessment. In particular, licensees collecting cones for reforestation of Crown lands should advise appropriate Forest District headquarters of their plans. Cooperation will assist in:

a) locating and assessing collectable crops
b) coordinating collection planning
c) coordinating felling on active cutting areas and approved right-of-ways
d) organizing joint training sessions
e) coordinating picking activity through issuance of permits
f) planning of subsequent collections

Contact should also be established with agencies not involved in collecting cones. For example, right-of-way and other cuttings by private parties, B.C. Hydro, Department of Highways, Parks Branch or other agencies should be checked as possible collection areas. Advance notice of collections may be given to the local press; this may aid in the recruitment of pickers or result in a feature story that would promote local interest and good public relations.

Training agenda for cone collection supervisors

Day 1 - Classroom

1. Biology of cone production.
   Life cycles, regulating factors, periodicity, etc.
2. Fundamental importance of tree seed to the reforestation program.
   Sources and costs of tree seed, importance of quality, role of genetics, seed collection zones, registration system, etc.
3. Planning; establishment of collection quotas.
   Levels of authority and responsibility, etc.
4. Monitoring the cone and seed crop.
   Cone crop forecasting and rating, seed crop evaluation, the cutting test, seed maturity, etc.
5. Pre-organization.
   Selection and preparation of collection areas, general methods of collecting, pre-selection of trees, readying equipment and interim storage facilities, hiring and pre-orienting cone pickers, etc.
6. Safety and supervision.
   Safety "do's" and "don'ts", W.C.B. requirements, crew organization, techniques of supervision, etc.
7. Collecting and handling the cones.
   Collecting techniques, cleaning cones, cone volume determination, record keeping, filling and tying sacks, labelling sacks, temporary field storage, interim storage, shipping cones, etc.
8. Forms and reports.
9. Processing at the extractory (background information).

Day 2 - Field

A day in the field provides an opportunity to review and further demonstrate many of the points covered in the classroom.

1. Visit a nursery and progeny or provenance test plantations.
   To demonstrate the importance of geographic origin of seed and parent tree quality.
2. Visit one or more forest stands (bearing cone crops if possible).
   To demonstrate and practice crop rating, seed crop evaluation and pre-selection of trees. To discuss collection methods, safety practices and cone handling procedures.

Training of supervisors

The quality and quantity of seed collected and the efficiency of the collection operation will depend mainly on the competence of collection supervisors. It is, therefore, of the utmost importance that these persons be well-trained in all facets of the collection operation. To provide necessary training and updating, the Forest Service organizes periodic (generally every other year) training sessions. These are 1- or 2- day sessions, usually held at the Training School in Surrey. In addition, intensified training sessions should be held at appropriate locations 2 to 3 weeks in advance of significant cone collection operations. These pre-collection sessions are primarily intended for supervisors responsible for collecting cones for reforestation of Crown and private lands.

The periodic sessions and the pre-collection sessions will cover the same general topics, although the latter afford the opportunity to deal with specific techniques and problems relating to the imminent collecting operation. This guideline is intended to serve as a training manual for both. A generalized training session agenda is presented on page 26.

An important additional opportunity for training and improving future collection operations exists immediately after a cone crop has been harvested. At this time, cone collection supervisors and local forestry staff should meet to review the collection operation and to consider means of improving future collections. Suggestions having potentially more than local interest should be forwarded to Reforestation Division.

Pre-Organization

Both planning and pre-organization are preliminary to the cone collecting operation and each contains elements of the other. However, planning is "decision-oriented", while pre-organization is "action-oriented" and involves such activities as preparing collection areas, accumulating and readying equipment, arranging for labor and transportation and setting up interim cone storage facilities. Because of the necessity for carrying out collections efficiently in the short time that will be available, pre-organization must begin as soon as possible. Every conceivable detail must be considered and the necessary arrangements completed in advance so that the fullest possible energy and time can be devoted to collecting cones once the seeds are sufficiently mature.

Pre-organization activities can begin when it has been determined that there is a potentially collectable crop. Monitoring of the crop must continue, however, because even at this stage cones may be damaged or destroyed by a variety of agencies or factors. By this time (mid-August or earlier), quotas based on species, seed zone, elevation and intended use should have been set and collection areas selected. In some cases, collection areas may not have been selected and field staff will have to undertake a search for suitable stands within the zone(s) and elevations prescribed.

Examination and preparation of collection areas

Pre-organization essentially begins with a closer examination of proposed collection areas. Many subsequent decisions and activities will depend on the species and type of stand in which collections are to be made. During examination, the supervisor should consider his choice of collecting method (see sub-section on determination of collecting method, page 34). If the choice is for felling, he must consider related matters such as utilization of timber, sale arrangements and other logging details. The supervisor must also satisfy himself that the stand(s) has sufficient area and number of cone-bearing trees to meet prescribed quotas and must note the size and density of the cones as a basis for estimating labor requirements.

Although primary collection areas should receive emphasis, alternate areas should also be examined in case losses to fire, insect outbreak or loss of access render collection from primary areas impossible or inadvisable.

The supervisor must plan and implement the preparation of collection areas. This will include such activities as pre-marking selected trees for climbing or felling (see page 30), improving roads and skid trails for better access to and within the area, and cleaning out windfalls. In many cases, permits will have to be obtained before preparatory work can commence.

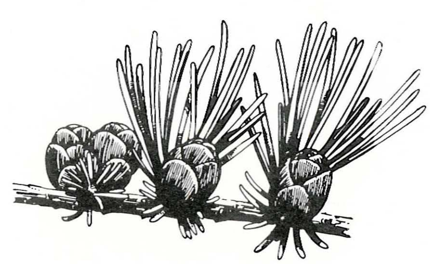
● Figure 13. **Reproductive and vegetative buds during winter.**

A-C. *Thuja plicata* (western red cedar). A. Vegetative shoot tips. B. Male buds. C. Female buds. Reproductive structures occur only at the tips of the current shoots.

D-F. *Abies grandis* (grand fir). D. Vegetative buds. E. Male buds clustered along the underside of the current shoots. F. Female buds on the upperside of the current shoots. These are 2 to 3 times as large as male buds.

G-I. *Tsuga mertensiana* (mountain hemlock). G. Vegetative bud. H. Two male buds on either side of a terminal vegetative bud. I. Two vegetative buds on either side of a terminal female bud.

J-L. *Tsuga heterophylla* (western hemlock). J. Vegetative buds. Note that pubescence (hairs) extends to the bud tip. K. Male buds. L. Female bud. These always occur singly at branchlet tips and are larger and more pointed than male buds. Both male and female buds are glabrous (smooth, not hairy) at the tip.



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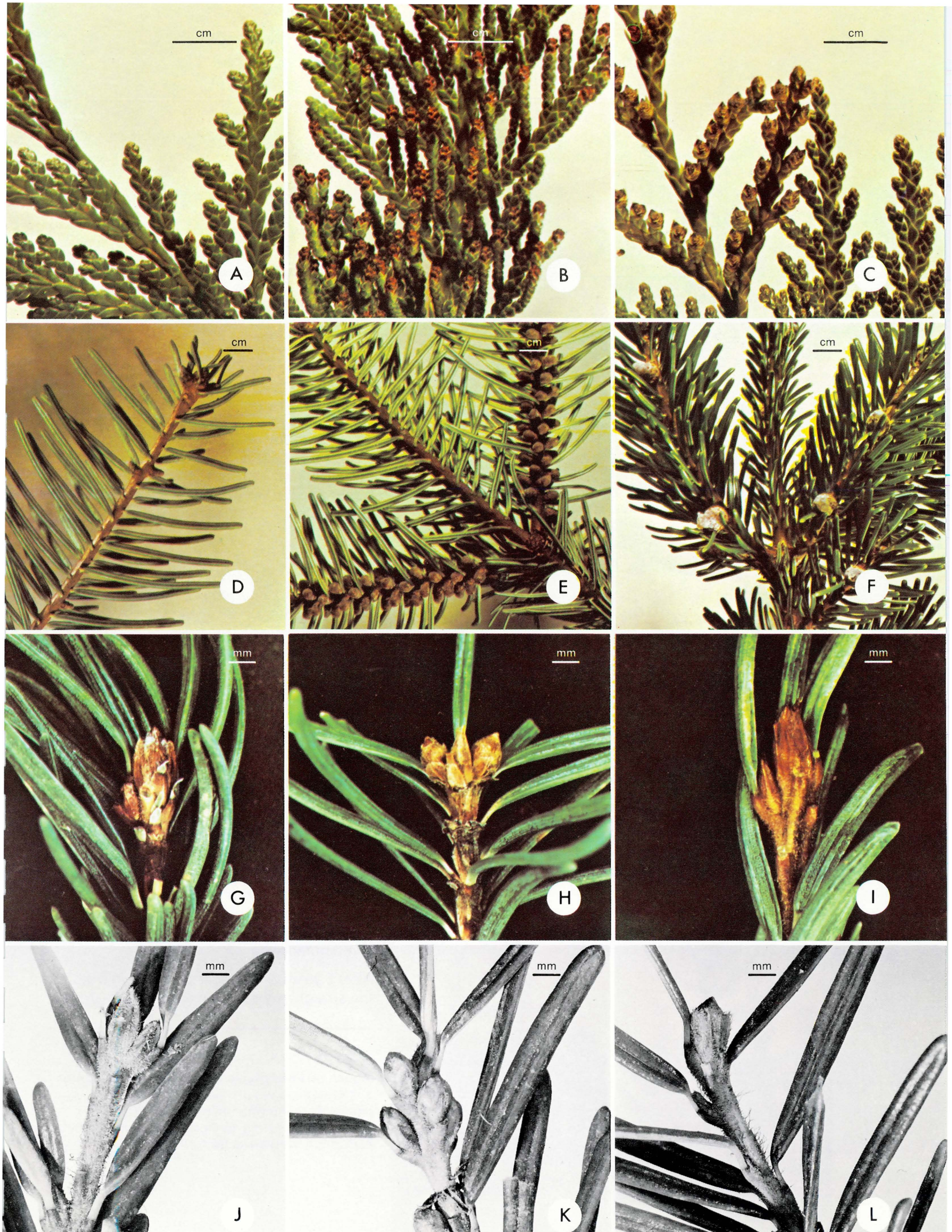
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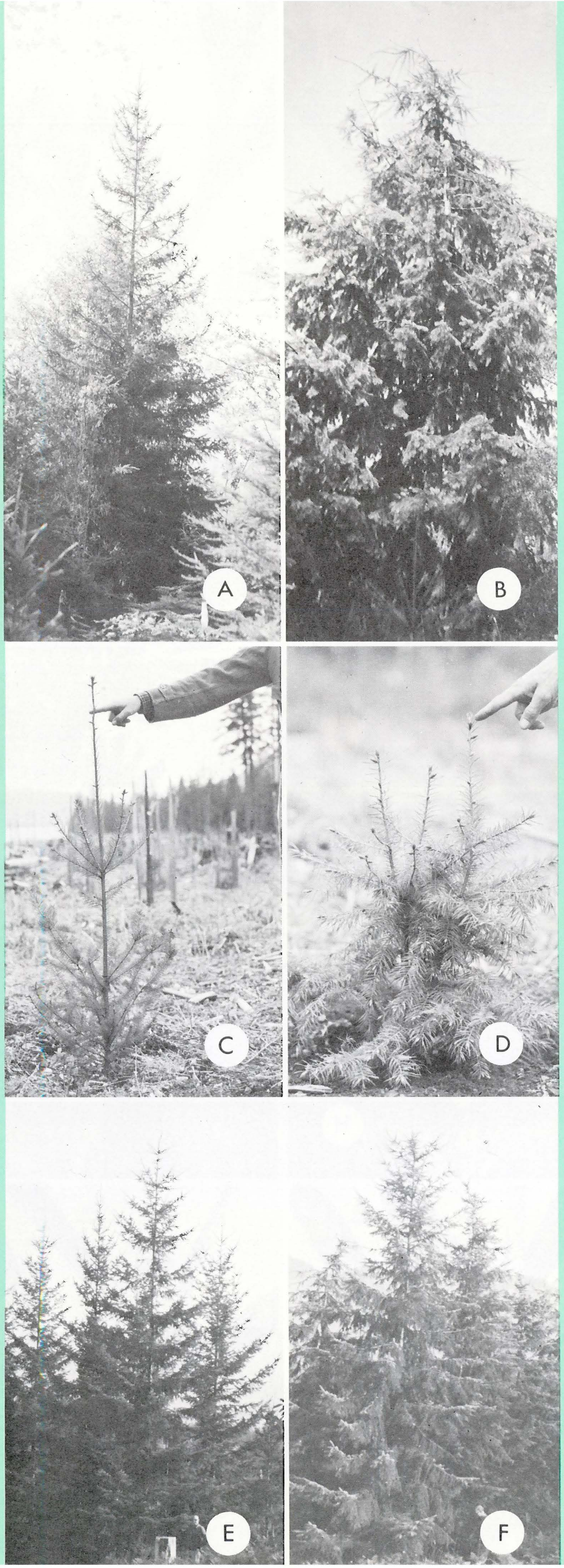

Pre-selection of trees

Trees of a given species vary markedly in shape, growth rate, branchiness and other characteristics that affect the quality of lumber or other products into which they may be made. These characteristics are collectively included in the ***phenotype*** of the tree. Cones should be collected only from trees of good phenotype, i.e. from trees having desirable characteristics, since genetics research has shown that many of these phenotypic characteristics are inherited. That is, seed from the "ugly-ducklings" of the forest produce similarly poor seedlings, while seed from trees exhibiting desirable characteristics are likely to produce seedlings having these same qualities.

Figure 14 (A-F), based on the work of Dr. A.L. Orr-Ewing (BCFS), illustrates the importance of selecting good phenotypes. Figures 14A and 14B show two 20- to 25-year-old Douglas-fir trees of markedly different phenotypes, growing within the same natural stand. The good phenotype (Figure 14A) shows rapid growth on a straight, single main stem that bears thin, straight, short branches. In comparison, the poor phenotype (Figure 14B) shows poor growth on a crooked stem that bears long, heavy, crooked branches. Branches of the good phenotype are swept upward, whereas in the poor phenotype they angle horizontally or downward. Cones were collected from both trees in the same year that the photographs were taken and, after extraction, the seeds were sown in the same nursery.

After 6 years, the seedling offspring from the straight-stemmed, well-shaped parent

Figure 14. **Phenotypic variation in Douglas-fir.** A. Good phenotype parent. B. Poor phenotype parent. C. Good phenotype seedling. D. Poor phenotype seedling. E. Good phenotype sapling. F. Poor phenotype sapling.

was also straight-stemmed and vigorous (Figure 14C). In contrast, the 6-year-old seedling grown from seed of the deformed, undesirable parent was likewise inferior in phenotype (Figure 14D).

These parent-offspring similarities do not disappear with time. In Figures 14E and 14F are 19-year-old offspring produced from seeds of good and poor parents respectively. This type of evidence — and there is an abundance of it — clearly demonstrates the importance to reforestation of collecting seed from only the better trees in wild stands.

Other conifer species also exhibit variations in phenotypic characters, some of which are undesirable. For example, the poor phenotype of western hemlock in Figure 15B shows marked curvature of the main stem and irregular and lop-sided branching. The poor phenotype of white spruce in Figure 15D displays repeated forking of the main stem and uneven branching.

Cones should be collected only from trees of good phenotype. In general, such trees are healthy, fast-growing dominants or co-dominants, with persistent, straight stems free from defects such as fluting, forking, ***epicormic*** shoots and spiral grain. Branch bases should be small in relation to the stem and the branches should project from the stem horizontally or angle slightly upward. The tree crown should be compact for the species, yet bear a large area of foliage. Ideally, the trees should have a history of previous cone production. Cones should not be collected from trees of unwanted species, those with deformed stems or branches, or those showing evidence of mistletoe or other

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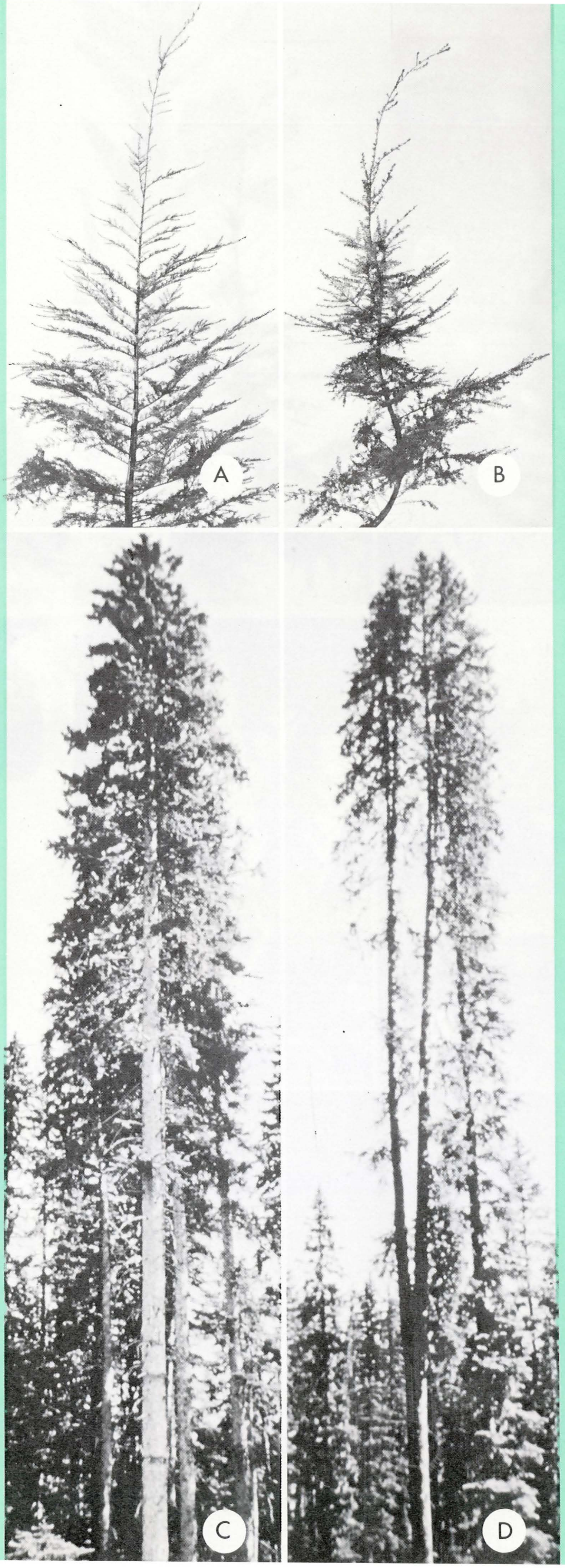


● Figure 15. **Phenotypic variation in western hemlock and white spruce.**
Western hemlock: A. Good phenotype. B. Poor phenotype. White spruce: C. Good phenotype. D. Poor phenotype.

Fig. 16

Fig. 17

● Figure 16. **Pollen cones and seed cones.**

A. *Pseudotsuga menziesii* (Douglas-fir). Receptive seed cones (red) ready to receive pollen and pollen cones (yellow) about to release pollen.

B,C. *Tsuga heterophylla* (western hemlock). B. A cluster of pollen cones as they appear in late March. C. The same pollen cones about a week later are on the verge of shedding pollen.

D. *Pinus monticola* (western white pine). Typical clusters of pollen cones just after bud burst.

E,G. *Picea glauca* (white spruce). E. Receptive seed cones (red) and a vegetative shoot just after bud burst. F. Conelets still in the upright position just after pollination. The cone scales are tightly closed in contrast to those in E. The conelets will soon turn down and develop into pendant cones. G. Pollen cones after pollen has been shed. These are normally pendant but the branch was turned over for the photograph.

H. *Picea sitchensis* (Sitka spruce). Pollen cone (upper right) shedding pollen and receptive seed cone (lower right). Two vegetative buds (center and left) have just burst.

● Figure 17. **Cones of spruces and true-firs.**

A. *Picea glauca* (white spruce). Ripening cones; some (upper right, center and lower right) show signs of premature opening, due perhaps to insect infestation.

B. *Picea sitchensis* (Sitka spruce). Cones ready for picking.

C,D. *Picea mariana* (black spruce). C. A ripe cone (upper left) and an old cone (lower right). D. A heavy cone crop, typically clustered at the top of the tree.

E. *Abies lasiocarpa* (alpine fir). Ripe cones are characteristically very pitchy.

F. *Abies amabilis* (amabilis fir). Although similar in color and pitchiness, amabilis fir cones are usually longer and wider (barrel-shaped) than alpine fir cones.

G. *Abies grandis* (grand fir). Readily distinguished from alpine and amabilis fir cones by their greenish color, grand fir cones are also less pitchy. Note the two cones showing premature opening and disintegration; this was caused by heavy insect infestation. All true fir cones are characterized by an upright stance.

(continued from page 31)

diseases — even though such trees may contain the heaviest crops. Also, isolated trees (i.e. more than 100 metres from the nearest stand of the same species) should be avoided as cones on these are often inadequately pollinated by other trees. Flagging tape or paint should be used to mark trees for cone collection; in some cases, it may be more efficient to mark the trees from which cones are **not** to be collected.

In selecting trees, safety and practical factors must also be considered. For example, if collection is to be accomplished by climbing, then only trees which permit safe climbing and efficient cone gathering should be selected. In some cases, this may force some compromise of phenotypic desirability, especially in regard to branch size and distribution. If trees are to be felled for cone collection, a major concern is their proximity to landings, roads, or skid trails; the area into which the crowns fall should be relatively clear of brush or slash to facilitate access and cone gathering.

Consistent with safety and practical considerations, the supervisor has, therefore, an opportunity — in fact, a duty — to select trees of good phenotype for cone collection. This will ensure that seeds of high genetic quality are available for the province's reforestation program.

Determination of collecting method

Efficiency, safety and the requirement of collecting high quality seed are the criteria that must be considered in choosing a collection method. Essentially, there are three methods available: 1) climbing, 2) felling or topping trees, and 3) mechanical shaking. A fourth method — collecting from squirrel caches — may occasionally be used, but is generally to be avoided. These methods are described in detail on pages 49-51; we are concerned here only with determining which method is most suitable under given circumstances.

Climbing is generally the method used for collection in Douglas-fir and ponderosa pine and, occasionally, in larch if experienced climbers are available. The stand should be fairly open; trees should be full-crowned almost to ground level and not over 15 metres in height. However, cones on lower branches should not be picked as these are often self-pollinated. Also, tree branches must be sufficiently large and well-spaced to permit safe climbing and the majority of cones must be accessible to the climber **while he remains belted to the main stem.** (Branch hooks may be used.)

Felling or topping trees is generally the method employed for reaching cones of species which do not lend themselves to efficient picking (e.g. hemlock, cedars) or when trees cannot be climbed readily (e.g. lodgepole pine, spruce). Whenever possible, felled trees should be salvaged after cones are collected; this may be facilitated by coordination with logging or clearing operations. If trees are to be topped, shooting down the tops with a high-powered rifle might be considered (see page 51).

Mechanical shaking is not usually an available option in that tree shakers are still in the developmental stage.

Collecting from squirrel caches is to be avoided, except as a **last resort** to augment critically low seed stocks when quotas cannot be obtained by other collection methods. Use of this method must be approved by the District Headquarters, and the collection supervisor must ensure that the source stand is of good quality before proceeding.

The collection plan

Having decided on the method to be used, the supervisor can begin to put a collection plan together. With an estimate of cone yield per tree (see method on page 17) and the expected quantity picked per picker-day (Table 3), the time required to achieve the quota can be calculated in relation to various crew sizes. Relating the crew size to the field supervision and transportation available, the supervisor can decide on the likely number of days of collecting in each area. When two or more areas are scheduled for collection, priorities should be assigned with regard to species, elevation, location and available labor.

Table 3. Approximate quantities of cones picked per picker-day from a medium-heavy crop.

	Method of Collection			
	Climbing		Felled trees	
Species	hectolitres	bushels	hectolitres	bushels
Douglas-fir	2-3	6-8	2-3	6-8
Interior spruce *	—	—	1-1.5	3-4
Lodgepole pine	—	—	1-1.5	3-4
Ponderosa pine	4-5	12-14	—	—
White pine	—	—	3.5-4.5	10-12
Western larch	0.5-0.8	1-2	0.7-1	2-3
Western red cedar	0.5	1	0.5	1
Western hemlock	0.5	1	0.5	1

* Refers to white and/or Engelmann spruce.

Amounts collected per picker-day will depend on a number of factors:

a) Species — some cones are harder to break off than others (e.g. lodgepole pine); in some species, old cones will still be on the branches and tend to confuse pickers (e.g. larch).

b) Size of cones — cone size varies by species. However, cones of the same species vary in size with tree age, elevation and from one geographical area to another.

c) Method of collection — it is generally more efficient to collect cones from the tops of felled trees rather than by climbing (especially in spruce).

d) Heaviness of crop — more cones on each tree and more trees with cones on them mean that pickers will not have to move as often.

e) Motivation of pickers — cone pickers are motivated and produce according to the nature of the job, the rate of pay, their age and how well the job is pre-organized and supervised.

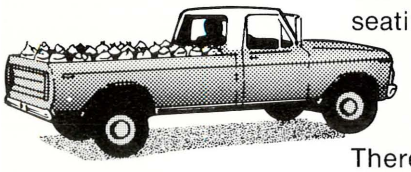
f) Weather, insects, travelling time, etc.

g) Training — a vital prerequisite to efficient cone collecting (see pages 27 and 40).

Table 3 is a guide to anticipating picker productivity; it assumes that a reasonable rate is being paid for cones and that pickers are fairly industrious.

Transportation

Necessary vehicles or boats for getting the crews to and from the collection area and for transporting cones to the interim storage facility should be arranged in advance. Vehicles should be suitable for the terrain and weather conditions, and should provide reasonably comfortable seating and shelter.



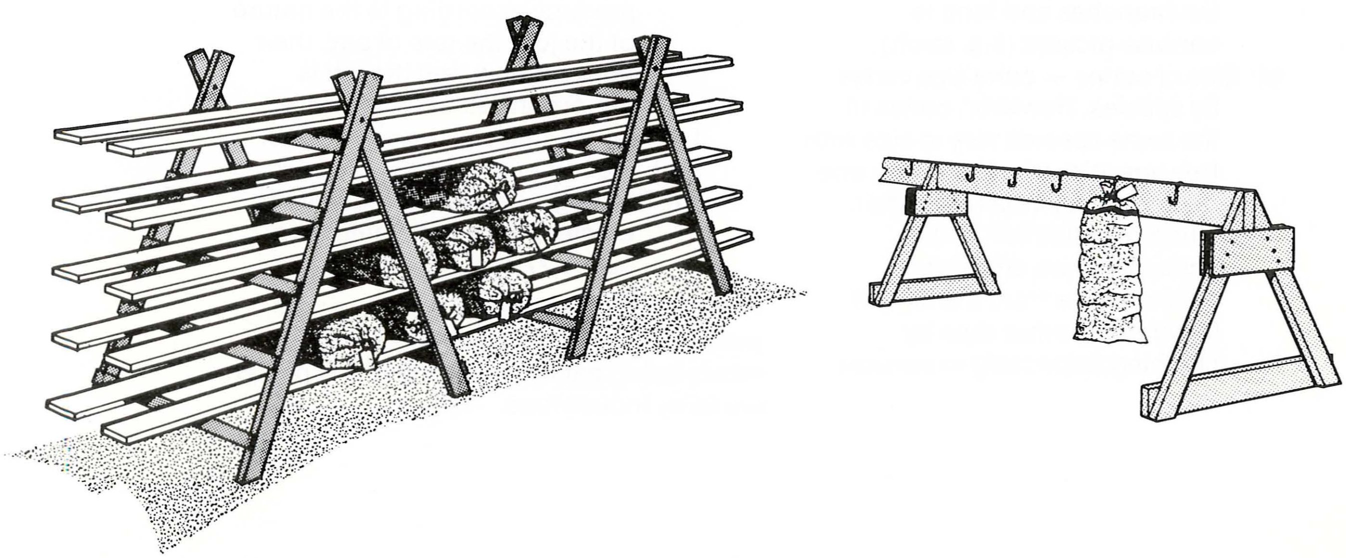
During the rush to collect cones, the supervisor cannot afford to have mechanical difficulties with vehicles. Therefore, units should be inspected and serviced in advance and should be checked for proper licensing, insurance and safety features. The supervisor should also ensure that assigned operators are qualified and have an appropriate Driver's Licence to operate their units.

Equipment and interim cone and storage facilities

The necessary equipment should be accumulated and made ready well in advance. Items needed will depend on the collection method and on other circumstances. A checklist of basic items is presented on page 37. The supervisor will have to determine what is necessary for a particular collection operation.

Interim cone storage facilities should be pre-organized at a convenient location, frequently the Ranger Station. This will involve the fabrication of a series of temporary shelves or racks having sufficient capacity to hold the anticipated collection of sacked cones in a manner allowing the movement of air between sacks (Figure 18). The facility should have a roof, or be located in a building having open walls or large doors and should be in a cool, shaded location. Portable fans may promote air movement. It may also be necessary to protect interim storage facilities against depredations by local squirrels and chipmunks. By applying ingenuity to the problem, it should be possible to meet the above requirements for temporary cone storage by using available or inexpensive materials.

● Figure 18. **Interim Cone Storage Racks.**
Two types of simple storage racks based on U.S. Forest Service designs. A. Knock-down saw-horse type supports, approximately 1 m high, are spaced at 2-3 m intervals along the bar. Supports can be of 2 x 4's with 1 x 4 or plywood braces; the bar could be a 2 x 6, preferably rough-sawn. Cone sacks are hung on double-S hooks — ∽ — placed at 30-40 cm intervals along the bar, to allow free air circulation around each sack. B. Ladder-like trestles, 2-3 m high, with parallel bars on which the sacks are laid. Both types, built of common materials, are completely portable.



Equipment Checklist

- ☐ First aid kit and stretcher
- ☐ "Forestry Crew at Work" signs
- ☐ Hard hats for crew
- ☐ Contour map of area
- ☐ Altimeter
- ☐ Binoculars (6X or 8X)
- ☐ Cone cutter (or strong knife and board)
- ☐ Hand lens (10X) and razor blades
- ☐ Flagging tape
- ☐ Axe and/or chain saw (fuel, file)
- ☐ Tarpaulins
- ☐ Plastic pails
- ☐ Burlap sacks (0.5 hectolitre)
- ☐ Ladders, aluminum extension or orchard type
- ☐ Safety belts for climbing
- ☐ "S"-shaped hooks (for attaching sacks to branch)
- ☐ Open-ended cans (for keeping sack mouths open)
- ☐ Branch hooks (1-2 m stick with hook on one end)
- ☐ Cone rakes (tooth spacing relative to cone size)
- ☐ Portable inspection bins and cleaning tables
- ☐ Cone volume measure (see Appendix VII)
- ☐ Strong twine for tying sacks
- ☐ Shipping tags, stencils and paint for sacks
- ☐ Collection report forms (F.S. 721 or 721A)
- ☐ Tally book
- ☐ Signalling device (whistle, horn, etc.)
- ☐ Hand cleaner and supply of clean rags or paper towels
- ☐ Water bags (or other containers)
- ☐ Insect repellent

Pre-organizing safety

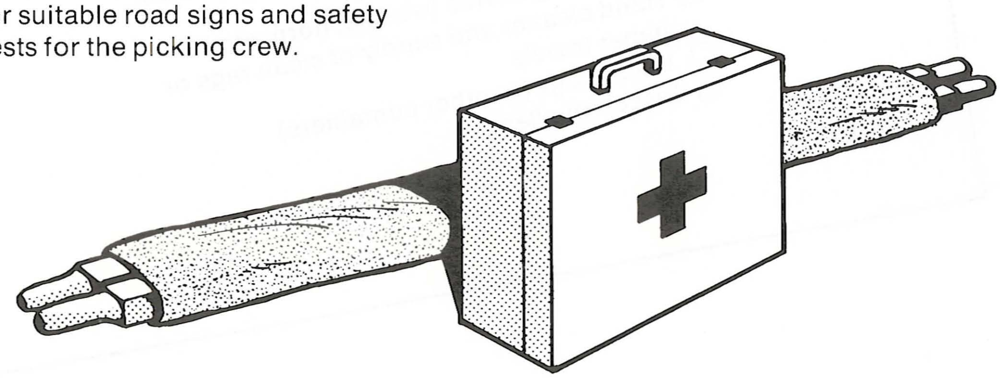
Forest Service cone collection operations have been assigned a class "B" hazard rating by the Workers' Compensation Board, and the regulations pertaining thereto apply. Other agencies should check with the W.C.B. regarding their hazard rating. It is absolutely essential that supervisors and foremen be familiar with the appropriate W.C.B. regulations and requirements for standby first aid equipment.

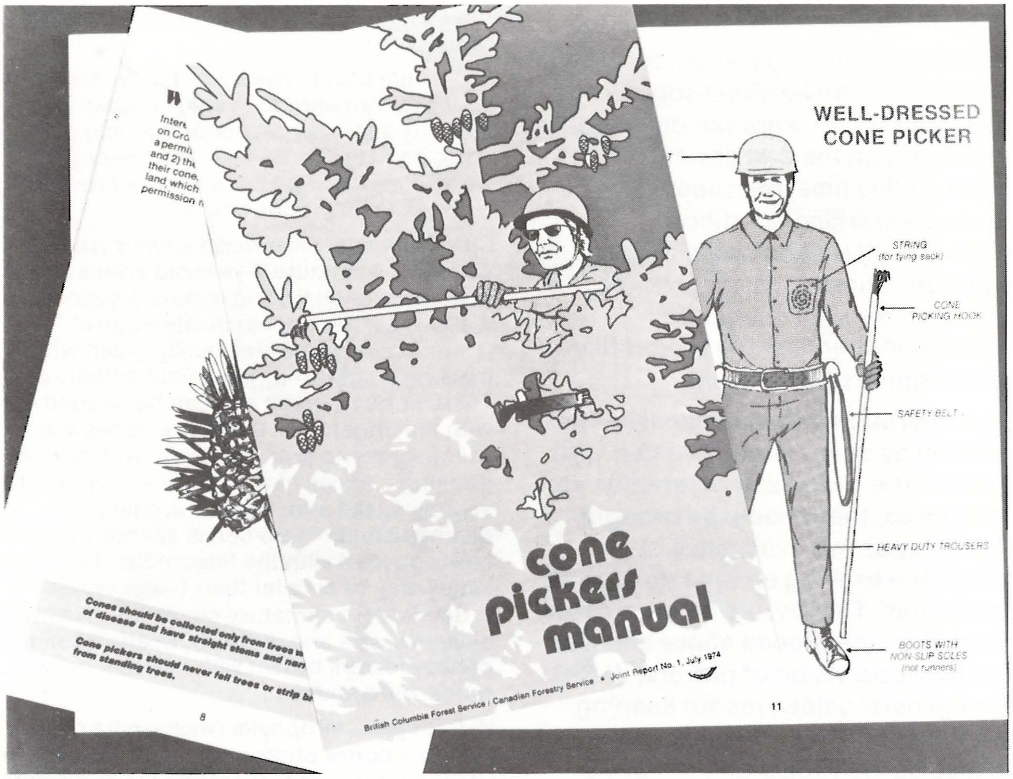
Pre-organization is as important to safety as it is to efficiency. Following are pre-organizational activities essential to a safe collecting operation:

1. Review W.C.B. requirements pertaining to safety.
2. During examination of collection areas, note potential hazards such as snags, unsafe trees and wasps' nests. Such hazards should be eliminated or pointed out to the crew foreman and/or pickers.
3. Check all equipment, including vehicles, boats and chainsaws, to ensure that it is of the proper type and in good condition. Ensure that equipment operators are qualified, capable and, when necessary, properly certified.
4. Arrange for necessary first aid equipment and certified personnel.
5. Arrange for safe travel over logging roads. Ensure that collection areas are sufficiently remote from active logging.
6. Cone collecting usually coincides with the hunting season! Arrange for suitable road signs and safety vests for the picking crew.

Cone prices

The Reforestation Division, Victoria, establishes and issues basic prices to be paid per hectolitre of cones collected on Crown lands. These are derived from past cone collection report data (Form F.S. 736) supplied by Forest Districts and cone collecting agencies. Prices are set so that industrious pickers can, under ordinary conditions, earn approximately the amount they would earn as laborers. However, conditions are often not "ordinary" and it may be necessary to adjust these basic prices to allow for local factors that may contribute to reduced production — e.g. extended travel time, small cones and poor picking conditions. Adjustments to the basic price should be carefully considered and must be approved in advance by the District Headquarters. In special cases, such as collections from seed production areas or where new collection techniques are being tested, special prices or hourly rates may be appropriate.





Cone picking labor

Labor requirements depend on quotas, anticipated duration of the collection and the availability of supervision. Prospective cone pickers, having seen the crop, will usually inquire about collections. However, it may be necessary to place advertisements in local newspapers calling for pickers and outlining expected starting dates, minimum age (15 years old for Forest Service) and place where further information can be obtained. In some localities, organized groups, such as Junior Forest Wardens, Boy Scouts and sporting clubs, may be interested in collecting as a unit, but crews will generally be made up of individuals picking for themselves.

To handle inquiries, it is advisable to have a notice posted on the bulletin board and/or printed handouts. These should provide the following information:

a) Probable starting date and duration of collection
b) Species to be collected
c) Equipment to be supplied by agency
d) What the picker should provide (e.g. clothing, gloves, boots, lunch, etc.)
e) Workers Compensation Board coverage
f) Rate of pay (hourly, per hectolitre, etc.)
g) Method and frequency of payments

The above information may be supplemented with a copy of the Cone Pickers' Manual (1974. B.C. Forest Service/Canadian Forestry Service, Joint Report No. 1). A phone list of those persons who remain interested should be retained to facilitate immediate contact when the crop is ready for harvesting.

Training of foremen and pickers

In a limited collection operation, the supervisor will exercise direct supervision over cone pickers. Pickers can be briefed in a short session on the first day of collection. At this time, the supervisor should review working conditions, collection objectives and safety matters. Detailed instructions must be given on use of equipment, on what constitute acceptable cones and on the proper filling, tying and tagging of cone sacks.

In a large operation, direct supervision will be exercised by one or more foremen who will report to the supervisor. If foremen are to be employed, they should be brought together a day or two in advance of collecting for a briefing on their duties and responsibilities. This should cover in detail the information mentioned above and also concern the supervision of pickers, W.C.B. rules and general safety, record keeping and handling of filled cone sacks. Foremen should also be instructed on the "why's" and "how's" of selecting trees for cone collection, although this is ultimately the supervisor's responsibility and, ideally, acceptable (or unacceptable) trees will already have been marked.

● Figure 19. **Cones of cedars, hemlocks and larch.**

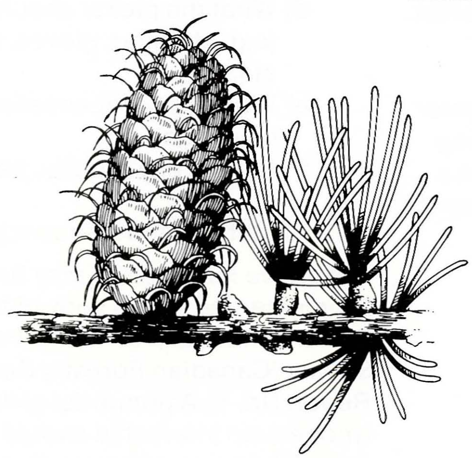
A,B. *Thuja plicata* (western red cedar). A. Green cones as they appear in early August. B. As maturity approaches, cones become golden (left); on the same branch, old cones (right) are easily distinguished by their dark brown or grey color and stiffly-open scales.

C-G. *Chamaecyparis nootkatensis* (yellow cedar). C. Immature 1-year-old cones (green) near the branch tip and mature 2-year-old cones (yellow) as they appear in late August.
D. Immature cones are usually green with purple markings; some may be almost entirely purple. These cones are soft and can be opened easily with the fingernails. E. Mature cones are yellow-green to golden-brown, with dark-brown markings; edges of the scales are usually brown, slightly raised and, therefore, easily distinguished. These cones are hard and not easily opened with the fingernails. Two-year cones may be smaller than 1-year cones.
F. Seeds from immature cones are creamy white or yellow, soft and moist. G. Seeds from mature cones are dark brown with medium brown wings, hard and dry.

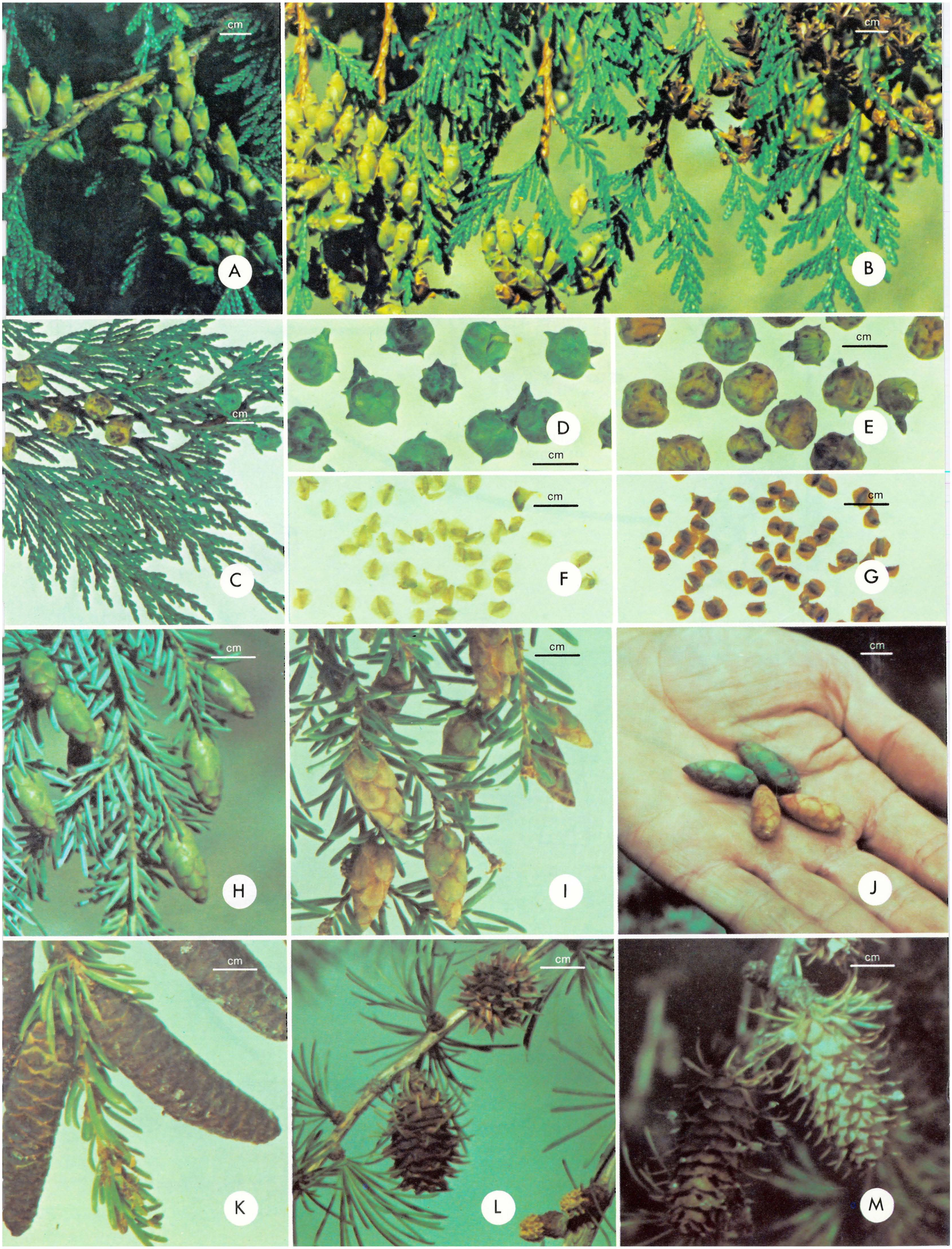
H-J. *Tsuga heterophylla* (western hemlock).
H. Green cones photographed in early August.
I. Mature cones, photographed in mid-September, are yellow-brown. J. Not all cones on the same tree, or even on the same branch, ripen at the same time. These cones, photographed in late September, developed side by side on the same branchlet.

K. *Tsuga mertensiana* (mountain hemlock). Ripe cones are easily distinguishable from those of western hemlock; they are usually 2-3 times larger and are purple or bluish in color.

L,M. *Larix occidentalis* (western larch).
L. Immature conelets as they appear in late July. Remains of pollen cones are seen at lower right.
M. Mature seed cones, in mid-September, are golden-brown.



Alpine larch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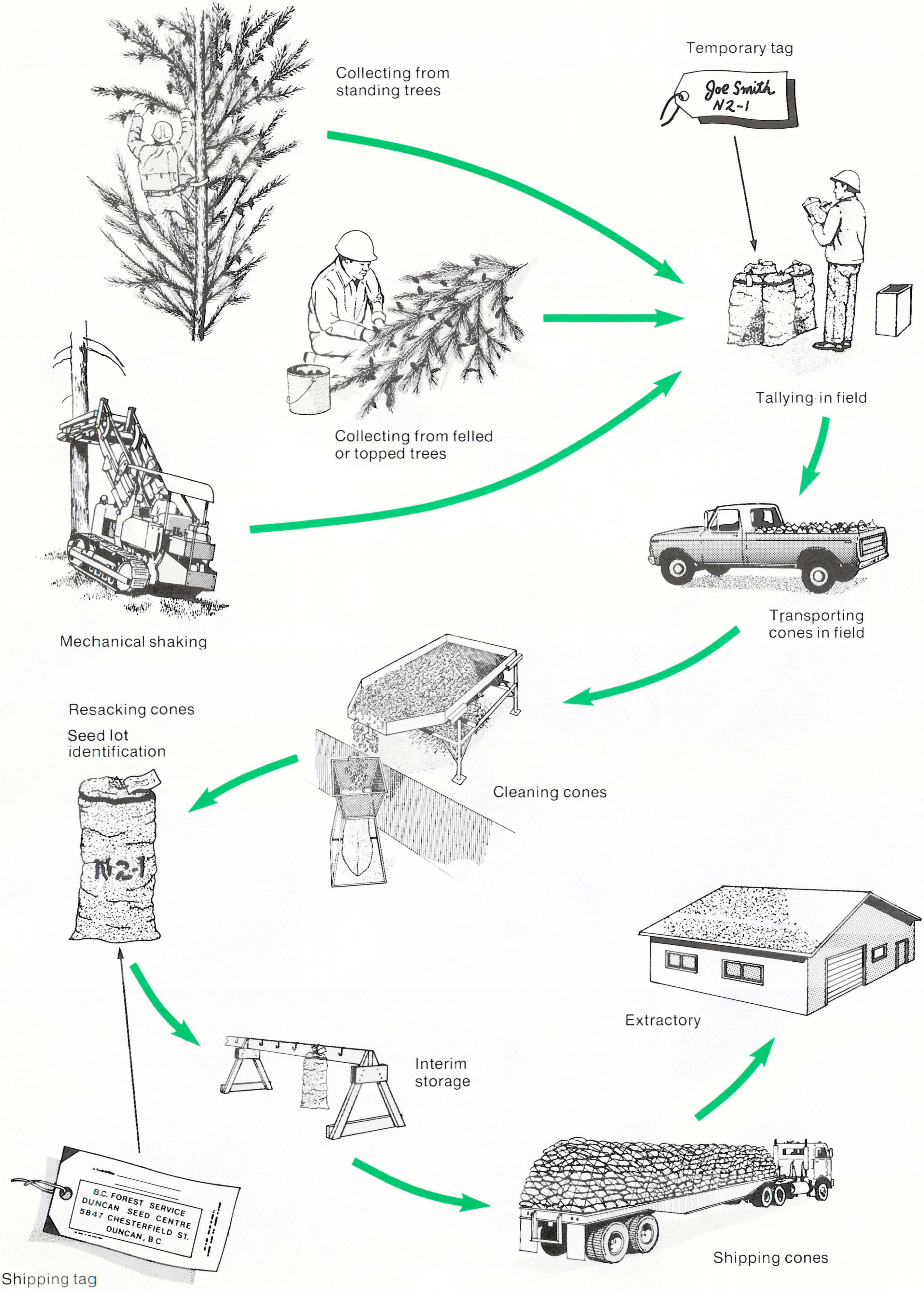

Collecting from standing trees
Temporary tag
Joe Smith
N2-1
Collecting from felled or topped trees
Tallying in field
Mechanical shaking
Transporting cones in field
Resacking cones
Seed lot identification
N2-1
Cleaning cones
Extractory
Interim storage
B.C. FOREST SERVICE
DUNCAN SEED CENTRE
5847 CHESTERFIELD ST.
DUNCAN, B.C.
Shipping tag
Shipping cones

Cone Collection and Handling

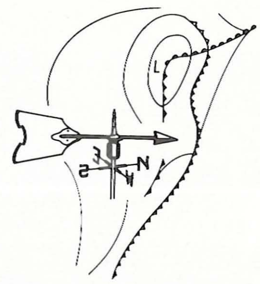
If the expectation of a collectable crop has been upheld and pre-organization has proceeded as it should, an efficient, well-organized collection operation can be expected. When checks show the cone crop to be ready for picking, the cone pickers, equipment and interim storage facilities will be ready. Necessary permits, licences and authorization will have been obtained and collection areas will long since have been selected and prepared. It remains to assemble the pickers and get started.

There can be major differences from one cone collection operation to another, depending on species, collection method, availability of a cleaning table at the interim storage facility, and many other factors. To take these differences into account, the following is necessarily generalized. Perspective is added by the operational flow diagram shown in Figure 20.

Weather information

Weather conditions affect the cone collection operation in many ways. High winds or rain may preclude tree climbing. Access to collection areas may be disrupted and picker productivity may be affected by inclement weather. Dry, windy conditions may shorten the collection period by hastening cone opening and seed dissemination. For these reasons, weather forecasts are a valuable aid to the collection supervisor in his day-to-day planning of the collection work. Daily forecasts and 5-day outlooks can generally be obtained through the District Office. The supervisor will find the following information of value:

a) maximum/minimum temperatures - by elevation zones
b) relative humidity - by elevation zones
c) winds - direction and force
d) percent chance of rain
e) duration of existing conditions
f) occurrence of inversions



● Figure 20. **Flow-diagram of the cone collection operation.**

Supervising the collection operation

A safe and efficient collection operation depends on effective supervision. The cone collection supervisor has overall responsibility and, alone or with the assistance of one or more foremen, must provide the needed supervision. Supervision is a continuous job entailing a) periodic seed crop evaluation, b) supervision and deployment of personnel and equipment, c) procurement and distribution of supplies, d) maintenance of accurate records and e) care of picked cones.

a) Periodic seed crop evaluation. Presumably a seed crop evaluation has indicated that cones contain adequate amounts of filled seeds and that they are sufficiently mature; otherwise the operation would not be in progress. However, because previous evaluations may be in error and seed quantity and quality may vary among trees and areas, seed crop evaluation should continue throughout the collection operation. **Manpower is too valuable to waste collecting worthless cones.** Periodic seed crop evaluation involves drawing samples of cones, cutting them longitudinally to determine the filled seed counts in the half-section, and applying the seed cutting test to a sub-sample of seeds (see page 22).

(continued on page 45)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● Figure 21. **Cones of B.C. pines.**

A,B. *Pinus contorta* var. *contorta* (lodgepole pine). A. Mature cones at the end of the second growing season after pollination. The golden-bronze color has replaced the olive green color of the immature cones, indicating that the seeds are fully mature. B. Immature conelets at the end of the first growing season following pollination. Fertilization of the ovules will occur in the next growing season, and these cones will be part of next year's crop. In most pine species, the 1-year-old conelets are much smaller than the mature cones and relatively inconspicuous since they are surrounded by the foliage.

C,D. *Pinus ponderosa* (ponderosa pine). C. One-year-old, pollinated but unfertilized, conelet. D. Ripening cones at the end of the second season following pollination. An old cone (from previous crop) can be seen at lower left.

E,G. *Pinus monticola* (western white pine). E. Mature cones. Color can vary from greenish (as shown) to golden-brown. G. One-year-old conelet.

F,H. *Pinus albicaulis* (whitebark pine). F. One-year-old conelet. H. Mature cones in a typical cluster around the branch.

I,J. *Pinus flexilis* (limber pine). I. Immature cones as they appear in mid-August. J. Mature cones are golden-yellow in color; the cone illustrated had already begun to open when photographed (mid-September). A persistent old cone is visible in the background.

b) Supervision and deployment of personnel and equipment. It is most important that the supervisor or foreman ensure that pickers are collecting only from the selected trees and that they are conforming to safety precautions. Pickers should be assigned to trees and instructed to remove all good cones before moving to another tree. In a climbing operation, only one picker should be assigned to a tree. In assigning selected trees, consideration should be given to density of cones and ease of picking so that pickers are given equal opportunities.

A picking crew often includes one or more non-pickers, i.e. persons paid on a hourly basis to do supplementary jobs, such as operating a cleaning table. Since pickers, by contrast, are paid on a contract basis, it is not usually feasible to rotate personnel among jobs. All persons making up the crew must be given the tools and equipment necessary to his job, such as hard hats, safety belts, branch hooks and cone rakes; these items should be turned in at the end of each work day.

Depending on progress toward achieving quotas, weather conditions and other factors, crew size may have to be varied on a day-to-day basis. The supervisor must keep abreast of requirements and advise pickers as necessary. Crews must be kept in balance; if additional pickers are hired, it may be necessary to hire more non-picking helpers. The supervisor or foreman should always know the whereabouts of his crew. The truck horn, a whistle or other signalling device should be agreed on as a means of calling in pickers. High morale is important; good work should be praised.

c) Procurement and distribution of supplies. Cone sacks, ties, tags, rags, hand cleaner, insect repellent and numerous other expendable items must be readily accessible to those workers needing them. The supervisor or foreman must ensure that the collection operation is not impeded by lack of such items.

d) Maintenance of accurate records. Collections from individual pickers must be accurately recorded in the field. In some operations, the foreman's tally will be the basis for paying pickers. Where this is the case, foremen must ensure that sacks are properly filled and that the cones are reasonably clean and free of debris such as needles, twigs, bark, etc. Such foreign material complicates the seed extraction process and represents volume that should be occupied by clean cones. Sacks containing unacceptable cones or excessive debris must be culled and cleaned by the picker before they are accepted for payment. To ensure that cones are acceptable, sample sacks from each picker's collection should be emptied into a hopper and examined. On the order of one sack in five should be so examined.

Fill lines on current sacks represent 1.5 bushels which nearly equals 54 litres; therefore, sacks filled to the base of the fill line should contain 50 litres or 0.5 hectolitre. A cone volume measure (see Appendix VII) should be on hand to check 50 litres in relation to fill lines and to settle any disputes that may arise. In those operations employing a cleaning table, the foreman's tally will serve as a check but payment will be based on number of properly filled sacks after cleaning.

Temporary tags showing the picker's name and provisional seedlot number should be affixed in the field; a duplicate tag should be placed inside each sack and the provisional seedlot number should be painted on each sack.

e) Care of picked cones. This subject is discussed in detail on page 52. Suffice it to note that proper care of sacked cones is an important responsibility of the person directly supervising the collection operation.

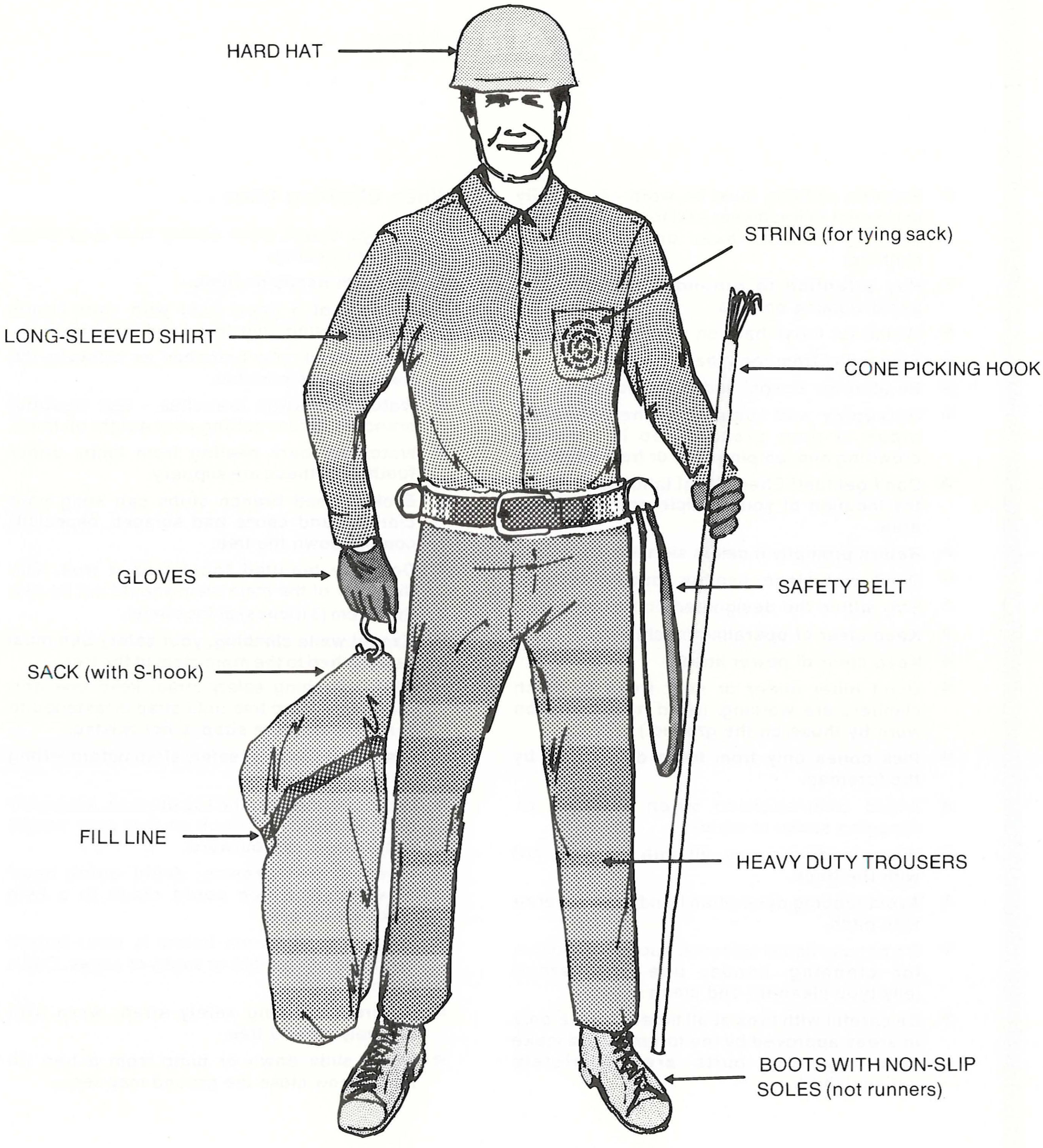
Safety during the collection operation

Cone picking is hazardous, especially when it involves climbing trees. However, a cone collection operation can be relatively safe if all personnel are: a) physically fit, b) properly dressed, c) well equipped (and trained to use their equipment) and d) safety conscious.

Some level of physical fitness is an obvious requirement but the minimum permissible level will depend on the nature of the collection operation. It stands to reason that a higher degree of fitness will be required of tree climbers than of persons picking cones from trees felled on a landing.

A properly-equipped cone picker is depicted in Figure 22. The Workers' Compensation Board requires that hard hats be worn when working on the ground and recommends that they be worn by tree climbers. Boots with non-slip soles (preferably soft rubber) and at least 15 cm (6 inch) tops are a must. A long-sleeved shirt that can be buttoned at the neck, heavy-duty trousers and leather gloves give protection against scratches, abrasions and pitch. Cone picking is hard on clothes, so durable clothing that can stand the abuse of dirt, pitch and snagging should be worn. During hunting season, brightly-colored clothing, such as an orange vest, should be worn.

(continued on page 49)



● Figure 22. **A properly equipped cone picker.**

Safety tips

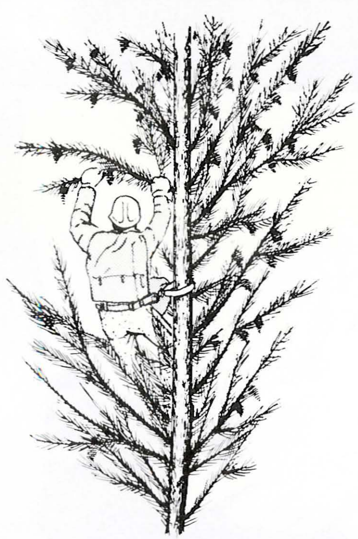
- Suitable clothing must be worn - especially in respect to headwear and footwear. During hunting season, wear brightly-colored clothing.
- Pay attention to ground conditions and avoid walking on logs.
- Watch for loose bark on windfalls.
- Stay away from logs that may roll.
- Be alert for wasps' and bees' nests.
- Horseplay and running in the collection areas is poor practice. So is rushing, crowding and jumping onto or from vehicles.
- Don't get lost! Check local landmarks, know the location of your vehicle and mustering area.
- Return promptly if call-in signal is sounded.
- Don't work alone; use the "buddy" system.
- Stay within the designated collecting area.
- Keep clear of operating machinery.
- Keep clear of power lines.
- Don't loiter under or near trees in which climbers are working. (Hard hats are to be worn by those on the ground.)
- Pick cones only from trees designated by the foreman.
- Avoid over-exertion when carrying or dragging sacks of cones.
- When loading cones, lift with the legs, not with the back.
- Avoid rubbing eyes when hands are covered with pitch.
- Do not use liquid solvents, such as gasoline, for cleaning hands; use commercial jelly-type cleaners and clean rags.
- Be careful with fires at all times. Smoke only in areas approved by the foreman and make sure cigarette butts are completely extinguished.

When climbing trees . . .

- Always check your safety belt and strap before climbing.
- Use both hands to climb.
- Be sure of a good hold with your hands before moving your feet - and vice versa.
- Stand on or grip branches as close to the main stem as possible.
- Watch for brittle branches - test doubtful branches before putting your weight on them.
- Watch for bark peeling from limbs under footholds - these are slippery.
- Broken dead branch stubs can snag your clothing and cause bad scrapes, especially coming down the tree.
- Don't be tempted too far up a tree. The diameter of the main stem should not be less than 8 cm (3 inches) at face level.
- Except while climbing, your safety belt must be attached to the main stem of the tree.
- While attaching safety strap, keep one arm securely around tree until strap is fastened to D-ring. Make sure strap is not twisted.
- Test weight against safety strap before letting go of tree.
- When picking near the top of a tree, keep your body close to the trunk so that your weight bears down, not outward.
- When in tree crowns, avoid quick head movements which could result in a twig poking your eye.
- Make sure the area below is clear before dropping equipment or sacks of cones. Call a warning first.
- Before detaching safety strap, wrap arm securely around tree.
- Never slide down or jump from a tree no matter how close the ground may seem.

Cone pickers must be given appropriate equipment in good condition and they must be instructed in its proper use. Of paramount importance is the climbing belt, which must be in top condition and be used properly. Figure 23 A-F illustrates the correct way to secure the belt.

Perhaps the most important element of a safe cone collection operation, and the most difficult to define, is a safety consciousness on the part of all personnel. The supervisor and foreman must be constantly alert to unsafe conditions and practices. So should the cone pickers. Safety consciousness starts with a knowledge and observance of all safety rules and regulations, but it goes much further. It involves the senses - common sense, a sixth sense and a sense of responsibility for personal safety and the safety of others. The following safety tips relate to practically all cone collection operations. The supervisor should use these to draw up a formal list of safety rules.



Collecting cones from standing trees

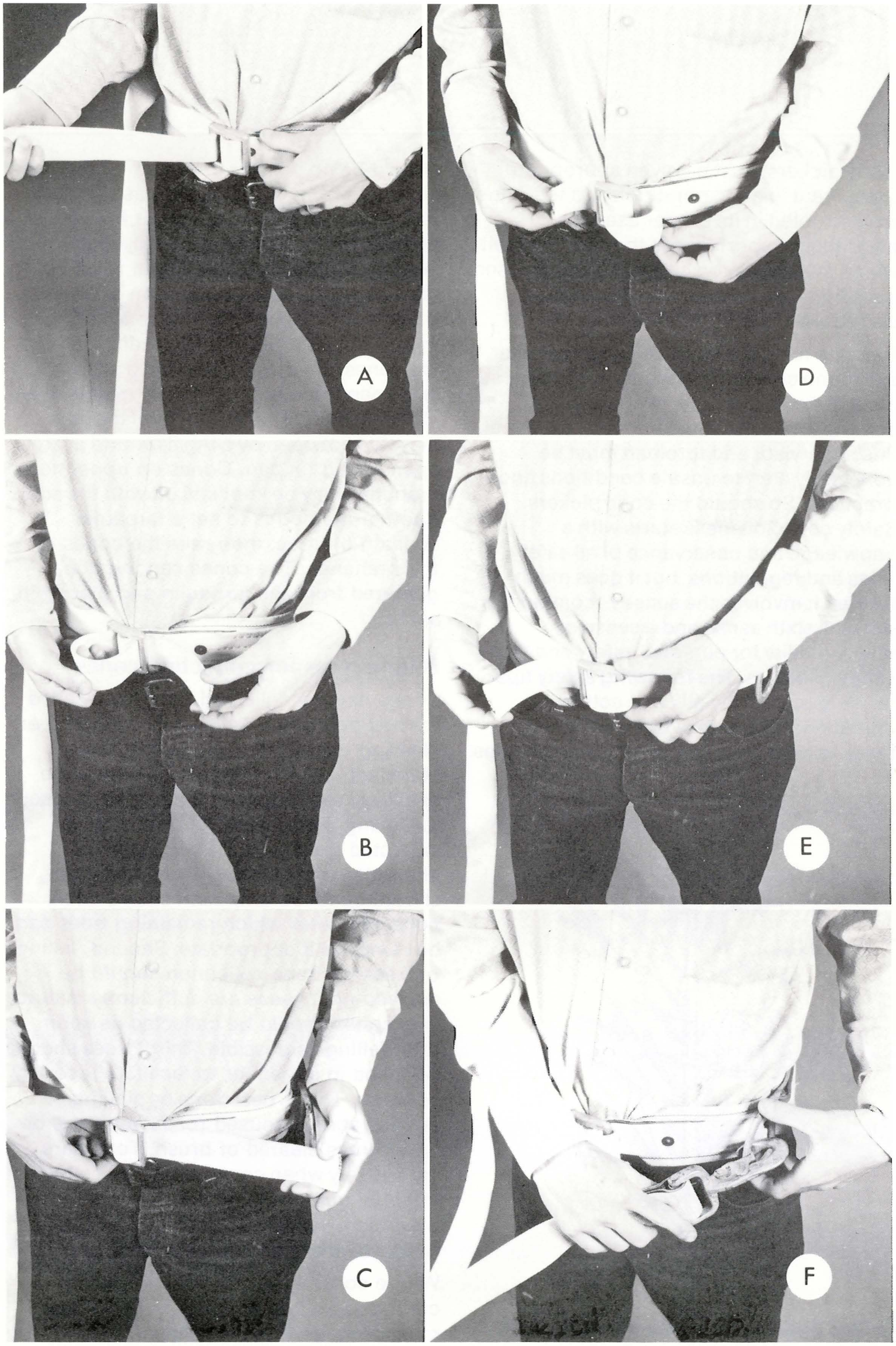
Climbing trees to pick cones is practical in immature stands of species having medium to large cones, e.g. Douglas-fir, ponderosa pine and spruce. Individual trees should be pre-selected on the basis of phenotypic and safety criteria. The picker should climb as high as is safely practical (the main stem should be no smaller than 8 cm or 3 inches at face level) and pick cones as he works his way down the tree. **Except for brief periods when moving expressly from one level to another, his safety belt must be attached around the main stem of the tree.** Using a short hooked stick, the picker pulls the branches upward and inward, gathers the cones and drops them into a sack which is suspended from a branch by means of an "S"-shaped hook. The mouth of the sack may be kept open by tying it around a large open-ended tin can. Cones on uppermost branches may be knocked off with the stick. Another method is to set a tarpaulin beneath the tree, then rake the cones off the branches. The cones can then be gathered from the tarpaulin and placed in sacks.

Felling trees for collecting cones

Cones may be collected from trees felled for this purpose or as part of a logging or clearing operation. If cones are to be collected, certain requirements must be satisfied, regardless of the primary reason for felling. First, cones should only be collected from trees having suitable characteristics. Ideally, only these trees should be felled until cones have been collected, after which remaining trees can be removed if appropriate. Second, felling of trees for cone collection should be delayed until seeds are sufficiently mature and cones should be collected as soon after felling as possible. Third, trees should be felled in a manner to facilitate recovery of cones. This is best done by placing crowns across unused roads, landings or other areas cleared of brush. To ensure crew safety when cones are being collected in conjunction with or near a felling operation, pickers must remain at least 3 tree lengths from the site of felling.

Where collections are made on active cutting-permit areas, prior agreements must be made with the licensee. It is important that trees are felled in accordance with cutting-permit specifications by competent fallers approved by the logging foreman; fallers must be briefed on specific requirements

(continued on page 51)



● Figure 23. **Approved method of fastening climbing belt.**

The belt should be placed around the waist, just above the hips. The free end of the belt is passed through the near side of the buckle (A), then pulled through the far side (B) until it is tight against the buckle (C). The belt should fit snugly but not over-tightly around the body. To ensure that it does not work loose by slippage at the buckle, the free end of the belt must be looped back across and through the first side of the buckle (D) and, again, pulled tight (E). The action of the snap-hook on the safety strap must be checked (F) before climbing commences.

(continued from page 49)

for the cone collecting operation. Where collections are made from seed stands, felled trees should be utilized. If silviculturally appropriate, residual trees within the collection area should also be utilized. A District Forester sale or direct sale may be prepared to facilitate this.

Pickers will find that many cones will be knocked off by felling and can be easily gathered, provided that ground conditions are favorable. For collecting small cones, cone rakes may be used as described above. It may also be easier to collect cones in pails, then transfer them to cone sacks.

Topping trees for collecting cones

In cases where trees would not otherwise be felled, or where subsequent utilization of logs is not feasible, topping may be the best method to reach cones. This would be particularly indicated for those trees whose cones are confined to the uppermost crown, e.g. true firs (balsam). Only personnel experienced in topping trees should be employed for this purpose. During topping, picking crews must remain well clear of the area.

Tops may also be brought down with a high-powered rifle. Stem diameters of up to 15 cm may be severed with only a few well-placed shots. Accurate shooting is essential; rifles used for this purpose must have telescopic sights. To achieve maximum effect, soft-nosed bullets should be used.

This method must never be used near populated areas or in conjunction with tree climbing. All personnel must be well clear of the line of fire and falling tree tops. Bullets must never be fired in the direction of other woods crews or even distant communities. **Prior approval must be obtained from the Chief Forester (see Division III of "Regulations" in Appendix III) before trees may be topped for cone collection.**

Collecting cones from squirrel caches

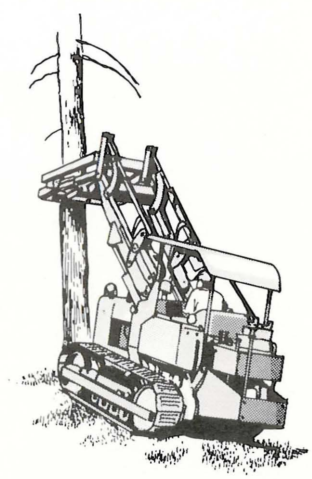
This method may be used when quotas cannot be met through other collection methods, **provided** that the source stand is of good quality and prior approval is obtained from the District Headquarters.

It is best to have a two-man crew reconnoiter areas and mark locations of caches for the pickers to gather later. Squirrels usually locate their caches year after year in the same places. Typically, they are found in damp areas near springs, small creeks or marshes, on northern exposures, and in decayed wood or duff or around old dead and down logs or windfallen trees. Fresh cones on the ground are a sign of squirrel activity; piles of cone scales and cores mark where they have been sampling cones and may indicate a nearby cache.

Mechanical cone collection

Cone harvesting to date has been primarily a manual task. Future intensive forest management will require larger amounts of high quality seeds. Consequently, dependence upon collections from seed production areas and seed orchards will increase. Stands tended primarily for seed production are best suited to partial or complete mechanical cone collection.

Partial mechanization of cone harvesting has been accomplished by use of tree shakers. Trials conducted in other countries indicate variable degrees of cone removal. It appears shakers will be most effective on species with cones which are easily detached, e.g. spruces, Douglas-fir, ponderosa pine and true firs (provided the latter can be collected prior to disintegration).



Cone handling

Freshly picked cones (except interior lodgepole pine) contain considerable moisture. As the cones lose this moisture, they expand and generate heat which may directly damage the seeds or which may encourage damaging molds. For this reason, individual cone sacks must be exposed to free movement of air; additional heating (e.g. by direct sunlight) must be avoided. During temporary storage in the field, cone sacks should stand free from each other in the shade. Collections should be transported daily to interim storage facilities (see page 36). If cones are wet, they should be removed from the sacks and surface-dried before being stored in dry sacks.

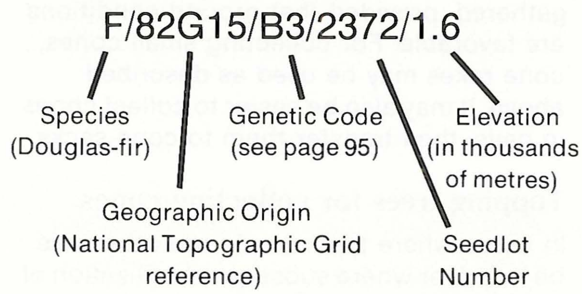
In those operations employing a cleaning table, cones will be cleaned at the interim storage facility. Following cleaning, cones are normally returned to their original sacks. An accurate tally of resacked, cleaned cones must be kept as this may be the basis for paying pickers.

Seedlot identification — Recording and tagging

A provisional seedlot number is assigned (by the collection coordinator) for each collection by species, area and collection year. This provides a means of identification during collection, interim storage and transport to the extraction plant. Each sack of cones must be identified by agency and/or owner and by provisional seedlot number. The provisional seedlot number should be painted on each sack in large numerals before it leaves the collection area (Figure 24). This is important because in most collection operations, cones arriving at the interim storage area will be coming from more than one collection area and the various seedlots must be kept separate. Temporary tags bearing this number should also be affixed to (and placed inside) each sack. These tags should show the picker's name, especially in operations where payment is based on cones cleaned and resacked at the interim storage area. The temporary tags will be replaced before transport to the extractory by shipping tags provided by the Reforestation Division. The shipping tag must be filled out on both sides and attached to the tie-string; the tear-off copy should be placed inside the sack (Figure 25).

Cone sacks should be securely tied well above the fill-line to allow for cone expansion. The only cones that will not expand as they dry are those of interior lodgepole pine. Cone expansion must be allowed during interim storage or cone scales may "case harden" or set and cause subsequent extraction problems. A secure tie is essential as much handling time is lost and cone wastage occurs when ties become loose and cones are spilled.

The provisional seedlot number will be replaced at the extractory by a Seedlot Registration Number (SRN), based primarily on geographic origin. The SRN comprises five components as shown in the following example:



Cone Collector's Report form

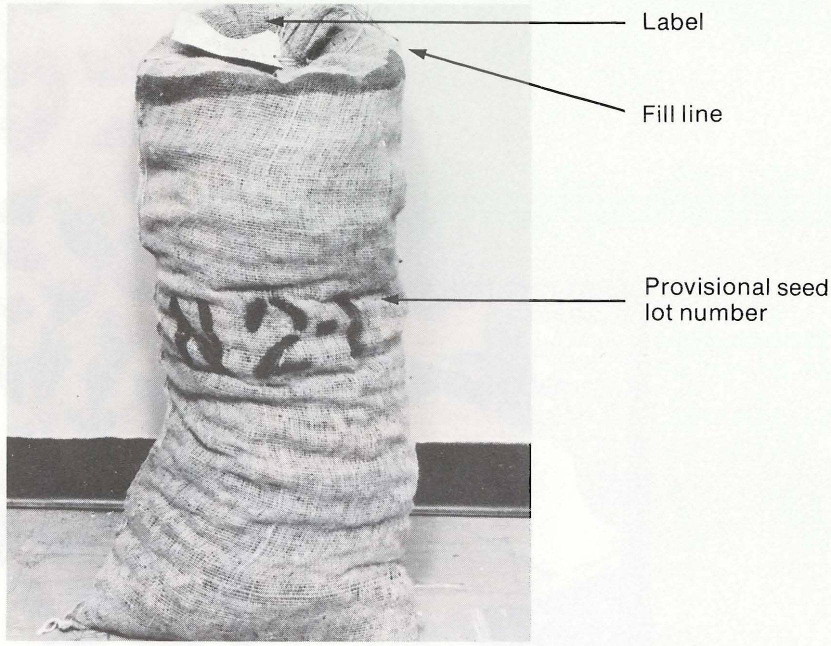
A Cone Collector's Report form (F.S. 721 - see Appendix VIII) should be promptly filled out by the supervisor after collection of each seedlot is completed. It is important that the instructions on completing this form be followed carefully to ensure smooth processing of seed and seed registration. Species and, where appropriate, variety should be clearly indicated; this is especially important where confusion might arise between Engelmann and white spruce, white and Sitka spruce or interior and coastal varieties of lodgepole pine or Douglas-fir. If collected cones are known or believed to be hybrids (e.g. white *x* Engelmann spruce), this should also be noted. A cost report form (F.S. 736 - see Appendix VIII) should also be completed and attached to the collector's report form. The completion of these forms and delivery of the cones to the extractory concludes the collection job. At the extractory, the seeds will be extracted, cleaned, tested and stored. Data from the seed tests and information from the collector's report form and cost report form are placed on a tree seed register card and, together with data for other seedlots, on a computer print-out. Examples of a tree seed register card and print-out sheet are shown in Appendix VIII. Collection supervisors wishing to follow-up particular seedlots may obtain seed test data from the District Headquarters or from the Duncan Seed Centre.

Shipment of cones to the extractory

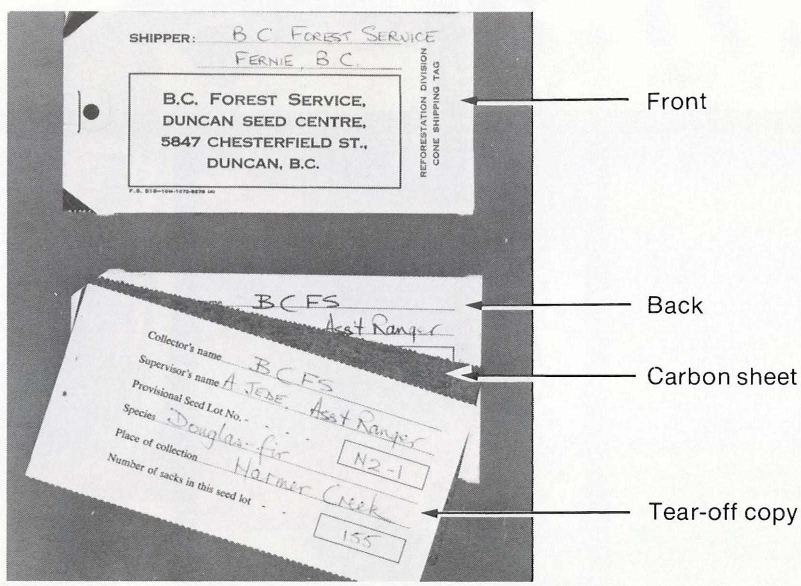
Good communication between the collection supervisor and extraction plant is essential. All cones must be delivered in the shortest possible time to the extraction plant, as even short stop-overs add to the heat build-up in cone sacks during transit.

Trucks and trailers with open flat decks should be used and cones should be stacked to prevent displacement during transit. A net must be used to stabilize the load as a safety precaution. Closed vans may be used for hauling interior lodgepole pine cones only. The truck driver should be informed of the nature of his load and the need for proper care and prompt delivery.

Information on the estimated time of arrival of a shipment of cones must be conveyed in advance to the extraction plant. This enables the receiving station to provide staffing for prompt unloading of cones. Each shipment should be accompanied by a shipping invoice indicating the number of sacks by seedlot number.



● Figure 24. **A properly marked sack of cones.**
A shipping tag has been filled out and securely attached; the tear-off copy has been placed inside the sack. The provisional seed lot number has been painted on the sack in large numerals.



● Figure 25. **Shipping tag for cone sacks.**
Both sides of a tag are shown. The tear-off copy, which must be placed within the sack, is separated from the main tag by a sheet of carbon paper.


B.C. FOREST SERVICE
FOREST NURSERY
DUNCAN B.C.

Part II

Information For Important B.C. Conifers

Information for the 20 B.C. conifers judged to have present or prospective importance in the provincial reforestation program is presented in part II. Of these, only five are prominent reforestation species at present: Douglas-fir, interior spruce (white and Engelmann combined), lodgepole pine, Sitka spruce and western hemlock. Importance in reforestation and importance in current harvesting are two different matters, as can be seen from Table 4.

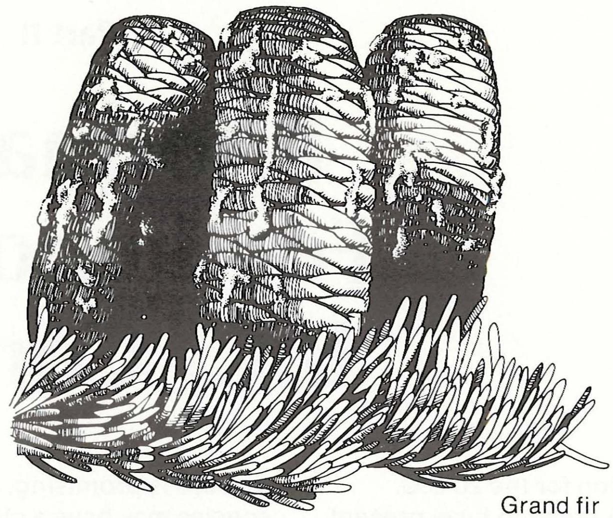
There are several reasons for species having a different order of importance in reforestation from that implied by their representation in current harvesting data. Among these are differences in economic value, rates of growth, ease of reforestation, potential management problems and, of course, availability of quality seed of the required provenances. There are also reasons why species not currently important in reforestation may become so in the future. For example, western white pine, while having several superior characteristics, is so readily killed by white pine blister rust that it cannot be considered a species for reforestation at this time. But recent progress in developing resistant strains of white pine and in controlling the disease is promising, and this species may have a place in future reforestation programs. Other species will become important in reforestation as more high elevation areas are harvested. Another reason for the prospective importance of currently unimportant species is that the growing emphasis on recreational and amenity requirements may bring about gradual changes in reforestation priorities.

The information in Part II is presented by species (or groups of species) in alphabetical order based on their scientific names. Subsections provide information on reforestation importance, distribution, cone production characteristics and special collection notes. These are supplemented by cone sketches, maps of distribution within B.C., and tabular data extracted from Table 7 (Appendix VI); additional data are presented in Tables 8 and 9. Cone sketches are approximately life-sized unless otherwise indicated. Distribution maps are based on "Native trees of Canada" (7th edition. Hosie, R.C. 1969. Canadian Forestry Service, Ottawa). Data are derived from various sources and cannot be guaranteed to be accurate in all cases, and are intended for guidance only. Wherever tabular data are missing, sufficiently reliable data were unavailable.

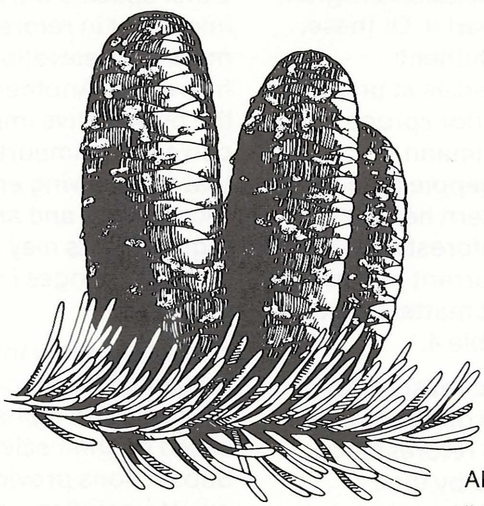
Table 4. Current harvesting and sowing data for B.C. species

Species	%of 1974 harvest	%of 1975 nursery sowing
Douglas fir - coastal	7.0	36.6
Douglas fir - interior	6.5	9.1
Interior spruce	19.3	29.9
Sitka spruce	2.0	5.3
Lodgepole pine	14.0	13.7
Western hemlock	22.2	4.3
True fir *(Abies* spp.)	13.2	1.1 (True fir, Western red cedar and Others combined)
Western red cedar	12.3	
Others	3.5	

Abies amabilis
amabilis fir or Pacific silver fir
Abies grandis
grand fir
Abies lasiocarpa
alpine fir



Grand fir
(slightly reduced)



Alpine fir
(slightly reduced)

Of the nine species of *Abies* indigenous to North America, only three grow in B.C. Both alpine and amabilis firs have been identified as important components of high (and some lower) elevational sites. Balsam woolly aphid infestations have prompted a total ban on artificial regeneration of true firs in B.C.; cones may be collected and transported for research or export purposes only. However, this ban is under study and may be modified.

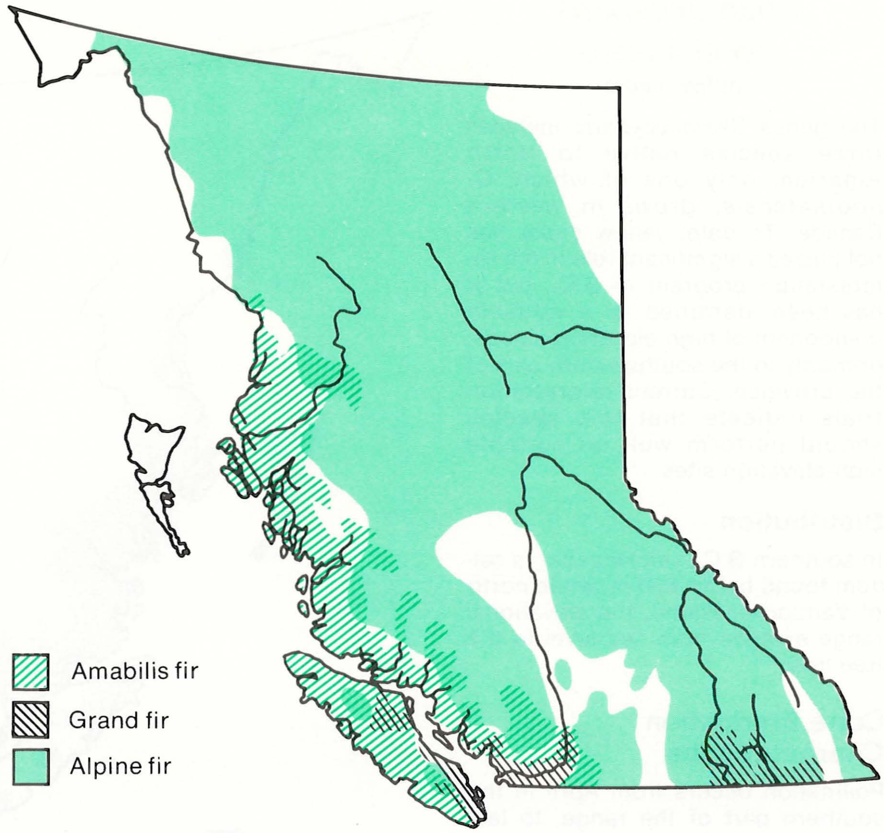
Cone Production Characteristics

In amabilis fir, pollination occurs from mid-April to mid-May or even later at higher elevations. In grand fir, pollination is usually completed in early May, while in alpine fir, pollination occurs between mid-May and mid-June. In all species, cones ripen the same year in which pollination occurs. Cones should be collected when embryos have reached 75% of their potential length and the endosperm tissue is firm. Cone color is not a reliable index of ripeness. The scales are not fused to the cone spike and ripe cones quickly disintegrate. Therefore, collections must be made before full maturity is reached. Insect damage may cause the scales to separate prematurely (Figure 17); therefore, the decision to collect must be based on embryo and endosperm development. Since most *Abies* cones will be collected before they are fully mature, it is especially important that they are stored in cool, well-ventilated areas to promote further ripening. Since ripe cones disintegrate on the tree, there is no danger of collecting old cones. (See Figures 13 and 17 for color photographs of true fir buds and cones.)

Species	Cone bearing age begins	Cone length	Period between collectable crops: avg.	Period between collectable crops: range	Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection: ½ sect.	Minimum filled seed count for collection: per cone	Collection period
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Abies amabilis	20	9-13	2-3			700			late Aug. to mid-Sept.
Abies grandis	20	5-12	5-6	3-8		700			late Aug. to mid-Sept.
Abies lasiocarpa	20	6-12	3	2-5		850			mid-Sept. to mid-Oct.

Distribution

Amabilis fir grows from sea level to 1500 m on Vancouver Island, but is not usually found this high on the adjacent mainland. Grand fir, the largest of the Canadian true firs, is found between sea level and 450 m on the coast, but up to 900 m in the Interior. Alpine fir grows abundantly between 600 and 2100 m in the Interior.



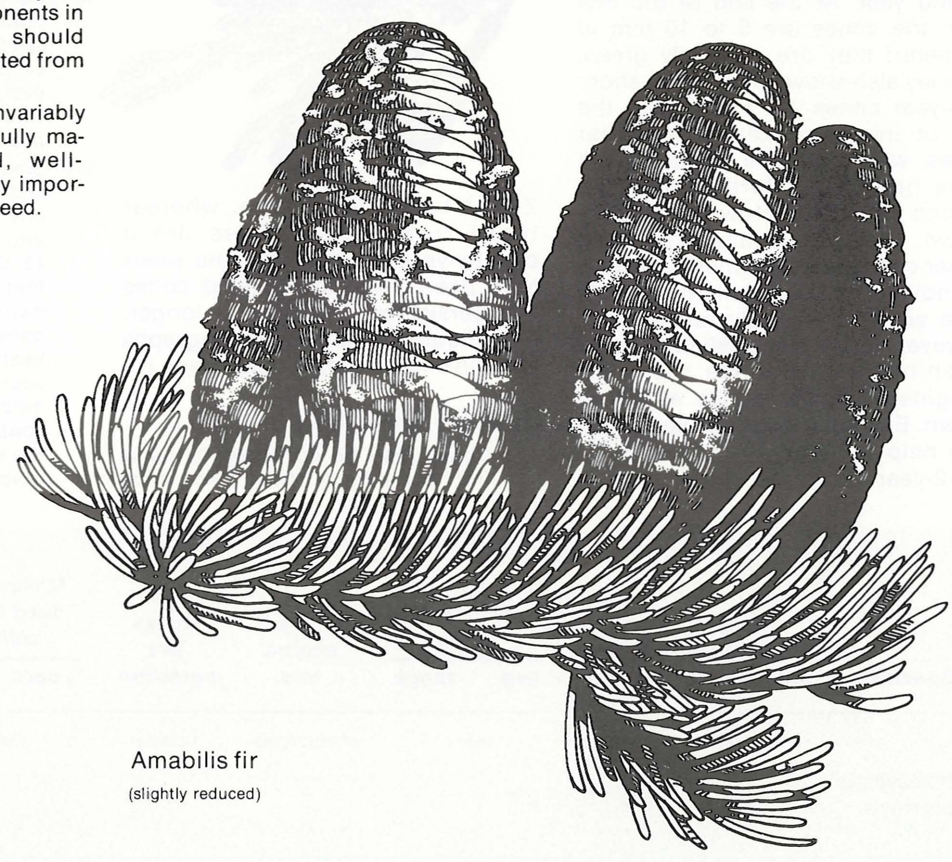
Special Notes

i) Cones should not be collected from stands in which balsam woolly aphid infestation has been observed. Under the provisions of the British Columbia Plant Protection Act, Balsam Woolly Aphid Regulation, movement of twigs of *Abies* species is forbidden. It is imperative, therefore, that all *Abies* cones be completely removed from twig or branch material before they leave the collection area.

ii) Cones may be collected from standing trees, but since the wood of most *Abies* species is brittle, considerable caution should be exercised. The uppermost cones should be regarded as inaccessible to climbers. However, trees may be topped, provided permission has been obtained from the District Headquarters.

iii) True fir trees may frequently be found as minor stand components in mixed stands. Collections should not be made from trees isolated from others of the same species.

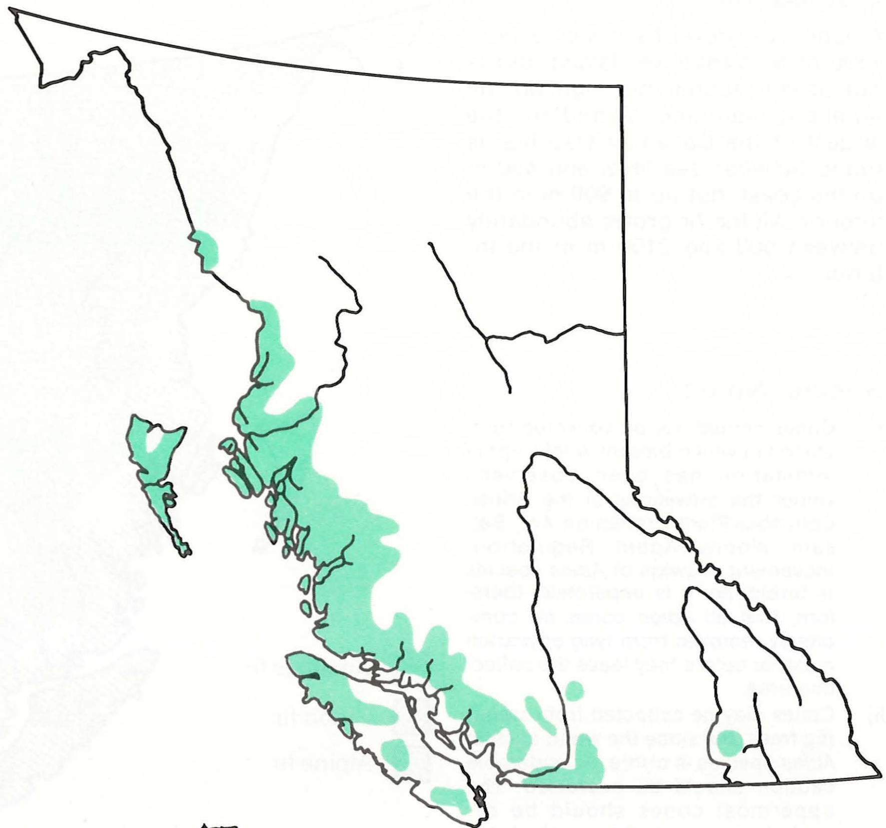
iv) Since true fir cones are invariably collected before they are fully mature, storage in a cool, well-ventilated area is particularly important to ensure best quality seed.



Amabilis fir
(slightly reduced)

Chamaecyparis nootkatensis

yellow cedar



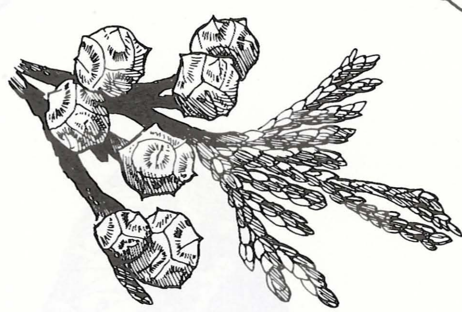
The genus *Chamaecyparis* includes three species native to North America, only one of which, *C. nootkatensis,* grows in western Canada. To date, yellow cedar has not played a significant role in the reforestation program in B.C., but it has been identified as a valuable component of high-elevation stands, primarily in the southwestern part of the province. Current reforestation trials indicate that this species should perform well on suitable high-elevation sites.

Distribution

In southern B.C., yellow cedar is seldom found below 600 m, while north of Vancouver Island, the elevational range extends from sea level to the tree line.

Cone Production Characteristics

Pollination occurs from April in the southern part of the range, to late May in the northern part, and cones may reach almost full size in the fall of the same year. They do not mature, however, until the fall of the following year. At the end of the first year, the cones are 5 to 10 mm in diameter; they are generally green, but may also show purple coloration. One-year cones are found near the tips of the branchlets. The 2-year cones, which may be found on the same branch but further from the branch tip, are yellow or golden-brown. They are usually larger than 1-year cones (up to 15 mm diameter), but not always so. The margins of the cone scales frequently turn brown; however, this is not a reliable distinguishing feature since the scale margins of 1-year cones may turn brown. Examination of the seeds will also help to distinguish between 1- and 2-year-old cones. Seeds from the



2-year cones are brown, whereas those from 1-year cones are a creamy-yellow color. After the seeds have been shed, the opened cones may persist for a third year or longer. (See Figure 19 for color photographs of yellow cedar cones and seeds.)

Special Notes

i) Cones may be collected by hand from standing or felled trees; cone rakes help in removing cones from branches.

ii) Multiple stemmed trees and coarse branching are characteristic of this species; consequently, the usual criteria for form do not apply. However, cone collectors should strive to select trees of the best possible phenotype.

iii) Since it is impossible to avoid collecting some unripe, 1-year cones in any collection, placing the cones into a kiln or heated room (not above 43°C) soon after collection, i.e. before they have had time to dry out naturally, will cause ripe, 2-year cones to open quickly. (Prolonged heating over several days will also open 1-year cones.) This method will help in separating 1- and 2-year cones. Seeds must be removed from the kiln as soon as the mature cones have opened.

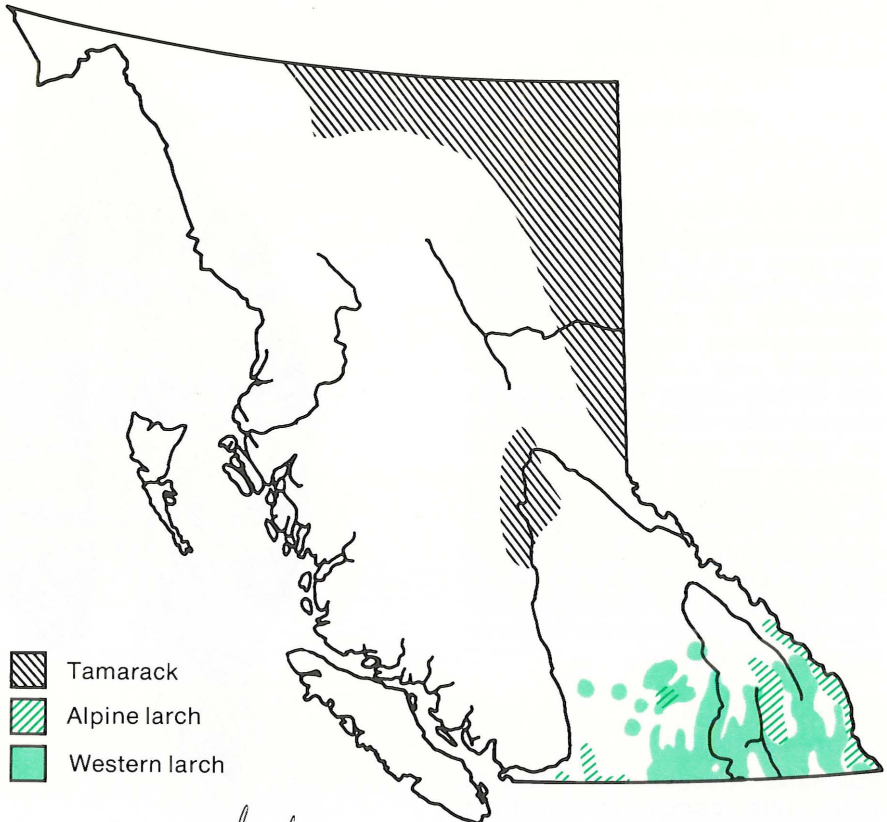
Species	Cone bearing age begins	Cone length	Period between collectable crops		Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection		Collection period
			avg.	range			½ sect.	per cone	
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Chamaecyparis nootkatensis	15	0.5-1.5	2-4			130 000		2	Aug. to Oct.

Larix laricina
tamarack
Larix lyalli
alpine larch
Larix occidentalis
western larch

All three of the *Larix* species native to North America occur in B.C. Western larch is an important reforestation species in the southern interior, while alpine larch and tamarack are currently of ecological value only.

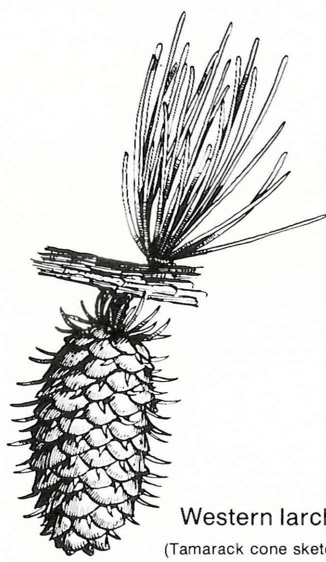
Distribution

Western larch is a characteristic tree of the southeastern part of B.C., growing between 450 and 1800 m. Alpine larch, found within approximately the same geographical area, grows between 1800 and 2100 m. These species may hybridize near their boundary. In B.C., tamarack grows best on favorable sites between 180 and 520 m.



Cone Production Characteristics

Pollination generally occurs from late May to early June in western larch and tamarack, but may be delayed until late June in alpine larch. Cones mature in the late summer-early fall of the same year. Cones should be collected as soon as they are ripe. Ripe cones are brown, and within them, seed coats are brown and hard, embryos are fully developed and endosperm tissue is firm. Cones may be found for some distance along the branch, being most common on 2- to 4-year-old branchlets, but are also found on branchlets 5 to 10 or more years old. Cones of alpine larch resemble those of western larch, but are larger and may have noticeably reflexed bracts. (See Figures 4 and 19 for color photographs of western larch buds and cones.)


Western larch

(Tamarack cone sketch, p. 28; alpine larch sketch, p. 40)

Special Notes

i) Cones should be collected only from trees free from infestation by dwarf mistletoe.

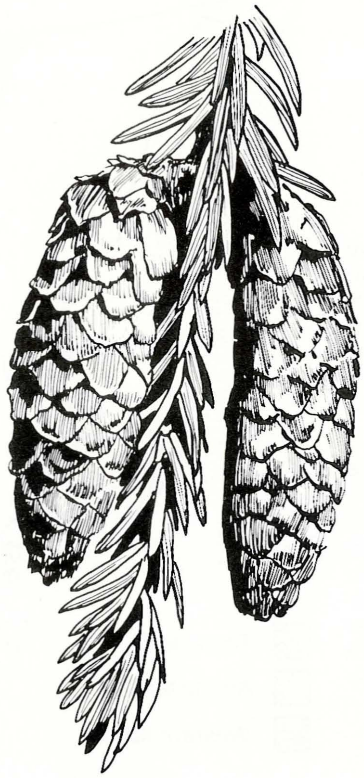
ii) Larch stems and branches are very brittle. Extreme caution must be exercised when climbing. Branches break off when bent toward the climber for cone picking.

iii) Old cones may persist indefinitely on the tree; therefore, it is generally not practical to attempt to rake cones from branches.

Species	Cone bearing age begins	Cone length	Period between collectable crops avg.	range	Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection ½ sect.	per cone	Collection period
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Larix laricina	40	1-1.5	5-6						Aug. to Sept.
Larix lyalli	30	4-5							Aug. to Sept.
Larix occidentalis	25	3-4	5-6			11 000	6-8	40	Aug. to Sept.

Picea engelmanni
Engelmann spruce
Picea glauca
white spruce

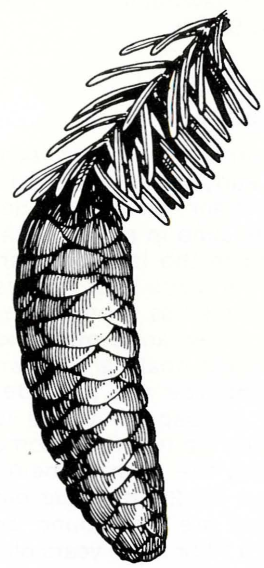
Of the 40 or more species of *Picea,* eight are native to North America and four grow in B.C. White and Engelmann spruce are similar species, especially in cone production characteristics, and are known to hybridize over a considerable portion of their range. For this reason, they are often referred to collectively as "interior spruce". Problems in achieving prompt natural regeneration of interior spruce have been encountered. In view of this difficulty, and the broad distribution of the species, seedling production has increased and interior spruce now represents a major component of the reforestation program.



Engelmann spruce

Cone Production Characteristics

Pollination occurs in mid-May to early June; cones are ripe from mid-August to early September of the same year. Cones are ready for collection when seed coats and wings have become golden-brown, the endosperm tissue is firm and the yellow-green embryos have elongated to 75% of their potential length. Collection period from standing trees seldom exceeds 14 days. (See Figures 4, 10, 16 and 17 for color photographs of white spruce buds, flowers and cones.)



White spruce

Species	Cone bearing age begins	Cone length	Period between collectable crops		Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection		Collection period
			avg.	range			½ sect.	per cone	
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Picea engelmanni	15	3-8	5	2-10		8 300	7-10		mid-Aug. to Sept.
Picea glauca	20	3-6	6	2-12		11 000	7-10		mid-Aug. to Sept.

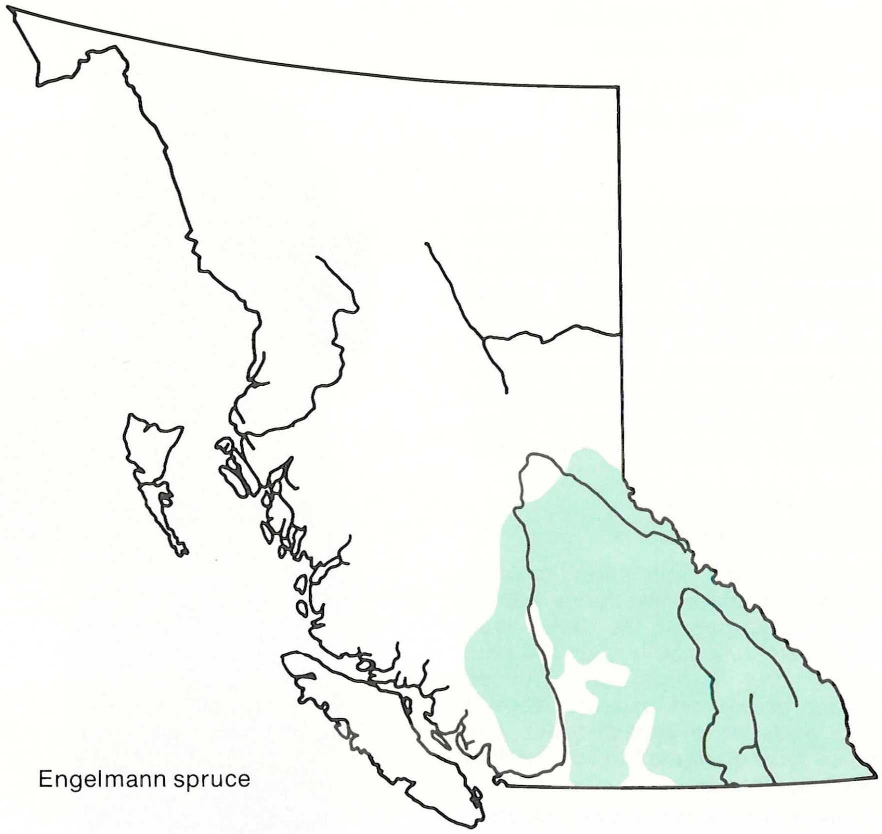
Distribution

In the southern part of B.C., Engelmann spruce is a minor forest component between 450 and 1000 m but becomes a major one between 1000 m and timberline. In that part of the range where the two species overlap, Engelmann spruce is found mainly on the upper slopes, with white spruce predominating at lower elevations; at intermediate elevations, hybrids of the two are common. In the central interior, interior spruce is a major component between 600 and 1500 m. In the northern part of the province, white spruce is a major component as low as 300 m.

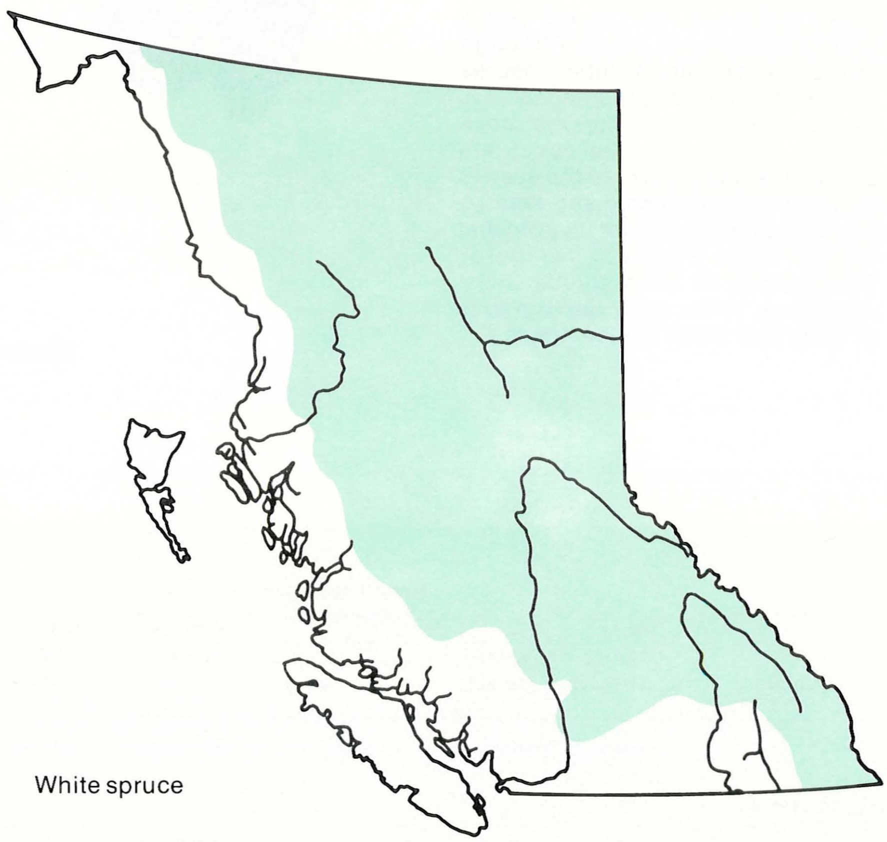
Special Notes

i) Climbing is usually difficult in unthinned natural stands since tree limbs are small and cones are predominantly in the uppermost parts of the crown; the foliage is also prickly. Climbing may be feasible, however, in seed production areas where controlled spacing has been practiced. Ladders may be useful in gaining access to limbs adequate for climbing.

ii) The cones are usually quite pitchy.



Engelmann spruce



White spruce

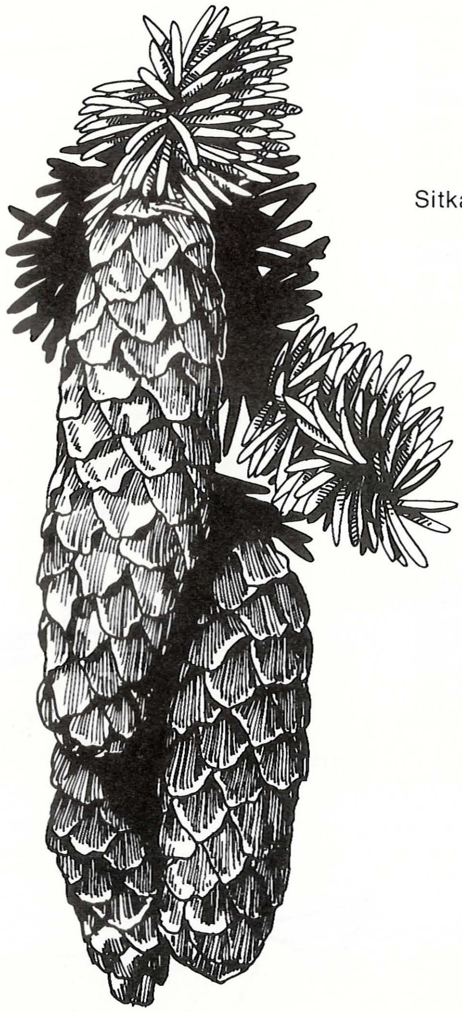
Picea mariana
black spruce
Picea sitchensis
Sitka spruce

Sitka spruce represents only a minor component of the provincial reforestation program. The susceptibility of this species to the Sitka spruce weevil has restricted planting in the south coastal area. Black spruce has not been included in the reforestation program to date, but this species could become important as close-utilization management is extended.

Cone Production Characteristics

In Sitka spruce, pollination occurs in late-April to early May; cones ripen in mid-September of the same year. Cones are collectable when the seed coats and wings have turned golden-brown, endosperm tissue is firm and the yellowish-green embryos have elongated to 75% of their potential length.

In black spruce, pollination occurs in mid-June and cones mature in early September of the same year. Cones are persistent and semi-serotinous; viable seeds are shed slowly over a period of about 4 years. Although this semi-serotinous habit ensures an almost constant seed supply, it is best to collect shortly after the cones mature. At maturity, the cones are purple, the endosperm of the seed is firm and the yellowish-green embryo has elongated to 75% of its potential length. (See Figure 4 for color photographs of Sitka spruce buds; see Figure 17 for color photographs of Sitka and black spruce cones.)



Sitka spruce

Black spruce

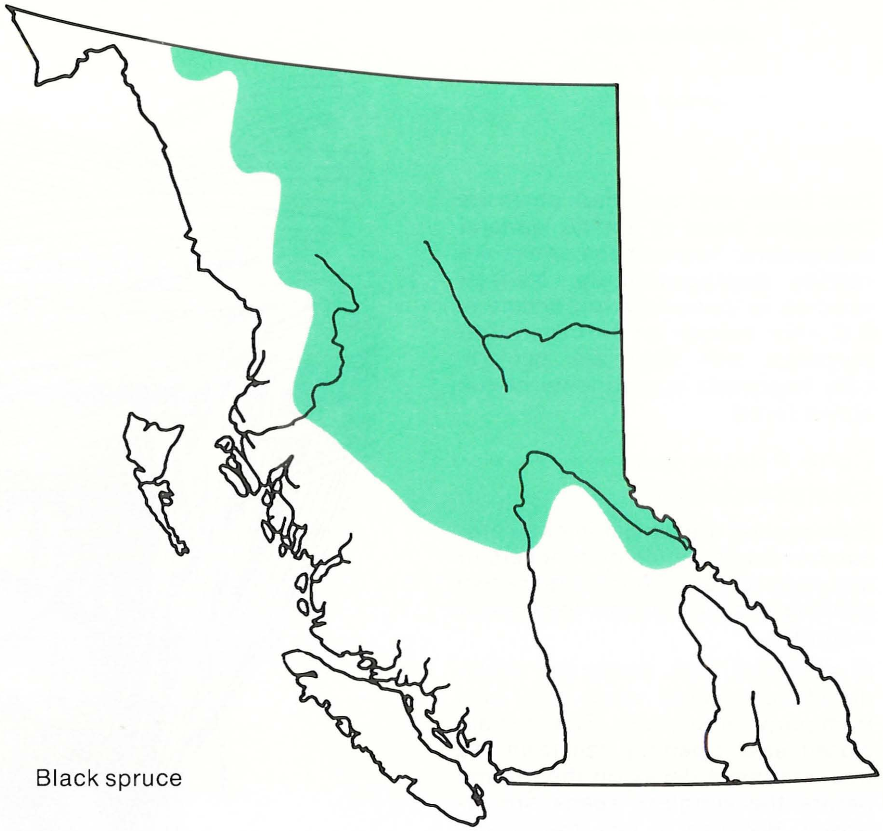
Species	Cone bearing age begins	Cone length	Period between collectable crops		Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection		Collection period
			avg.	range			½ sect.	per cone	
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Picea mariana	10	1-4	4-5	2-6					Sept.
Picea sitchensis	20	6-10	3-4	2-5	0.5-1	4 700	7-10		Sept.

Distribution

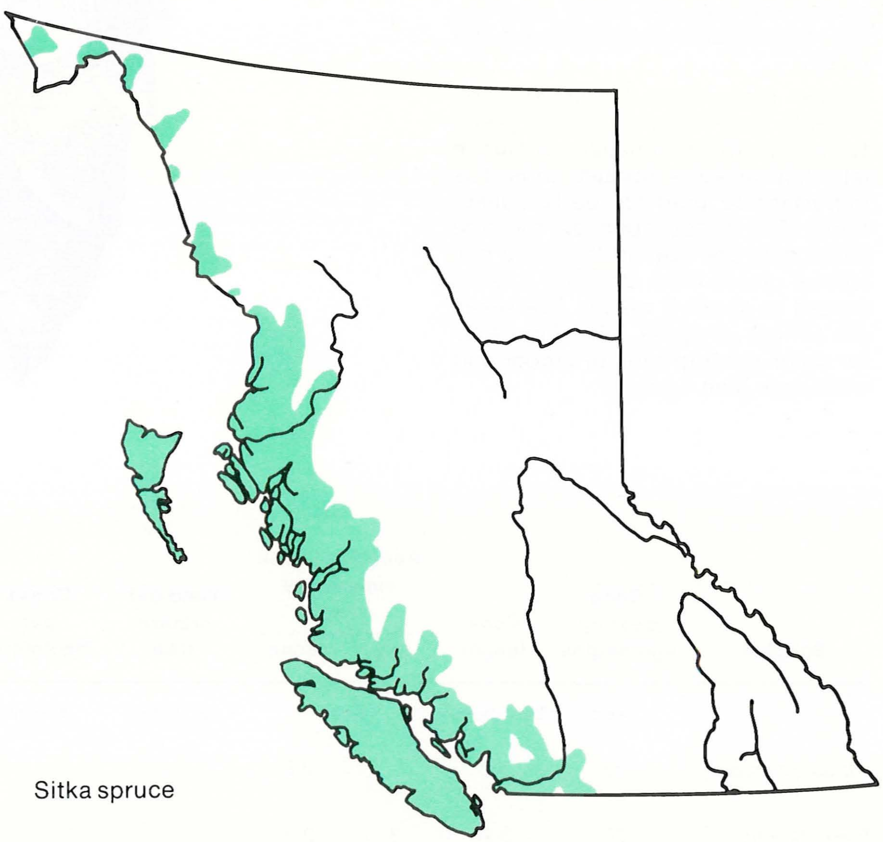
Sitka spruce grows between sea level and 800 m but best growth is found below 300 m; it occupies the most humid and productive forest land along river valleys. Black spruce occurs mostly between 300 and 1000 m.

Special notes

i) Cone collections for both species are usually made from felled trees. Since mature Sitka spruce can be 60 m tall and surrounded by heavy underbrush, it is especially important to fell trees into areas that have been cleared of brush and debris.



Black spruce



Sitka spruce

Pinus albicaulis
whitebark pine
Pinus flexilis
limber pine

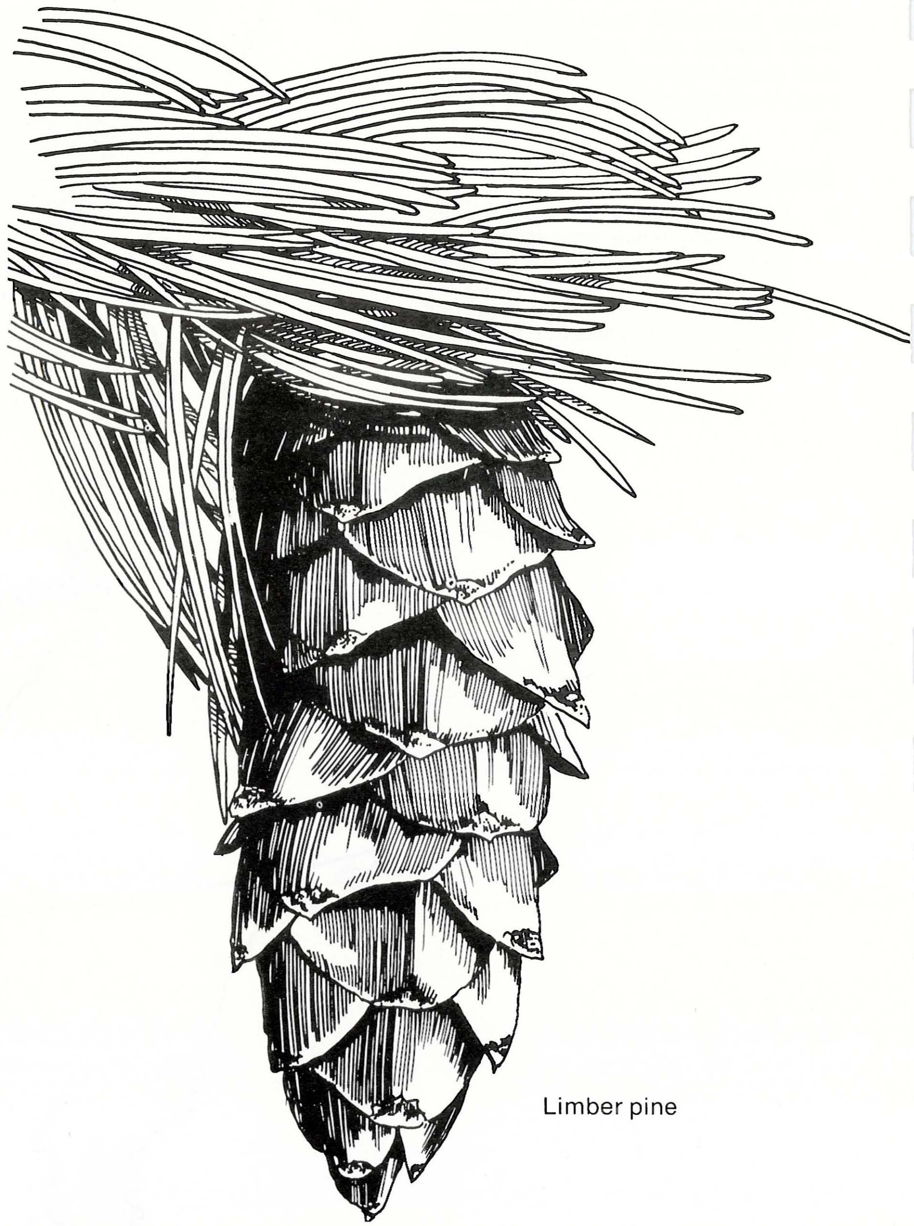
Both limber and whitebark pines are timberline trees of similar general appearance; however the cones are readily distinguishable. Neither species is currently important in B.C., for timber or reforestation purposes, but they are ecologically important components of the alpine forest.

Cone Production Characteristics

Both species are similar in cone production habits. Pollination occurs in late June to July. Cones require two growing seasons before they reach maturity.

In whitebark pine, cones are considered collectable when they turn from purplish to brown. They remain closed after ripening, fall from the tree, and must decay on the ground before the wingless seeds are released. Because of this, the collection period is a prolonged one. However, the seeds are a favorite food of ravens and jays and heavy seed losses may occur if collections are delayed.

Limber pine cones are usually collectable when they turn from green to light brown. This usually occurs in late July or early August, thus it is important to plan for early collections. The cones open on the tree when they are ripe so the cone collection period from standing trees is limited to about 3 weeks. The seeds are almost wingless. (See Figure 21 for color photographs of limber and whitebark pine cones.)



Limber pine

Species	Cone bearing age begins	Cone length	Period between collectable crops avg.	Period between collectable crops range	Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection ½ sect.	Minimum filled seed count for collection per cone	Collection period
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Pinus albicaulis	20	4-8		3-5					Aug. to Sept.
Pinus flexilis	20	8-20	3	2-4					late July, Aug. to Sept.

Distribution

Limber pine is found only in the headwaters of the Columbia River, between 1000 and 2000 m. Whitebark pine occurs in both the southern parts of the Rocky Mountains and the Coastal Range, between 1000 and 2000 m.

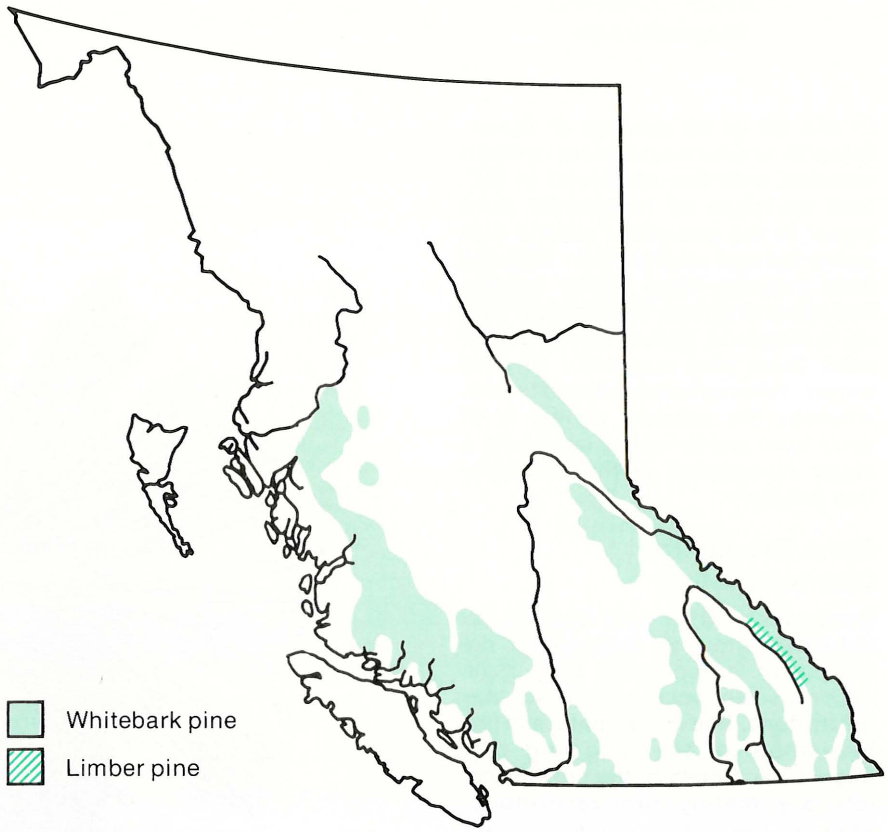
Special Notes

i) Coarse branching and multiple stems are common to both species. Cone collections should be made from the best phenotypes available.

ii) The usual method of collecting is by climbing; since both species seldom exceed 15 m in height, pruning hooks may be used. Collections from closed stands of whitebark pine should be from felled trees; if snow conditions permit, intact fallen cones might be collected from the ground.

iii) In limber pine, old cones, recognizable by their grey-brown weathered appearance and open scales, should be avoided.

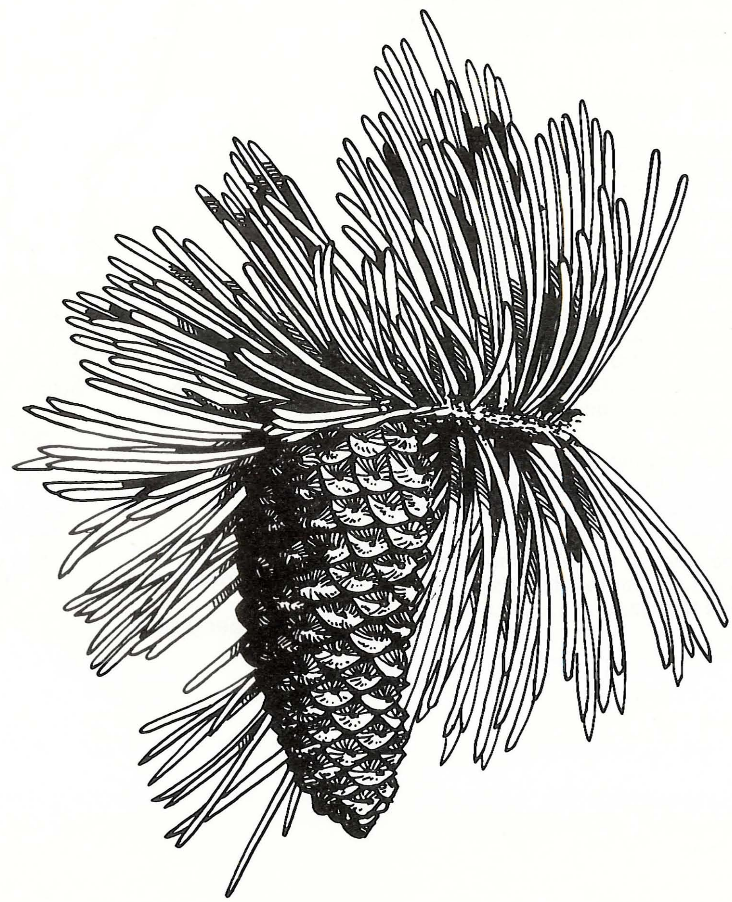
iv) See Special Note ii, *Pinus contorta* (page 67), for restrictions on moving pine foliage.



Whitebark pine

Pinus contorta
lodgepole pine

Of the 80 or 90 species of *Pinus*, some 35 of which are native to North America, only five are found in B.C. Two varieties of lodgepole pine occur in the province: coastal (var. *contorta*) and interior (var. *latifolia*). Both varieties have similar foliage, flowers and cones. The coastal variety is, however, generally scrubby, of poor form and currently of only minor reforestation importance, whereas the interior variety is of good form and is rapidly becoming a major component of the reforestation program.



Cone Production Characteristics

Cones of all B.C. pine species require two growing seasons for development. In lodgepole pine, pollination usually occurs from mid-May to late June. The cones mature in late September of the following year (Figure 21). Cones of the coastal variety are mainly non-serotinous, whereas the interior variety usually bears serotinous cones. Cone serotiny is silviculturally important, in that large quantities of viable seeds are available for release following a wild fire or cutting. In both varieties, cones persist on the trees for many years but only freshly ripened cones have the highest numbers of viable seeds. This makes cone selection an important feature of lodgepole pine cone collections. Immature 2-year-old cones are dark green in August and early September. The seeds are ripe when the cones have turned a shiny golden-brown (late September-October).

In the coastal variety, only freshly ripened cones, found near the branch tips, should be collected. Cones further along the branch are older, have a weathered appearance and are often open; they contain negligible amounts of usable seeds, and should be avoided. The collection period from standing trees is variable, depending upon the degree of cone serotiny; the period between cone ripening and seed dispersal may be 4 weeks or longer.

For the interior variety, the cones of which are mainly serotinous, the following classes have been defined:

Species	Cone bearing age begins	Cone length	Period between collectable crops: avg.	Period between collectable crops: range	Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection: ½ sect.	Minimum filled seed count for collection: per cone	Collection period
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Pinus contorta	10	3-5	3	2-4	0.5-1	8 300		20	Oct. to Mar.

Class I - Freshly ripened, current year's cones
Class II - Partially weathered, closed cones
Class III - Fully weathered, closed cones
Class IV - Partially-opened or opened, old or new cones

Classes I and II may be collected; classes III and IV are to be avoided. These classes are illustrated in Figure 26. The period of cone collection is much longer than in the coastal variety; collections can be made any time after ripening, since few cones open while on the tree unless exposed to the high temperatures produced by forest fires. Fall collections (both varieties) are preferable to allowing the seed to remain on the tree overwinter, which may reduce seed viability. Best cone opening in the kiln, and thus seed recovery, is also obtained from fall collections that are promptly processed. (See Figures 21 and 26 for color photographs of lodgepole pine cones.)

Distribution

Lodgepole pine is the most widespread conifer within B.C. and may be found on a wide variety of sites from sea level to timberline.

Special Notes

i) Cones should not be picked from trees heavily infested with dwarf mistletoe.

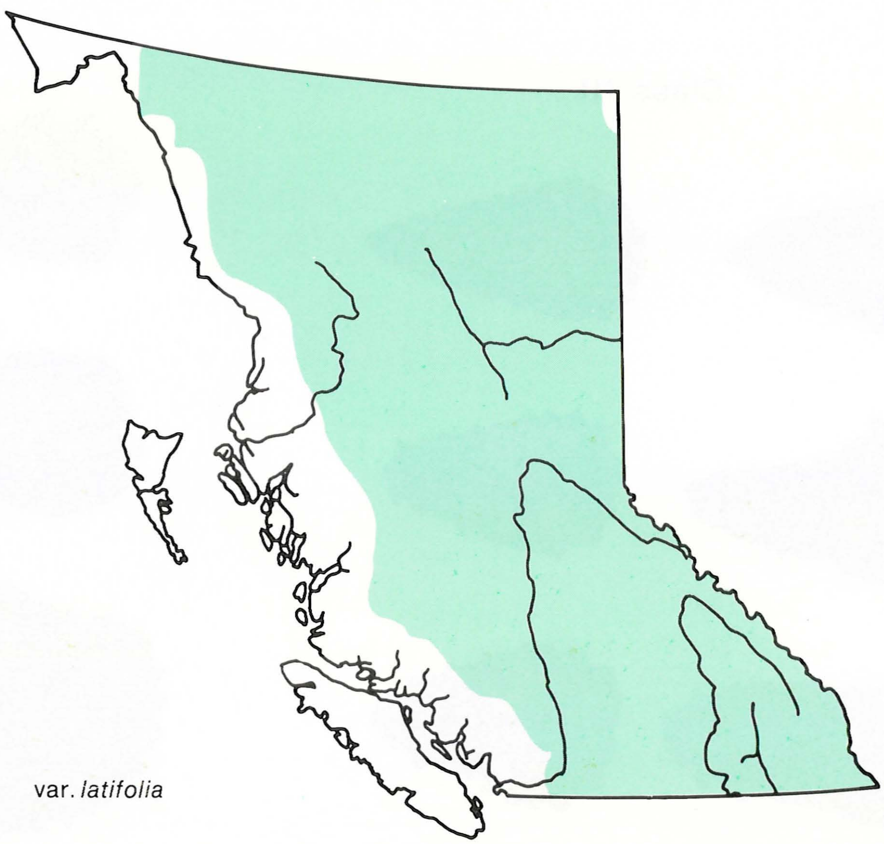
ii) Because provisions of the British Columbia Plant Protection Act, European Pine Shoot Moth Regulation, restrict the movement of the foliage of any *Pinus* species within and from the Vancouver Forest District, it is imperative that all foliage be separated from pine cones before they leave the collection area.

iii) Cones are usually picked from felled trees. They are persistent and picking is easier when temperatures are below -15°C, since the cone stalks are then brittle.

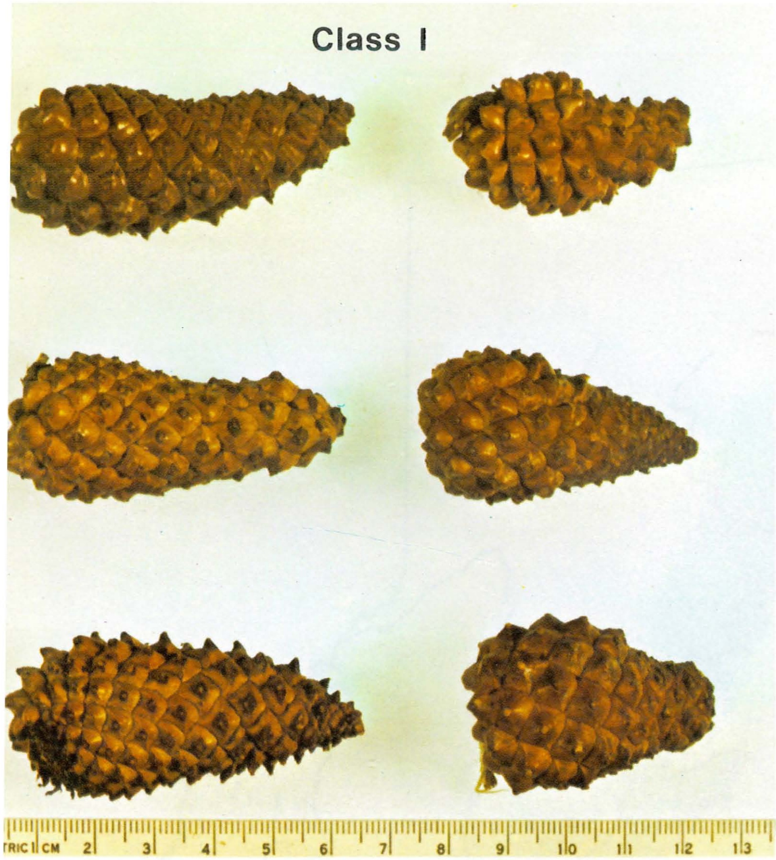
iv) Collections may be delayed until cone crops of other species have been harvested. However, cones should be processed soon after collection.

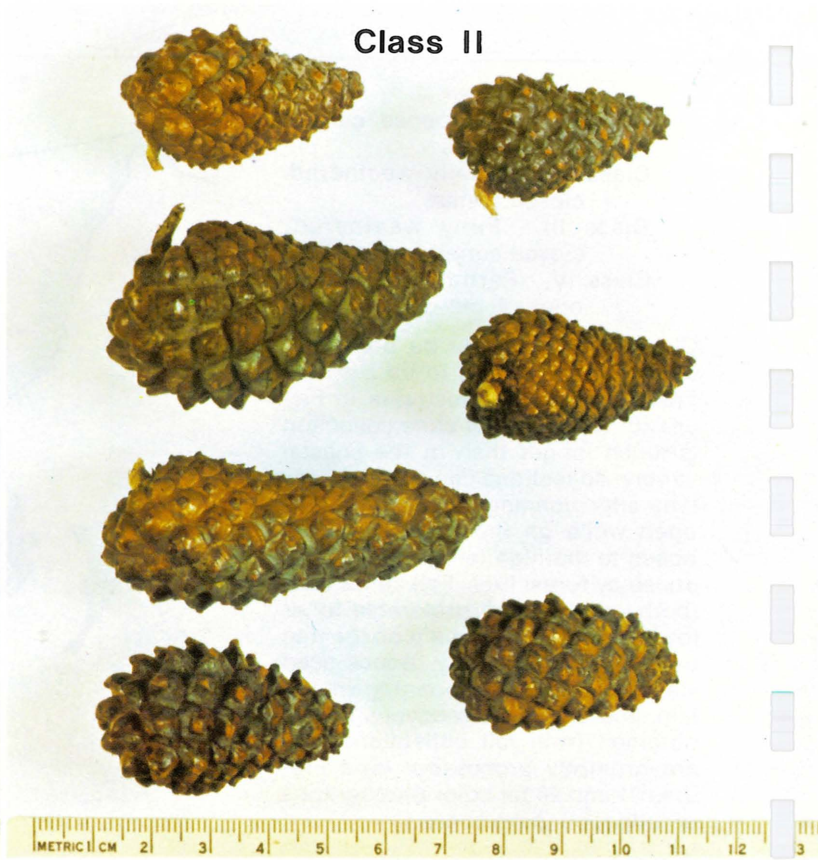
v) Since cone moisture levels are usually low, well-ventilated interim storage, while desirable, is not essential. Prolonged storage should be avoided as there appears to be tension loss in the cone scale release mechanism, leading to subsequent extraction problems.

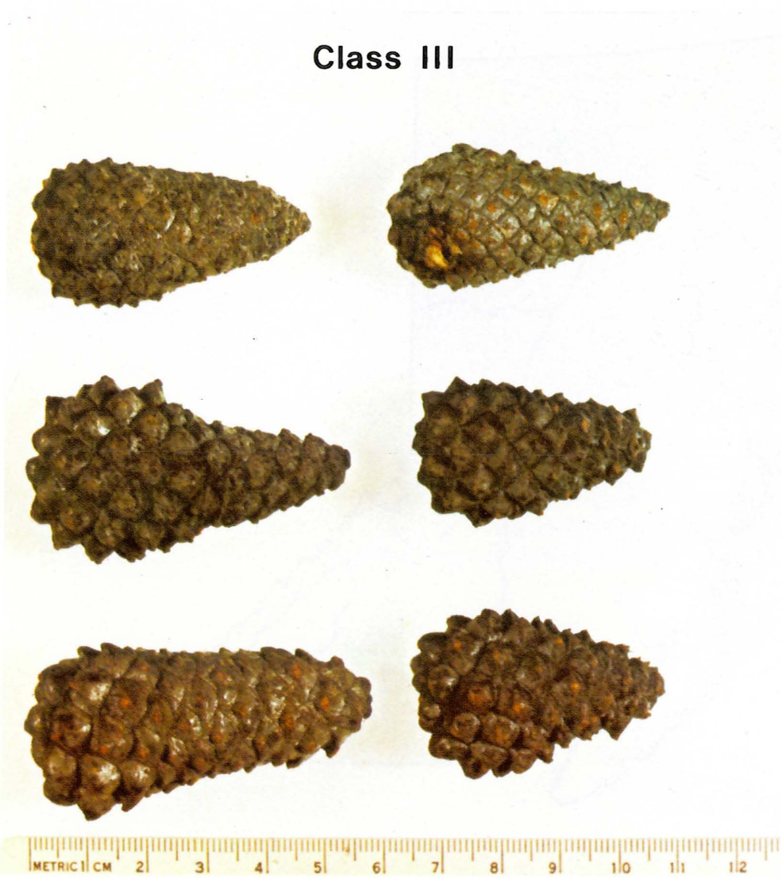
var. *contorta*



var. *latifolia*


Class I


Class II


Class III


Class IV

● Figure 26. **Lodgepole pine cone classes.**

Cones to Be Collected

Class I

Current Year's Cones
Usually brown, bronze or gold color on all faces, and tightly closed.
Cone age, 2 years.
Note - Do not collect when cones are olive in color, as the seeds are not fully mature.

Interior lodgepole pine cones require 2 years to open and are mostly serotinous, i.e. maturity occurs in late autumn and they are persistent and remain closed at maturity and for a lengthy time thereafter.

Class II

Partly Weathered Cones
Usually bronze, brown or gold on one face and grey (weathered) on other faces.
Cones tightly closed.
Cone age, 3 to 5 years (approximately).

Only a few cones open after ripening in the undisturbed stand at normal temperatures. A fire or logging disturbance is usually required to open and disperse seeds from serotinous cones.

Cones NOT to Be Collected

Class III

Fully Weathered Cones
Generally grey color and weathered appearance on most faces of cone, but tightly closed.
Cone age definitely greater than class II cones.

Non-serotinous cones usually open at maturity in the undisturbed stand at normal temperatures.

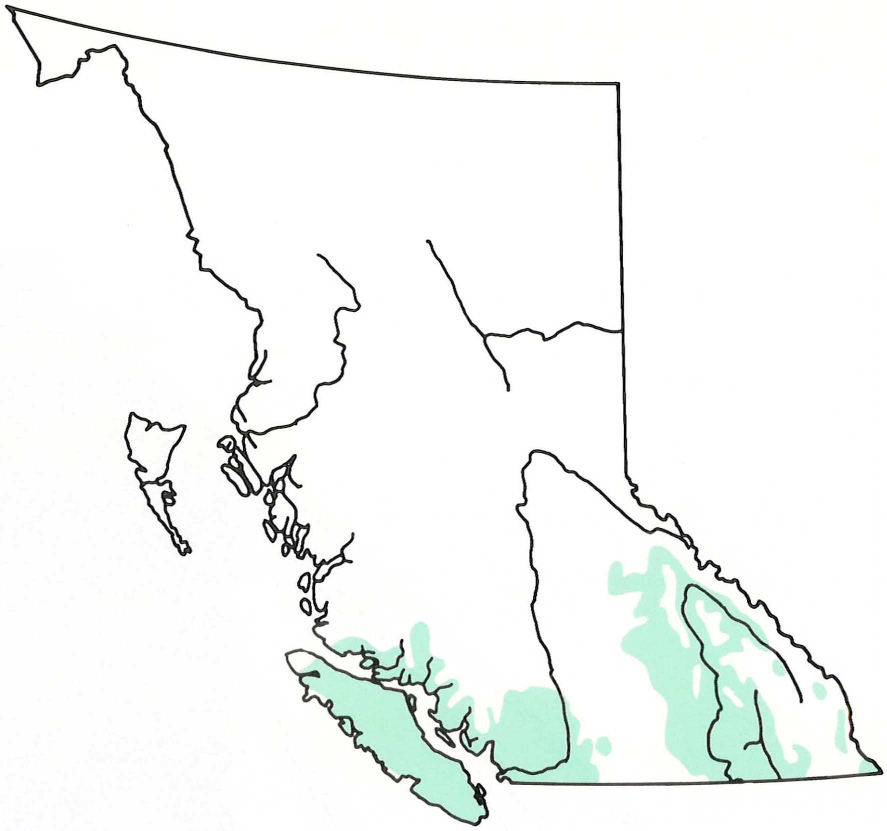
Class IV

Opened Cones
Cones variable in color, but have opened or partially opened and some or all seeds have been dispersed.

Western white pine

Pinus monticola

western white pine



Throughout its range in B.C., western white pine grows on a wide variety of soils and sites. It is a fast growing tree, generally overtopping its competitors on most sites. The species is highly susceptible to white pine blister rust and many trees fail to reach merchantable size. Due to the severity and extent of this disease, reforestation of western white pine has been negligible. However, efforts in breeding rust-resistant strains are promising and this species could gain a role in the reforestation program.

Distribution

Western white pine occurs in the southern part of the coastal mountains from sea level to timberline. In the wet belt of the Interior, it is found between 300 and 1700 m.

Cone Production Characteristics

Pollination occurs in mid-June to mid-July. The female conelets are 1.5 to 3.5 cm long at pollination, and are 5 to 10 cm long at the end of the first growing season. When mature, at the end of the second season, they may exceed 25 cm in length. Cones are collectable when they turn from green to yellowish or red-brown. The cone collection period from standing trees is about 14 days. (See Figure 21 for color photograph of western white pine cones.)

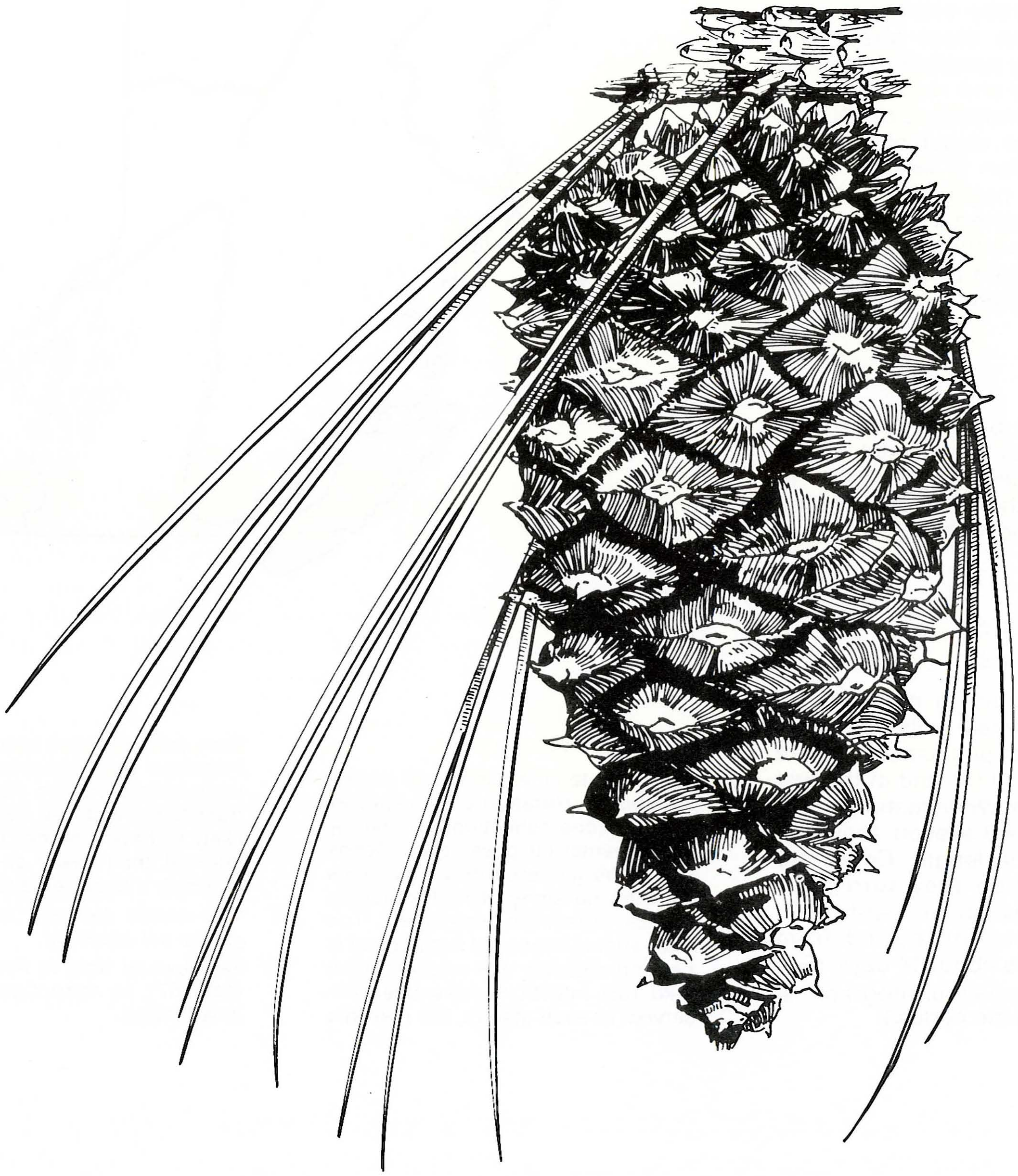
Special Notes

i) As the white pine blister rust has restricted reforestation of this species to date, cone collections will be for experimental purposes only. Cones should be gathered only from trees showing no signs of rust infection, unless otherwise instructed. The trees should be part of a stand that is nearing rotation age and in which mild rust infections have been observed. In such stands, the rust-free trees probably have been exposed to infection and, therefore, may be more resistant to the disease. Seeds from these rust-free trees are more likely to have a higher resistance to the rust than seeds collected from infected, immature trees.

ii) The cones are very resinous and gloves are essential.

iii) See Special Note ii, *Pinus contorta* (page 67), for restrictions on moving pine foliage.

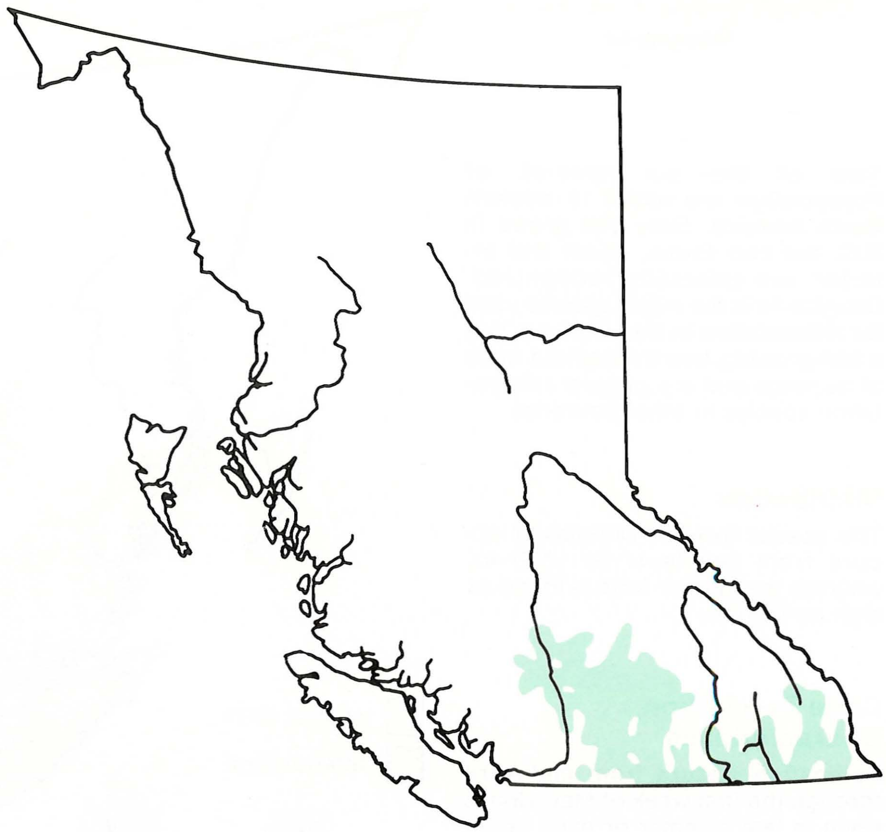
Species	Cone bearing age begins	Cone length	Period between collectable crops avg.	Period between collectable crops range	Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection ½ sect.	Minimum filled seed count for collection per cone	Collection period
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Pinus monticola	10	10-25	4	3-7	0.2-0.5	280		90	late Aug. to early Sept.



Ponderosa pine

Pinus ponderosa

ponderosa pine or yellow pine



Ponderosa pine frequently occurs in pure, but open, park-like stands on dry and generally unproductive forest sites. It will grow on a wide variety of soils, but makes its best growth on well-drained, deep soils. This species represents a very minor component of the provincial reforestation program.

Distribution

Ponderosa pine is found only in the south-central and southeastern parts of the province, from 250 m in the Fraser Canyon area to 1100 m further east.

Cone Production Characteristics

Pollination occurs between mid-May and mid-June. At this time, the female conelets are about 2.5 cm long and, at the end of the first growing season, they are 3 to 4 cm long; they reach full size about mid-August of the second growing season. Cones are ripe in late August to early September and are collectable when they have turned from green-yellow or purplish to a yellowish-brown. The cone collection period from standing trees is about 14-20 days. (See Figures 16 and 21 for color photographs of ponderosa pine flowers and cones.)

Special Notes

i) The branches of ponderosa pine are brittle, so extra care must be taken when climbing.

ii) Cones should be bent toward end of branch to break the stalk; they can also be knocked or shaken off and gathered from the ground later. (Heavy cones and wind-firmness make this species a candidate for mechanical tree shaking as a collection method.)

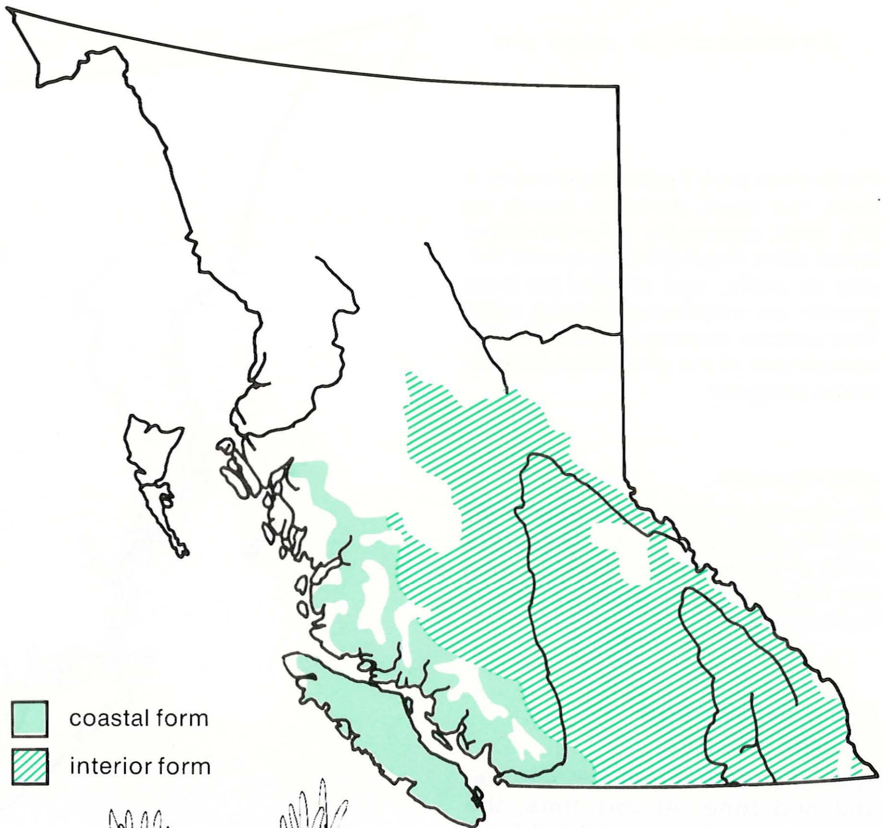
iii) As cones have sharp prickles protruding from the scales, gloves are essential.

iv) See Special Note ii, *Pinus contorta* (page 67), for restrictions on moving pine foliage.

Species	Cone bearing age begins	Cone length	Period between collectable crops		Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection		Collection period
			avg.	range			½ sect.	per cone	
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Pinus ponderosa	15	8-15	3	2-5	1-1.5	700		75	late Aug. to early Sept.

Pseudotsuga menziesii

Douglas-fir



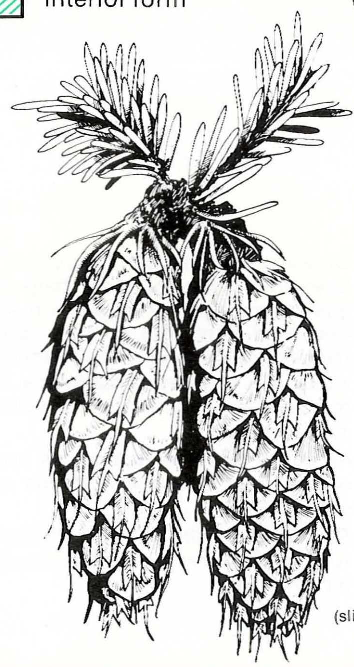
Two of the six species of *Pseudotsuga* are native to western North America. Only one grows in B.C. but two forms, coast and interior, are generally recognized. Douglas-fir is the major species used for reforestation in the province. It is a fast-growing tree throughout most of its range and is a popular reforestation species in other countries.

Distribution

The coastal form of Douglas-fir occurs from sea level to 1200 m, whereas the interior form is found as high as 1500 m.

Cone Production Characteristics

Pollination occurs from mid-April through the first week of May. Cones ripen in late summer or early fall of the same year. Cones may be picked up to 4 weeks before seed dissemination begins and, if stored in sacks in cool, well-ventilated and shaded areas, they will continue to ripen artificially and good quality seeds will be obtained. Cones are usually considered collectable when they begin to turn from green to yellowish-brown; the seed coats and wings are then a golden-brown, the seeds detach readily from their scales and their endosperm has become firm. In addition, the embryo has elongated to at least 75% of its potential length. (See Figures 5, 6, 8, 9 and 16 for color photographs of Douglas-fir buds, flowers and cones.)



(slightly reduced)

Special Notes

i) Cones must not be collected from trees heavily infested with dwarf mistletoe.

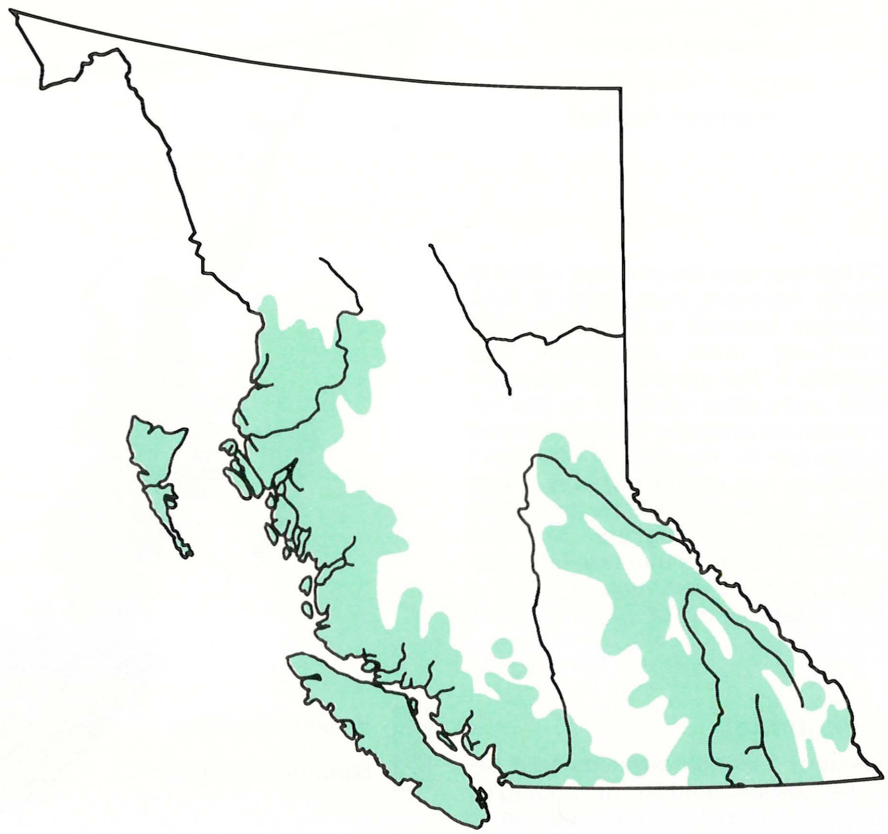
ii) Young, full-crowned trees are easily climbed.

iii) Old cones, recognizable by their grey-brown weathered appearance and stiffly open scales should be avoided.

iv) Plantations should be avoided for cone collections, unless original provenance is known.

Species	Cone bearing age begins	Cone length	Period between collectable crops: avg.	range	Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection: ½ sect.	per cone	Collection period
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Pseudotsuga menziesii	15	5-10	5	2-10	0.5-1	2 800	5-7		mid Aug. to early Sept.

Thuja plicata
western red cedar



Of the two species of *Thuja* native to North America, only *T. plicata* grows in B.C. Because this species regenerates well naturally, only minimal numbers of seedlings have been planted to date. It is expected that its reforestation importance will increase in the future as decadent, overmature western red cedar stands are rehabilitated.

Distribution

Western red cedar is confined almost entirely to regions with abundant precipitation and atmospheric humidity. It may be found above 1500 m, but its growth becomes very stunted.

Cone Production Characteristics

Pollination may occur as early as mid-April on warmer sites but, at higher elevations, flowering may be delayed until late May or early June. Cones mature in late summer or early fall of the same year. They should be picked as soon as they turn brown and the seed has become firm. Current cones are borne very near branchlet tips; old cones, distinguishable by their weathered, grey-brown color and open scales, are found further along the branch and should be avoided. Cedar seed seems to have a shorter storage life than that of many other conifers, but this is offset by frequent seed crops; therefore, it is unnecessary to maintain more than a 5-year seed inventory. (See Figures 13 and 19 for color photographs of western red cedar buds and cones.)

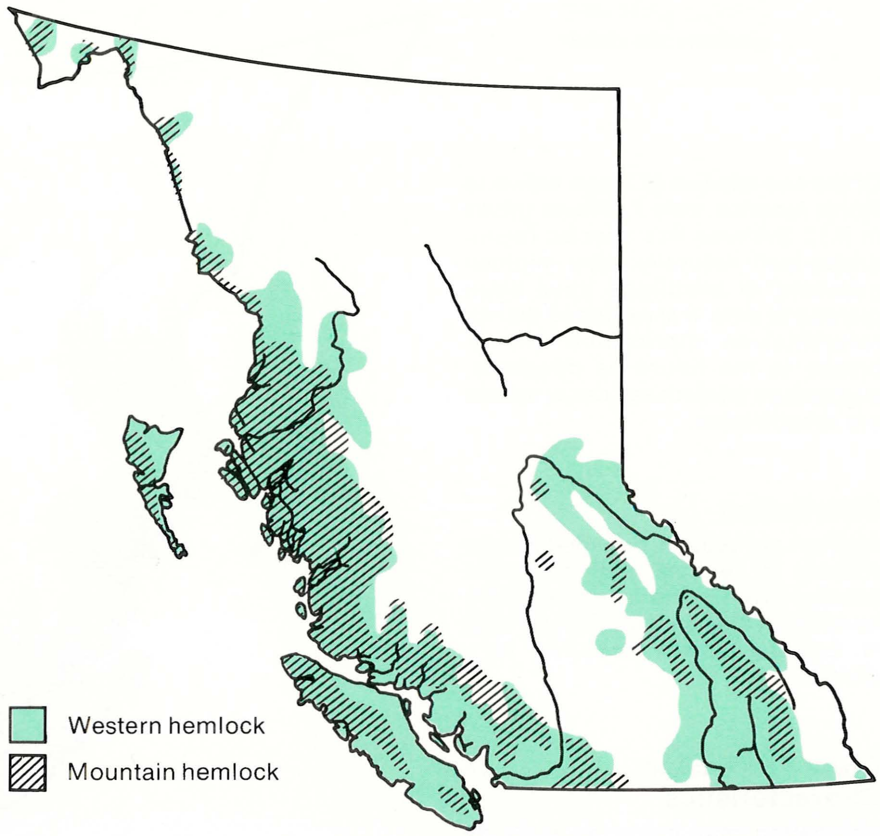
Special Notes

i) There are few limitations in selecting cedar trees from which cones may be collected. Only severely deformed trees should be avoided.

ii) Cone rakes may be used to collect cones from felled trees.

Species	Cone bearing age begins	Cone length	Period between collectable crops		Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection		Collection period
			avg.	range			½ sect.	per cone	
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Thuja plicata	15	1-2	2-3	1-4		110 000			Aug. to Sept.

Tsuga heterophylla
western hemlock
Tsuga mertensiana
mountain hemlock



Of the four species of *Tsuga* native to North America, two grow in B.C. Western hemlock is one of the commercially most important tree species in the province. It has come into increasing demand in the reforestation program and this trend is expected to accelerate. Mountain hemlock has comprised only a very small component of the provincial reforestation program, but this species is likely to increase in importance as more attention is given to the regeneration of high elevation sites.

Distribution

Western hemlock develops best between sea level and 600 m, ranging up to 1200 m on the coast and up to 1500 m in the Selkirk Mountains. Mountain hemlock is a timber line species commonly occurring between 1000 to 1500 m. At elevations where they overlap, hybridization between these two species may occur.

Cone Production Characteristics

In western hemlock, pollination occurs from April in the southern part of the range, to May in the northern part. In mountain hemlock, pollination takes place in June or July. In both species, cones ripen in the autumn of the same year in which pollination occurs. Cones should be picked as soon as they ripen, which is usually indicated by a color change from green to purplish or yellow-brown. (See Figures 13, 16 and 19 for color photographs of western and mountain hemlock buds, flowers and cones.)

Special Notes

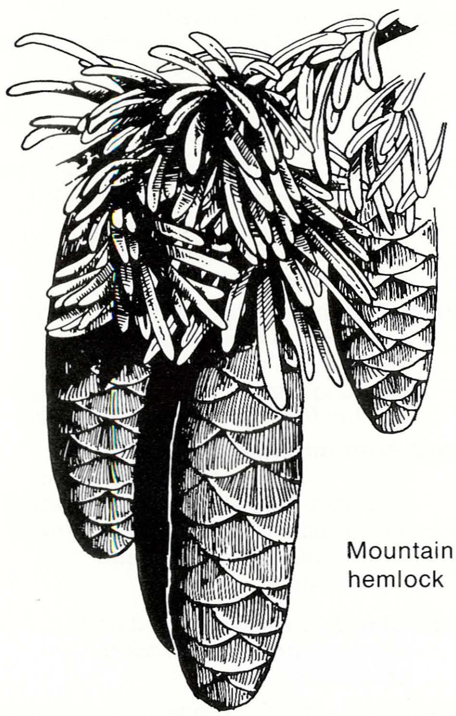
i) Cones should not be collected from trees heavily infested with dwarf mistletoe.

ii) Cone rakes may be used when picking from felled trees.

iii) If picked too early, while still green, problems with cone opening may be encountered at the extractory. On the other hand, since western hemlock seeds can germinate in cool, moist conditions, cones should be extracted promptly after picking. Under coastal conditions, cones must be extracted within 1 month after collecting.

iv) Old cones of western hemlock should be avoided; these are recognizable by their dark brown/greyish color and their open scales. In Mountain hemlock, cones usually fall off the tree in the spring or early summer of the second year.

Species	Cone bearing age begins	Cone length	Period between collectable crops: avg.	range	Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection: ½ sect.	per cone	Collection period
	years	*centimetres*	*years*		*hectolitres*	*number*	*number*		
Tsuga heterophylla	20	2-3	3-4	2-8		83 000	3-4		Sept. to Oct.
Tsuga mertensiana	20	2-8		1-5					Sept. to Oct.



Mountain hemlock

Appendices

		Page

Western hemlock

Appendix I

Glossary of terms

Cotyledon - a seed leaf; the first leaf or leaves of an embryo.

Embryo - the rudimentary plant within a seed; the product of fertilization.

Endosperm - the nutritive tissue surrounding the embryo within the seed. The endosperm provides food for the embryo during germination and early development. (Strictly speaking, the term endosperm should not be applied to conifer seeds but no convenient substitute is available.)

Epicormic - refers to a shoot arising spontaneously from a dormant bud on a stem or branch.

Fertilization - the fusion of male and female nucleii effected by the transfer of genetic material from pollen grain to ovule. This results in an embryo within the ovule.

Ovule - the structure within the seed cone that, if fertilized, develops into a seed.

Periodicity - the tendency for cone crops to recur at intervals. The interval may be short (i.e. every year) or long, regular or irregular. For example, cone crops of Douglas-fir occur with an average periodicity of 5 years, although the period between crops can vary between 2 and 10 years.

Phenotype - the characteristics of an organism as determined by the interaction between genetics and environment. Characteristics may be external (e.g. stem form, branch angle) or internal (e.g. wood quality).

Pollen cone - the male reproductive structure, or flower, of conifers, which produces pollen grains.

Pollination - the transfer of pollen from the male flower (pollen cone) to the receptive part of the female flower (seed cone).

Provenance - the geographical area and environment to which the parent trees are native. The geographical source or place of origin of a given lot of seed or pollen. Frequently synonymous with seed source.

Seed - a matured ovule containing an embryo and nutritive tissue enclosed by a protective seedcoat.

Seedcoat - the outer protective layer of a seed.

Seed cone - the female reproductive structure, or flower, of conifers. After opening to receive pollen, the seed cone enlarges and becomes woody. Usually two seeds are borne on each scale, which are arranged in spiral fashion around the central axis of the cone. The mature cone or, more specifically, the seeds that it contains, is the objective of any collection operation.

Seedlot- an indefinite quantity of seeds having in common species, provenance, year of collection and handling history, and identified by a number for reforestation purposes.

Seed Production Area - a stand of better than average quality that is upgraded and opened by removal of undesirable trees and then cultured for early and abundant seed production.

Seed stand - a stand reserved and managed primarily for seed production.

Seed zone - in B.C., a somewhat arbitrary area designated on the basis of biogeoclimate and forest management unit. Seed zones serve as a means of ensuring that reforestation stock is planted within the general area from which its seeds were collected. (This is a working definition; seed zone boundaries may be periodically re-defined based on further provenance testing.)

Serotinous - a term applied to cones that remain on the tree, without opening, for a year or more after they mature.

Viable - in reference to seeds, means capable of germinating. Viable seeds are filled, but not all filled seeds are viable.

Appendix II

Tree names and symbols

Scientific name	Principal Common Names used in B.C.	Symbol [1]
Abies amabilis	amabilis fir, Pacific silver fir, balsam [2]	Ba
Abies grandis	grand fir, balsam [2]	Bg
Abies lasiocarpa	alpine fir, subalpine fir, balsam [2]	Bl
Chamaecyparis nootkatensis	yellow cedar, Alaska yellow cedar, yellow cypress	Cy
Larix laricina	tamarack, larch	Lt
Larix lyalli	alpine larch	Ll
Larix occidentalis	western larch	Lo
Picea engelmanni	Engelmann spruce, interior spruce [3]	Se
Picea glauca	white spruce, interior spruce [3]	Sw
Picea mariana	black spruce	Sb
Picea sitchensis	Sitka spruce	Ss
Pinus albicaulis	whitebark pine	Pa
Pinus contorta var. *contorta*	lodgepole pine, shore pine	Pl
Pinus contorta var. *latifolia*	lodgepole pine	Pl
Pinus flexilis	limber pine	Pf
Pinus monticola	western white pine	Pw
Pinus ponderosa	ponderosa pine, yellow pine	Py
Pseudotsuga menziesii	Douglas-fir, fir	F
Thuja plicata	western red cedar	C
Tsuga heterophylla	western hemlock	Hw
Tsuga mertensiana	mountain hemlock	Hm

1/ These symbols are from the B.C. Forest Service, Cartographic Manual (1974 Edition).

2/ *A. amabilis*, *A. grandis* and *A. lasiocarpa* are erroneously, but frequently, referred to collectively as "balsam".

3/ *P. engelmanni* and *P. glauca* are often referred to collectively as "interior spruce".

Appendix III

Regulations pertaining to the picking of tree cones and seeds

B.C. Reg. 197/71

FOREST ACT

REGULATION MADE BY ORDER IN COUNCIL 3061, APPROVED AUGUST 24, 1971

REGULATION ON THE PICKING OF TREE CONES AND TREE SEEDS

Division (1)—Application of Regulation

1.01 For the purpose of this regulation, tree cones and tree seeds include any cones from trees or tree seeds of forest-tree species of British Columbia, or those tree species grown in tree-seed orchards or specificially for the purpose of producing tree seeds for reforestation or afforestation.

Division (2)—Permits

2.01 No person shall take tree cones or tree seeds from trees on lands the title to which is in the Crown without having first obtained a permit so to do, as further provided in this regulation.

2.02 The Chief Forester may grant or refuse to grant a permit to any person for the purpose of collecting tree cones or tree seeds from trees on Crown lands not held under licence or lease, subject to this regulation and to such further and other terms and conditions as the Chief Forester deems advisable.

2.03 The Chief Forester may grant or refuse to grant a permit to any person for the purpose of collecting tree cones or tree seeds from trees on lands held under licence or lease from the Crown on the consent of such licensee or lessee, subject to this regulation and to such further and other terms and conditions as the Chief Forester deems advisable.

Division (3)—Damage to Trees

3.01 No person shall cut down or top or cause to be felled any tree, or cut or break off branches of any tree, or otherwise damage any tree on Crown lands for the purpose of collecting the tree cones or tree seeds from such tree.

3.02 Section 3.01 shall not apply to tree cones and tree seeds collected from lands designated for the continuous production of tree cones and tree seeds, and lands maintained as seed orchards, provided that the management of all of the said lands is under the supervision of a professional forester registered under the laws of the Province of British Columbia.

3.03 Notwithstanding section 3.01, the Chief Forester may authorize the felling of trees on Crown lands not otherwise alienated for the purpose of harvesting tree cones or tree seeds therefrom or the cutting of branches or parts of the tree as may be necessary for the propagation of seed orchards.

Division (4)—Licences to Purchase Tree Cones or Tree Seeds

4.01 Every purchaser, including agents of purchasers, of tree cones or tree seeds shall

(*a*) secure and be in possession of a licence to purchase tree cones and tree seeds granted by the Minister of Lands, Forests, and Water Resources;

(*b*) not purchase tree cones or tree seeds from any person who does not possess a valid permit issued by the Chief Forester to harvest tree cones or tree seeds from lands the title to which is in the Crown;

(*c*) not purchase tree cones or tree seeds from any person who does not hold a written consent from the owner of private lands or the lessee or licensee of lands;

(*d*) keep a register in which shall be entered every purchase of tree cones or tree seeds showing
(1) name and address of vendor;
(2) date of purchase;
(3) number of bushels of tree cones or weight of tree seeds purchased;
(4) area from which tree cones and (or) tree seeds were obtained and the legal description thereof;
(5) name and address of the person issuing the permit or consent;
(6) number of permit, if any;

(*e*) keep every register, as required under 4.01 (*d*) above, within the Province of British Columbia, which may be inspected and notations made therefrom by any person authorized by the Chief Forester at any reasonable hour.

Division (5)—Manufacture Within the Province

5.01 All tree cones collected from Crown lands pursuant to this regulation shall be processed for the seeds from them within the Province; provided, however, the Chief Forester may grant permission relieving a person of the requirement of this regulation.

Division (6)—Penalty

6.01 Every person who violates or fails to comply with any of the provisions of this regulation or any term or condition of any permit or licence or consent issued or given thereunder is guilty of an offence and liable, on summary conviction, to the penalties provided under the general provisions of the *Forest Act*.

Reprinted from *The British Columbia Gazette*—Part II, September 9, 1971.

Appendix IV

Permit to harvest, and licence to purchase, tree cones and seeds. (The licence may be signed by the District Forester on behalf of the Minister of Lands, Forests, and Water Resources.)

PROVINCE OF BRITISH COLUMBIA	FOREST SERVICE	DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES

Permit to Harvest Tree-seed and Cones on Crown Lands or Lands Held under Licence or Lease from the Crown

Nº 28028

J. Dee, of Kitwanga, B.C.
is hereby authorized to harvest tree-seed and cones from the following Crown lands:
Lots 110 & 111
Cassiar Land District
or, having duly secured the consent of the respective Licensee or Lessee or their authorized representatives as indicated by the signature herewith ______, is hereby authorized to harvest tree-seed and cones from the following lands held under licence or lease from the Crown: ______

______ Land District,
from the date of this permit until 30th September, 1975
subject to the following conditions:—

(1) No tree shall be cut down, felled, or topped, or the branches cut or broken off, or the tree otherwise damaged in any way for the purpose of collecting the cones or tree-seed from such tree.
(2) The Permittee named herein is authorized to collect cones or tree-seed only in the area described in this permit.
(3) This permit shall be automatically suspended during any forest closure covering the area described in this permit.
(4) No person shall transport any cones during a general forest closure.

August 15, 1975
(Date of issue)

J. White, *Forest Officer,*
Kitwanga *Ranger District,*
Prince Rupert *Forest District.*

I have read and understand the terms and conditions of this permit and the regulations governing the collection and sale of cones and tree-seed under which it was issued and solemnly declare that I will comply therewith in every respect.

J. Dee, *Permittee.*

F.S. 504—250 bks. (50)-570-4499 (4)

PERMIT ISSUED FREE OF CHARGE.

THE GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA

FOREST SERVICE

VICTORIA, BRITISH COLUMBIA

No. 7

LICENCE to PURCHASE TREE CONES and TREE SEED

(Issued pursuant to the Forest Act and Regulations)

Pursuant to the provisions of B. C. Reg. 197/71, being a regulation on the picking of tree cones.

"Allwest Seed Co."

(Name)

1621 River Road, Hazelton, B. C.

(Address)

is hereby licensed to buy, sell and deal in tree cones and tree seeds subject to the provisions of the said B.C. Reg. 197/71: and subject to the following conditions:

1. The licensee shall comply with all the requirements set forth in Division 4 of the said regulation on back hereof;
2. This licence shall expire on the 1st day of July following date of issue;
3. Date of issue July 21, 1975.

D. C. Brown

(for) Minister of Lands, Forests, and Water Resources.

(reverse side of "Licence to Purchase Tree Cones and Tree Seed")

Division 4 of the said regulation B.C. Reg. 197/71 provides as follows:

4.01 Every purchaser, including agents of purchasers, of tree cones or tree seeds shall

(a) secure and be in possession of a licence to purchase tree cones and tree seeds granted by the Minister of Lands, Forests, and Water Resources;

(b) not purchase tree cones or tree seeds from any person who does not possess a valid permit issued by the Chief Forester to harvest tree cones or tree seeds from lands the title to which is in the Crown;

(c) not purchase tree cones or tree seeds from any person who does not hold a written consent from the owner of private lands or the lessee or licensee of lands;

(d) keep a register of every purchase of cones or tree seed showing

(1) name and address of vendor;
(2) date of purchase;
(3) number of bushels of tree cones or weight of tree seeds purchased;
(4) area from which tree cones and (or) tree seeds were obtained and the legal description thereof;
(5) name and address of the person issuing the permit or consent;
(6) number of permit, if any;

(e) keep every register, as required under 4.01 (d) above, within the Province of British Columbia, which may be inspected and notations made therefrom by any person authorized by the Chief Forester at any reasonable hour.

Note: The British Columbia Forest Service will only store and handle tree seed that has a ninety-five percent purity analysis; that is between six to nine percent moisture content; and that is properly identified as to origin as certified on the Cone Collector's Report Form (F.S. 721).

Original - Licensee
Copy - District Forester
Copy - Reforestation Division

Appendix V

Cone crop forecasting procedures for Douglas-fir and white spruce

All practical methods of forecasting cone crops are based on numbers of female reproductive buds which are usually recognizable up to a year in advance of when the crop in question would be harvested.

Specific procedures for Douglas-fir and white spruce are outlined below. They are condensed from published reports as indicated; for more detail on methods and limitations, the reader should refer to the appropriate report. A procedure for forecasting western larch cone crops, developed by Roe (1966. U.S. For. Serv., Res. Note INT-99), has not been tested in B.C. and is therefore not included here.

Although the procedures differ somewhat, they entail three operations: sampling, identification of buds, and interpretation of data. Moreover, they share an important limitation: they provide an estimate only of the **potential** cone crop. If sampling indicates a poor to nil crop, the forecast may be accepted confidently, but a forecast of a medium or better crop must be considered tentative because of the numerous agencies that can damage or destroy a developing crop. For this reason, forecasts should be confirmed the following spring and early summer by an examination of the flower crop and a cone crop rating (see page 15).

For convenience, the following symbols are used:

♀ bud - female reproductive bud
♂ bud - male reproductive bud
V bud - vegetative bud

Douglas-fir

The procedure for forecasting Douglas-fir cone crops, based on reports by Allen (1941. J. For. 39: 1014-1016) and Finnis (1953. Forest. Chron. 29: 122-127), requires collection of branches, tallying of ♀ buds and V buds, and determination of "flower intensity" which is calculated by dividing number of ♀ buds by number of V buds. Tentative cone crop rating is based on "flower intensity".

Sampling

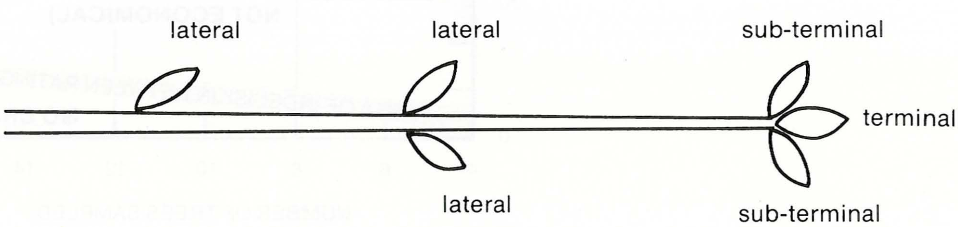
Branches should be obtained from a minimum of six eligible trees widely scattered throughout the stand being assessed. Eligible trees are those of cone-bearing age, of good phenotype and of the dominant or codominant crown class. Sample trees should be selected,without conscious bias, from among those eligible in the stand. Three branches should be collected from each sample tree - one each from the upper, middle and lower crown. Branches may be collected by climbing, shooting (with a small-bore rifle) or from felled trees.

Identification of buds

♀ buds and V buds are counted and tallied for each branch. Although ♂ buds are not tallied, they are likely to be present and must be recognized as such. With practice, buds may be distinguished by their position on the twig, as well as their external and internal appearance. Only V buds occupy terminal positions. (Position nomenclature is shown in Figure 27.) ♀ buds tend to occur toward the distal (tip) end of twigs and often occupy sub-terminal positions; they may occur singly, in pairs or in groups of more than two. ♂ buds often occur in clusters toward the base of the current year's twig although they may be scattered along its length.

Color photographs of Douglas-fir buds are shown in Figure 5. V buds are dark with conspicuous, shaggy-edged scales; those in terminal positions are larger than those in lateral positions. ♂ buds are egg-shaped with smooth-edged, glossy scales and are generally lighter in color than V buds. ♀ buds are larger (longer and fatter) than ♂ or V buds; they are also more pointed than ♂ buds. Upon removal of bud scales, ♀ buds look like miniature cones and ♂ buds resemble raspberries in shape.

To confirm bud identification, small branches may be placed in water in a warm, well-lighted room. This procedure, termed "forcing", causes buds to break dormancy and open, at which time they can be readily identified (Figure 6). Only fresh samples collected in January or later respond well.



● Figure 27. **Bud location nomenclature.**

Interpretation of data

Flower intensity for each sample tree is determined by dividing the number of ♀ buds by the number of V buds on the three sample branches. The flower intensities thus determined for each sample tree are averaged to obtain a figure for the stand; this forms the basis for the cone crop forecast according to Table 5. The calculations are demonstrated in Table 6.

This procedure may be used to develop a cone crop prediction for a region or district by sampling several stands, depending on size and diversity of the area. Separate forecasts should be developed for different elevational classes; suggested classes are 0-300 m, 301-600 m, 601-900 m, etc.

Table 5. Tentative cone crop ratings for Douglas-fir.

CALCULATED FLOWER INTENSITY	TENTATIVE CONE CROP RATING	
0	Nil	1
0.10	Very light	2
0.15	Light	3
0.20	Medium	4
0.25	Heavy	5

White Spruce

(probably applicable to Engelmann spruce as well)

The procedure for forecasting white spruce cone crops, based on reports by Eis (1973. Can. Forest. Serv. B.C.-P-7; and 1967. Forest. Chron. 43: 247-252) and Eis and Inkster (1972. Can. J. For. Res. 2: 460-466), depends on the cumulative total count of ♀ buds on sample branches. According to Eis (1973), this method ". . . can be applied in cone crop assessments on a regional basis by sampling several stands distributed throughout the region. Thus a start might be made with three stands (a total of 15 to 25 trees) in a ranger district."

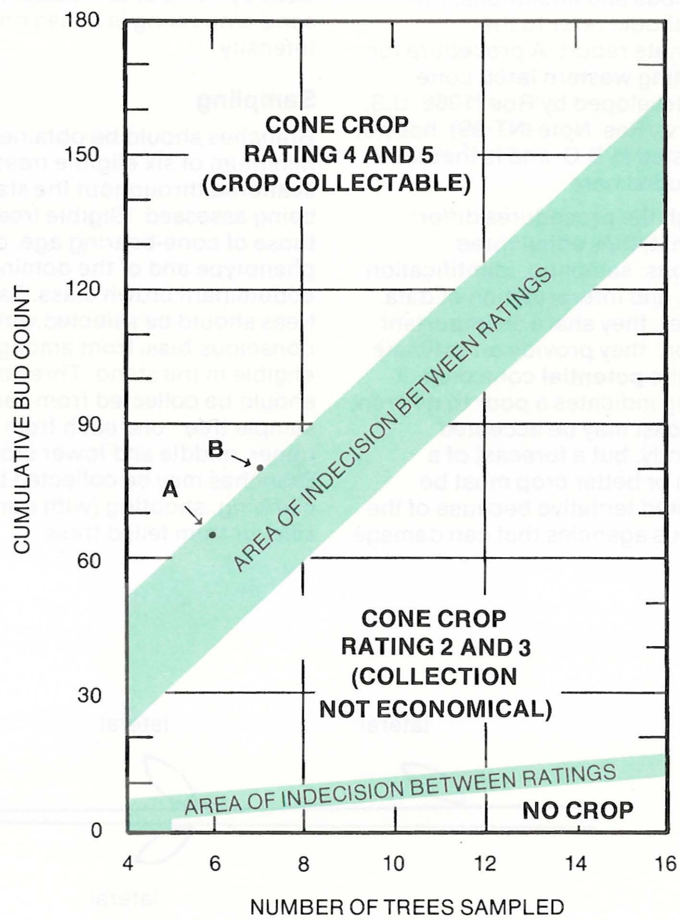


Figure 28. **Prediction graph for forecasting white spruce cone crops** (after Eis 1973; see Appendix IX).

Table 6. Bud counts and flower intensity calculations for six Douglas-fir sample trees. Glenora, Duncan, B.C., 1968.

Tree No.	Bud Type	Crown Position: Upper	Middle	Lower	Total	Flower Intensity
1	♀ buds	0	4	0	4	0.04
	V buds	34	31	35	100	
2	♀ buds	0	0	0	0	0.00
	V buds	40	39	45	124	
3	♀ buds	15	9	5	29	0.24
	V buds	43	33	43	119	
4	♀ buds	24	20	6	50	0.26
	V buds	64	72	58	194	
5	♀ buds	9	20	0	29	0.25
	V buds	36	39	45	120	
6	♀ buds	17	20	14	51	0.36
	V buds	59	49	34	142	
					Total	1.15

Calculated flower intensity for the area:
1.15/6 = 0.19, which corresponds nearly to a tentative cone crop rating of 4 or medium.

Sampling and interpretation of data

One branch is obtained **from the third whorl** (counting from the top) of each of four or more eligible sample trees. Eligible trees are 45 to 80 years old, 15 to 20 metres tall, with well-developed crowns, and of the dominant crown class. Successive trees are sampled and ♀ buds are counted; counts are accumulated until a prediction can be made using the graph in Figure 28. For example, a total count of 65 ♀ buds on branches from the first six sample trees is indicated by point A on the graph; no decision is reached and sampling continues. If the next sample tree branch yields 15 ♀ buds, the total count reaches 80 buds on seven trees and point B is located. This leads to a prediction of a collectable crop in the sampled stand or area and, accordingly, sampling may stop. Occasionally, as many as 16 trees may be sampled without reaching a decision. In such cases, sampling should stop and the crop should be classified into the nearest category approached by the cumulative count. The potential cone crop rating can be accurately classified with 80% probability with this method.

Identification of buds

Bud identification is made relatively easy by the fact that ♂ buds do not occur as high in the crown as the third whorl (Eis, S; personal communication). This reduces the task to that of distinguishing between ♀ buds and V buds. V buds are smaller than ♀ buds, although they approach the size of ♀ buds when they occur in the terminal position. **Note:** ♀ buds of white spruce often occur in the terminal position, in contrast to Douglas-fir. V buds are dome-shaped and the outermost scales completely cover the bud, whereas ♀ buds are ovate (football-shaped) and the inner scales protrude to cover the upper portion of the bud. Figure 4 shows color photographs of white spruce buds.

Appendix VI Cone and seed data.

Table 7. Cone production characteristics of B.C. conifers

Species	Cone bearing age begins	Cone length	Period between collectable crops		Yield per mature tree	Cones per hectolitre	Minimum filled seed count for collection		Collection period
			avg.	range			½ sect.	per cone	
	years	centimetres	years		hectolitres	number	number		
Abies amabilis	20	9-13	2-3			700			late Aug. to mid-Sept.
Abies grandis	20	5-12	5-6	3-8		700			late Aug. to mid-Sept.
Abies lasiocarpa	20	6-12	3	2-5		850			mid-Sept. to mid-Oct.
Chamaecyparis nootkatensis	15	0.5-1.5	2-4			130 000		2	Aug. to Oct.
Larix laricina	40	1-1.5	5-6						Aug. to Sept.
Larix lyalli	30	4-5							Aug. to Sept.
Larix occidentalis	25	3-4	5-6			11 000	6-8	40	Aug. to Sept.
Picea engelmanni	15	3-8	5	2-10		8 300	7-10		mid-Aug. to Sept.
Picea glauca	20	3-6	6	2-12		11 000	7-10		mid-Aug. to Sept.
Picea mariana	10	1-4	4-5	2-6					Sept.
Picea sitchensis	20	6-10	3-4	2-5	0.5-1	4 700	7-10		Sept.
Pinus albicaulis	20	4-8		3-5					Aug. to Sept.
Pinus contorta	10	3-5	3	2-4	0.5-1	8 300		20	Oct. to Mar.
Pinus flexilis	20	8-20	3	2-4					late July, Aug. to Sept.
Pinus monticola	10	10-25	4	3-7	0.2-0.5	280		90	late Aug. to early Sept.
Pinus ponderosa	15	8-15	3	2-5	1-1.5	700		75	late Aug. to early Sept.
Pseudotsuga menziesii	15	5-10	5	2-10	0.5-1	2 800	5-7		mid-Aug. to early Sept.
Thuja plicata	15	1-2	2-3	1-4		110 000			Aug. to Sept.
Tsuga heterophylla	20	2-3	3-4	2-8		83 000	3-4		Sept. to Oct.
Tsuga mertensiana	20	2-8		1-5					Sept. to Oct.

Table 8. Seed yields of B.C. conifers (metric units)

Species	Basis of Yield Data		Average Seed Yield 1/						Storage Period 3/
	Seedlots	Volume of cones	Weight of cleaned seed per hectolitre of cones	Total seeds per kilogram of cleaned seed		Viable seeds per hectolitre of cones			
				Average	Range	Average	Minimum 2/ (80% Prob.)	Range	
	number	*hectolitres*	*kilograms*	*number*	*number*	*number*	*number*	*number*	*years*
Abies amabilis	12	96	2.18	34 000	25 000 – 49 000	15 900		8 000 – 61 000	5-15
Abies grandis	5	24	2.26	49 000	43 000 – 55 000	65 000		23 000 – 174 000	5-15
Abies lasiocarpa	12	74	2.33	105 000	100 000 – 146 000	72 600		8 000 – 98 000	5-15
Chamaecyparis nootkatensis	3	26	0.24	200 000	195 000 – 214 000				
Larix laricina	3	1	0.17	629 000	595 000 – 694 000	32 300		21 000 – 42 000	6-10
Larix occidentalis	17	134	0.60	289 000	178 000 – 343 000	83 000		28 000 – 206 000	6-10
Picea engelmanni	199	3 527	0.66	485 000	268 000 – 681 000	190 600	126 000	15 000 – 446 000	10+
Picea glauca	182	5 416	0.67	513 000	414 000 – 878 000	183 900	118 000	23 000 – 582 000	15-20
Picea mariana	3	3	0.07	855 000	683 000 – 1 056 000	40 700		22 300 – 67 500	17-20
Picea sitchensis	76	1 841	0.56	460 000	349 000 696 000	164 900	104 000	30 000 – 492 000	10+
Pinus albicaulis	1	3	2.26	8 000					
Pinus contorta									
var. *contorta*	27	235	0.41	372 000	334 000 – 460 000	120 400	52 000	11 000 – 377 000	20
var. *latifolia*	309	17 766	0.22	336 000	273 000 – 460 000	46 100	33 000	8 000 – 166 000	20
Pinus flexilis	1	3	1.75	10 000		3 800			
Pinus monticola	11	26	0.60	64 000	53 000 – 87 000	9 800		8 000 – 91 000	8-15
Pinus ponderosa	11	412	2.07	21 000	18 000 – 24 000	36 300		23 000 – 45 000	11-30
Pseudotsuga menziesii									
Coast, 0-450 m	92	8 049	0.65	108 000	83 000 – 139 000	52 900	33 000	8 000 – 91 000	15
Coast, above 450 m	91	6 089	0.62	110 000	80 000 – 160 000	52 400	33 000	15 000 – 76 000	15
Interior Dry Belt	92	2 627	0.61	107 000	82 000 – 133 000	46 900	30 000	15 000 – 106 000	15
Interior Wet Belt	201	5 530	0.74	109 000	79 000 – 148 000	61 300	44 000	8 000 – 121 000	15
Thuja plicata	29	132	1.31	884 000	563 000 – 1 060 000	831 100	385 000	227 000 – 1 021 000	7
Tsuga heterophylla	94	440	0.76	530 000	371 000 – 909 000	254 100	143 000	23 000 – 726 000	10
Tsuga mertensiana	7	11	0.77	405 000	346 000 – 477 000	204 300		78 000 – 387 000	10

1/ Seed yields are based on B.C. Forest Service data for 1962-1974 cone crops. Wide ranges generally occur because data have not been segregated by cone crop rating. Higher yields (per unit of cones) and better quality seeds are usually obtained during bumper crop years; lower yields and poorer quality seeds occur during poor crop years. Variability in cone handling and seed processing also contribute to wide ranges.

2/ Numbers in this column represent the minimum number of viable seeds per hectolitre of cones with 80% probability - i.e. collections should yield at least this many viable seeds 80% of the time. Use of these figures in setting collection quotas will give added insurance (compared to use of averages) against collecting inadequate amounts of viable seed; the chances of collecting excessive amounts are increased, however.

3/ Based on Wang 1974 (See Appendix IX).

Table 9. Seed yields of B.C. conifers (imperial units)

Species	Basis of Yield Data		Average Seed Yield 1/						Storage Period 3/
			Weight of cleaned seed per bushel of cones	Total seeds per pound of cleaned seed		Viable seeds per bushel of cones			
	Seedlots	Volume of cones		Average	Range	Average	Minimum 2/ (80% Prob.)	Range	
	number	*bushels*	*pounds*	*number*	*number*	*number*	*number*	*number*	*years*
Abies amabilis	12	264	1.75	15,000	11,000 – 18,000	5,800		3,000 – 22,000	5-15
Abies grandis	5	66	1.81	22,000	20,000 – 25,000	23,700		8,000 – 63,000	5-15
Abies lasiocarpa	12	203	1.87	48,000	45,000 – 66,000	26,400		3,000 – 36,000	5-15
Chamaecyparis nootkatensis	3	71	0.19	91,000	88,000 – 97,000				
Larix laricina	3	3	0.14	285,000	270,000 – 315,000	11,700		8,000 – 15,000	6-10
Larix occidentalis	17	368	0.48	131,000	81,000 – 156,000	30,200		10,000 – 75,000	6-10
Picea engelmanni	199	9,697	0.53	220,000	122,000 – 309,000	69,300	46,000	5,000 – 162,000	10+
Picea glauca	182	14,891	0.54	233,000	188,000 – 398,000	66,900	43,000	8,000 – 212,000	15-20
Picea mariana	3	7	0.05	387,000	309,000 – 478,000	18,400		10,000 – 30,500	17-20
Picea sitchensis	76	5,062	0.45	209,000	158,000 – 316,000	60,000	38,000	11,000 – 179,000	10+
Pinus albicaulis	1	8	1.81	4,000					
Pinus contorta									
var. *contorta*	27	646	0.33	169,000	152,000 – 209,000	43,800	19,000	4,000 – 137,000	20
var. *latifolia*	309	48,848	0.18	152,000	124,000 – 209,000	16,800	12,000	3,000 – 60,000	20
Pinus flexilis	1	8	1.40	5,000		1,400			
Pinus monticola	11	71	0.48	29,000	24,000 – 39,000	3,600		3,000 – 33,000	8-15
Pinus ponderosa	11	1,133	1.66	10,000	8,000 – 11,000	13,200		8,000- – 16,000	11-30
Pseudotsuga menziesii									
Coast, 0-450 m	92	22,131	0.52	49,000	38,000 – 63,000	19,300	12,000	3,000 – 33,000	15
Coast, above 450 m	91	16,742	0.50	50,000	36,000 – 73,000	19,100	12,000	5,000 – 28,000	15
Interior Dry Belt	92	7,223	0.49	49,000	37,000 – 60,000	17,100	11,000	5,000 – 39,000	15
Interior Wet Belt	201	15,205	0.59	49,000	36,000 – 67,000	22,300	16,000	3,000 – 44,000	15
Thuja plicata	29	363	1.05	401,000	255,000 – 481,000	302,300	140,000	83,000 – 371,000	7
Tsuga heterophylla	94	1,210	0.61	240,000	168,000 – 412,000	92,400	52,000	8,000 – 264,000	10
Tsuga mertensiana	7	30	0.62	184,000	157,000 – 216,000	74,300		28.000 – 141,000	10

1/ Seed yields are based on B.C. Forest Service data for 1962-1974 cone crops. Wide ranges generally occur because data have not been segregated by cone crop rating. Higher yields (per unit of cones) and better quality seeds are usually obtained during bumper crop years; lower yields and poorer quality seeds occur during poor crop years. Variability in cone handling and seed processing also contribute to wide ranges.

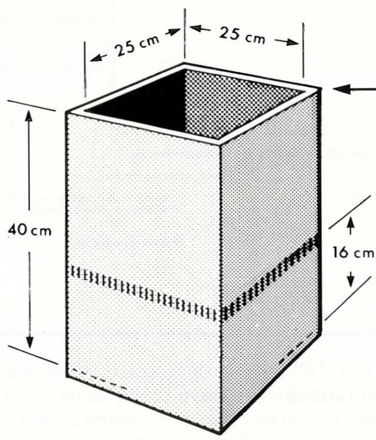
2/ Numbers in this column represent the minimum number of viable seeds per hectolitre of cones with 80% probability - i.e. collections should yield at least this many viable seeds 80% of the time. Use of these figures in setting collection quotas will give added insurance (compared to use of averages) against collecting inadequate amounts of viable seed; the chances of collecting excessive amounts are increased, however.

3/ Based on Wang 1974 (See Appendix IX).

Appendix VII
Metrication and Cone Volume Measure

Because Canada is committed to metric conversion by 1980, metric units have been given priority over traditional units throughout this guideline. Of the many units that will undergo conversion, the two main ones concerned in cone and seed collection are a) the bushel, for cone volume measure, which will be replaced by the hectolitre and the litre (one hectolitre equals 100 litres), and b) the pound, for cone and seed weight, which will be expressed in kilograms (one kilogram equals 1000 grams). Stand area, traditionally measured in acres will, in future, be measured in hectares. Table 10 shows metric and imperial equivalents for a number of measuring units likely to be used in cone collecting. These conversions are not all exact, as most equivalents have been rounded to the second decimal place.

For verification of the quantity of cones collected, a standard cone volume measure should be available. An open box, or boxes, of appropriate dimensions can easily be constructed from plywood. For very small cones, such as those of yellow cedar, western red cedar or even western hemlock, a 10-litre measure is recommended; for larger cones, a 25-litre measure is more suitable. The smaller measure may be marked off inside the larger measure. Recommended dimensions for these standard cone volume measures are as follows:



N.B.
All measurements are **inside** dimensions. In imperial units, dimensions are 9-13/16 x 9-13/16 x 15-3/4 inches, with the 10-litre line being 6-5/16 inches above the base.

● Figure 29. **Standard cone volume measure.**

Table 10. Approximate Metric Equivalents

1 g (gram)	= 0.04 oz	1 oz	= 28.35 g
1 kg (kilogram)	= 2.21 lbs	1 lb	= 0.45 kg
1 hl (hectolitre)	= 2.75 bushels*	1 bushel	= 0.36 hl
1 h (hectare)	= 2.47 acres	1 acre	= 0.41 h
1 cm (centimetre)	= 0.39 ins	1 in	= 2.54 cm
1 m (metre)	= 3.28 ft	1 ft	= 0.31 m
1 km (kilometre)	= 49.71 chains	1 chain	= 20.12 m
1 km	= 0.62 mile	1 mile	= 1.61 km

*For practical purposes, the standard cone sack will be 50 litres to the fill line. This corresponds very nearly to the 1.5 bushel fill line on present sacks (1.5 bu equals 54 litres).

Appendix VIII

B.C. Forest Service forms. Forms should be completed in metric units as shown, even though forms currently in use are designed around imperial units. Units must be specified (as in items 13 and 23 of F.S. 721 form on page 93), especially when the unit used contradicts that printed on the form.

BRITISH COLUMBIA FOREST SERVICE — **CONE-CROP SURVEY AND EVALUATION, 1974** — REFORESTATION DIVISION

Species FIR Forest District N Ranger District 2 FERNIE Location HARMER RIDGE
Ownership (if known) T.F. 27 - CN1 Nat. Topog. Grid Ref. 82 G 15 Aspect WEST
Elevation range 1515 - 1667 m. Slope MODERATE Approx. ~~acreage~~ area 49 ha. Age-class: —40. ☐ 40-100. ☐ 100+ ☑
Lot, TS, etc. N.A. Accessibility GOOD - 2WD Stand description F-B-PL
Collection methods: Squirrel cuttings. ☐ Climbing. ☐ F.&B. ☑ Cone condition
Insects Seed condition: Milky. ☐ Doughy or firm. ☐
Embryo development Wing and seed colour: White. ☐ Pale brown. ☐ Brown. ☐

CUTTING TEST

Filled Seeds per Cone Section (Sample trees must be well distributed throughout stand.)

Tree No.	Cone Position in Crown: Top 1	Top 2	Top 3	Middle 4	Middle 5	Middle 6	Lower 7	Lower 8	Lower 9	Totals	Average
1											
2											
3											
4											
5											
6											
Totals											

NUMERICAL RATING OF CONE CROP
(Circle numerical rating which applies.)

None.	1. No cones on any seed trees.
Very light.	2. Few cones on less than 25 per cent of the seed trees.
Light.	3. Few cones on more than 25 per cent of the seed trees.
Medium.	4. Many cones on 25 to 50 per cent of the seed trees.
(Heavy.)	5. Many cones on more than 50 per cent of the seed trees. *A seed tree is any dominant and codominant tree of seed-bearing age.*

Date JULY 13/74 Initials J.N.C.

I have examined this stand and recommend/do not recommend it for cone-collecting to commence about .... and estimate possible yield at approximately .... hL. ~~bushels~~.

Please forward along with the Summary Form F.S. 719B in duplicate to the District office by July 31st of each year.

District Reforestation Officer to submit summary copy of F.S. 719B's to Victoria as soon as possible.

(Date)........ *Reforestation Officer*........

F.S. 727—5M bks. (25)-771-5985 (2)

NOTE: The F.S. 727 form is completed in two stages. In the first stage (above), the developing cone crop in a particular stand is rated. Several weeks later, a seed crop evaluation is performed **in the same stand** and the form is completed (below).

BRITISH COLUMBIA FOREST SERVICE — **CONE-CROP SURVEY AND EVALUATION, 1974** — REFORESTATION DIVISION

Species FIR Forest District N Ranger District 2 FERNIE Location HARMER RIDGE
Ownership (if known) T.F. 27 - CN1 Nat. Topog. Grid Ref. 82G15 Aspect WEST
Elevation range 1515 - 1667 m. Slope MODERATE Approx. ~~acreage~~ area 49 ha. Age-class: —40. ☐ 40-100. ☐ 100+ ☑
Lot, TS, etc. N.A. Accessibility GOOD - 2 WD Stand description F-B-PL
Collection methods: Squirrel cuttings. ☐ Climbing. ☐ F.&B. ☑ Cone condition GOOD - BROWN COLOR
Insects VERY FEW Seed condition: Milky. ☐ Doughy or firm. ☑
Embryo development 60-70% Wing and seed colour: White. ☐ Pale brown. ☐ Brown. ☑

CUTTING TEST

Filled Seeds per Cone Section (Sample trees must be well distributed throughout stand.)

Tree No.	Cone Position in Crown: Top 1	Top 2	Top 3	Middle 4	Middle 5	Middle 6	Lower 7	Lower 8	Lower 9	Totals	Average
1	8	7	5	7	6	6	6	5	5	55	6.1
2	6	7	7	6	5	8	7	5	8	59	6.6
3	8	8	6	5	7	8	6	6	7	61	6.8
4	5	7	7	8	7	7	7	7	7	62	6.9
5	6	8	9	6	5	8	8	5	4	59	6.6
6	7	7	6	7	5	7	7	6	6	58	6.4
Totals	40	44	40	35	44	41	41	34	37	354	6.6

NUMERICAL RATING OF CONE CROP
(Circle numerical rating which applies.)

None.	1. No cones on any seed trees.
Very light.	2. Few cones on less than 25 per cent of the seed trees.
Light.	3. Few cones on more than 25 per cent of the seed trees.
Medium.	4. Many cones on 25 to 50 per cent of the seed trees.
(Heavy.)	5. Many cones on more than 50 per cent of the seed trees. *A seed tree is any dominant and codominant tree of seed-bearing age.*

Date July 13/74 Initials J.N.C.

I have examined this stand and recommend/~~do not recommend~~ it for cone-collecting to commence about SEPT. 2, 1974 and estimate possible yield at approximately 4,300 hL. ~~bushels~~.

Please forward along with the Summary Form F.S. 719B in duplicate to the District office by July 31st of each year.

District Reforestation Officer to submit summary copy of F.S. 719B's to Victoria as soon as possible.

(Date) Aug. 19/74 *Reforestation Officer* [signature]

F.S. 727—5M bks. (25)-771-5985 (2)

BRITISH COLUMBIA FOREST SERVICE

Reforestation Division

FOREST SERVICE CONE COLLECTOR'S REPORT

(see inside cover for instructions)

4030	N - 2 - 1	
Seed Zone Number (see instructions)	**Collector's Provisional Number** (see instructions)	**Official Registration Number** (leave blank)

1. Forest District Nelson 2. Ranger District #2, Fernie 3. Forest (PSYU) Fernie
4. Owner's Name B.C. Forest Service 5. Owner's Address Box 730, Fernie, B.C.
6. Collected by B.C. Forest Service 7. Supervisor Adolf Jede
8. Number of Permit to Harvest Tree Seed and Cones (F.S. 504) ......
9. Species Fir 10. Seed Class B3 11. Associated Species in Stand Balsam Fir & Pl
12. Aspect of Stand West 13. Elevation Limits 1,515 - 1,667 m.
14. Location (River, Creek, Mountain, etc.) Harmer Creek (T.F. 27)
15. National Topographical Grid Reference R82G/15C 16. Latitude 49° 48' 17. Longitude 114° 47'
18. Age of Trees collected from: Under 40 yrs ☐ 40-100 yrs. ☐ over 100 yrs. ☒
19. Number of Trees collected from Approx. 600 22. Number of Sacks of Cones Shipped 155
20. Date of Collection Sept. 5 - 19, 1974 23. Number of ~~xxxxxx~~ of Cones Shipped 84.5 hectolitres
21. Method of Collection Falling and picking 24. Condition of Cones when Shipped good
25. Purpose of Collection: Research only ☐; General stock ☒ Owner's Use ☐ Reforestation special ☐; Special request ☐ Other ☐ – ......
26. Collector's remarks (description of special trees, shipping instructions, etc.) Cone Crop Rating - very heavy (5) The fallers were hired from C.N.I. and the collection was supervised by the Fernie Ranger Staff

Date: October 7 19 74 Supervisor's Signature A.J. Jede

Extractor's Report (see instructions)

Date Cones received ...... 19 ...... Number of sacks received ......

Number of bushels received ......

Condition of Cones when received ......

Date Extracted ...... 19 ......

Yield of Seed ...... Kgm. (or) ......lbs. Purity ...... %

Number of Containers of Seed ...... Shipped to ......

Date Shipped ...... 19 ...... Shipped by ......

Moisture Content of Seed when Shipped ...... %

Extractor's Remarks: ......

Extractor's Signature ......

F.S. 721

DISTRICT HEADQUARTER'S COPY

(The instructions reproduced below may be found on the inside front cover of Form F.S. 721 and 721A pads. Note revisions on page 95.)

INSTRUCTIONS FOR COMPLETING CONE COLLECTOR'S REPORT FORM (F.S. 721 and 721A)

All forest tree seed handled by the British Columbia Forest Service must be registered. A central registry at the Duncan Seed Centre records and registers each seed lot. The completion of this form (F.S. 721 or 721A) is required for registration.

While most items to be completed are straightforward, special note should be made of the following items when completing this form:

Provisional Seed Zone Number — to be completed by the Forest District office or Duncan Centre. This number will relate to the Seed Zone map issued in November 1971 and subsequent revisions.

Collector's Provisional Seed Lot Number — This is the number by which the cones are identified when they are received at Duncan and given an official registration number. Each individual collector, if working alone on a small collection, or the person in charge of a crew collecting together from a single stand or location, will allot a collector's provisional seed lot number to each cone lot. These will run consecutively for each collector for each season. Normally all the cones from one species in one stand should be included in one seed lot unless the elevation range is more than about 500 feet.

Forest Service collections will be given provisional numbers based on Forest District, Ranger District and collection number (e.g. G15-1, G15-2, etc.).

Company collections should NOT use the Forest Service system of provisional number as this creates confusion. Company collections should be numbered according to Licence; e.g. TFL 18-1; TSHL A01445-3, etc. or should designate seed lots by company name or initial; e.g. Kaiser-1; C.F.I.-3.
All provisional numbers will begin at 1 on July 1st of each year.

Official Seed Registration Number — to be completed by the Duncan Seed Centre.

Item 6—This refers to the agency making the collection for the owner and not to the individual collector.

Item 7—This is the name of the person supervising the actual collection.

Item 8—Order-in-Council 3061 approved August 24, 1971, requires that a permit be secured to collect cones on Crown Land and written consent of the owner of private land or the tenant of Crown Land held under licence or lease.

Item 10—Seed Class — Production tree seed collections are classified as follows:

A. Classes — A5 — "Type" trees or individual tree collections.	
B. Classes	is seed from—
B1	Cleaned and registered plus stands.
B2	Plus stands or normal stands collected under supervision.
B3	Normal stands.
B4	Minus stand or no information.
B5	Plantations.

At the present time most cone collections will be from normal stands and will accordingly be classed B3. If cones are collected only from the better trees in a normal stand, the seed may be classed B2. Seed from cleaned seed production areas where only the better trees remain will be classed B2. Where insufficient information is provided, collections will be classed as B4. Seed from plantations will be classed separately, as the type of parent tree is often unknown. The ultimate objective, of course, is to have cones collected only in Classes B1 and B2.

Item 13—Normally single lots of cones will be limited to a 500-foot elevation range, more or less. If the range is considerably more than this, the stand should be broken into two or more lots.

Item 14—Location should be pin-pointed as closely as possible, giving name of district or nearest geographical feature (lake, river mountain, etc.) and distance and direction from nearest post office if possible.

Additional Instructions

1. Forest Service Collections

The original of the Cone Collector's Report Form for each separate seedlot should be mailed directly to the Seed Centre, B.C. Forest Service, 5847 Chesterfield Street, Duncan, as soon as the collection is finished. The duplicate copy should be sent to the District office and the third copy retained for Ranger District files. Every item on the form should be filled in except the extractor's report.

Tagging—All Forest Service collectors will normally receive a supply of Cone Collector's Shipping Tags (F.S. 518) addressed to B.C. Forest Service, Forest Nursery, Duncan, B.C. On the face of this tag is a space for shipper's name and address. On the reverse side are spaces for collector's name, the seed lot number he gives to this particular lot as explained above, species, place of collection, and number of sacks. When the back of the tag is completed, the perforated paper portion should be torn off and inserted inside the sack with the cones. It will be seen that this sheet has been duplicated on the back of the heavier outside shipping tag.

Standard two-bushel sacks will normally be supplied for collecting. When filling, do not place more than 1½ bushels in a sack. After inserting the perforated sheet removed from the back of the tag, sacks should be sown or tied and the tag attached. Every sack must have a tag on the outside and the corresponding duplicate sheet on the inside. As an additional aid to identification, the provisional seed lot number should be spray-painted in large print on the sacks.

Color of Cone Collector's Shipping Tags (F.S. 518) indicates the Forest District from which the cones originated: Vancouver Forest District, yellow; Prince Rupert Forest District, green; Prince George Forest District, blue; Nelson Forest District, white: Kamloops Forest District, red; Cariboo Forest District, brown.

2. Company and Private Collections

Company and private collections will be processed by commercial extractories. Plain tags showing the owner's name, company provisional seedlot number, species, location of collection and number of sacks in the lot should be placed both inside and outside the sack when shipping to the extractory. The date and method of shipping should be shown under Item 26 of the report form.

Cone Collector's Report Forms (F.S. 721A) are available from Reforestation Division, Victoria, from the District Forester's office or from Ranger District offices. When completed, the company should retain the **second** copy and forward the original and triplicate to the extractory along with the cones. The extractor will then complete his report and forward the original to the Duncan Seed Centre with the seed, keeping the third copy for his records.

At the Duncan Centre, seed will be tested and placed in storage, and a complete report showing the official registration number will be forwarded to the owner.

Extractor's Report

This section is designed to aid the private owner, the extractor and the Forest Service in following the movement and treatment of this valuable product. It is not necessary to enter extraction details such as kiln time, temperature, etc. but this may be shown under remarks if desired. Extracted seed should be forwarded with the original of the report form as soon as convenient to Duncan Seed Centre, 5847 Chesterfield Street, Duncan, B.C.

Revisions to INSTRUCTIONS FOR COMPLETING CONE COLLECTOR'S REPORT FORM (F.S. 721 and 721 A)

The instructions for completing the Cone Collector's Report Form have been revised as indicated below. **These revisions are in effect now** and will be incorporated in the printed instructions at the next printing.

- **Item 10 - Seed Class** (Note: The following codes categorize type of seed; they do not indicate ranking by genetic superiority.)

A. **Seed Orchard or Special Seed** = seed from,

Code
A1 - Breed orchards. Seed from orchards which include only progeny-tested stock, and are thus of proven superiority over seed from normal stands.
A2 - Full-sib orchards. Seed from seedling orchards made up of families raised from controlled pollination between selected plus trees.
A3 - Half-sib orchards. Seed from seedling orchards made up of families raised from open- or wind-pollinated plus trees.
A4 - Clonal orchards.
A5 - Combined clonal, full-sib and/or half-sib seedling orchard.
A6 - Single tree collections (open- or wind-pollinated).

B. **Stand Seed** = seed from,

Code
B1 - Seed Production Area (SPA), a natural stand which has been treated and had undesirable phenotypes removed.
B2 - Pre-selected seed stands and/or selected single trees within natural stands. Collections must be made under direct supervision.
B3 - Normal stands. Stand is of normal appearance and no effort has been made to select desirable phenotypes from within this stand.
B4 - Natural stand for which there is no information.
B5 - Squirrel caches and/or cuttings. This type of collection will only be permissible with prior approval of the reforestation officer, based on stand quality.
B6 - Plantations

- **Item 26 - Collector's Remarks** - in addition to any pertinent remarks the cone crop rating should be included for each seedlot collected, e.g. very light, light, medium, or heavy.

- **2. Company and Private Collections.** Substitute following for first sentence.

Company collections intended for reforesting Crown forest lands and private lands within Tree Farm Licenses will be delivered to the Forest Service for extraction at the Forest Service extraction plant. Private collections intended for reforesting Crown-granted forest lands will be processed at commercial extractories.

- **Change of Address - Duncan Seed Centre**

5847 Chesterfield Street, Duncan, B.C. has been replaced by
Box 816, Duncan, B.C. V9L 3Y2

- **Metrication**

Imperial units appearing in the form or instructions will be replaced by metric units.

TREE SEED REGISTER

Card No.	Seedlot	Species	Genetic Class	*	Age of Stand	Elevation in Metres	Location
1	2372	F	B3	C	003	1615	HARMER CRK

Prov. or Country	**	National Topo. Grid	Lat	Sq. Grid	Latitude Deg.	Latitude Min.	Longitude Deg.	Longitude Min.	Date of Collection Day	Mo.	Year	Method	***	hl Collected	No. Cones/hl
01	N	82	G	15	49	48	114	47	05	09	74	FE		84.6	

Extractor	Date of Extraction Day	Mo.	Yr.	% Moist. Content	% Purity	Original % Germ. Test
FS	08	10	74	8.7	98.6	90.5

* Plant Family
** Native or Exotic
*** Cone Crop Rating

Card No.	Forest Dist.	Management Unit	Seed Zone	Agency	Direct Cost of Collection/hl
2	N	FERNIE	4030	BCFS	51.27

Total Cost of Collection/hl	Cost of Shipping/hl	Cost of Extraction/hl	Cost of Collection and Extraction/kg	Cost/M Viable Seeds	Yield (kg.seed per hl cones)	No. seeds per gram	Grams in Storage
58.97		5.39	.	.	0.666	113	56220

% Latest Germ. Test	Vigour Rating	Nursery Factor	Est. Yield Plantables/M. (Based on gms. in Storage)	Seed Orchard No.
90.5		.515	3278	

Collecto...
Associa...
Purpose of Collect...
Date Cones Received ________, 19__, and No. Hectolit... AMOUNT EXTRACTED 56.320 kg
Extractor's Remarks
Seed Cutting Test ____ % Filled. Seed Tester's Remarks

WITHDRAWALS

Date	Order No.	Whom for -	Amount	Bal. on Hand	Germin'n %	Date of Test	Remarks
3/4/75	1827	PFRC	0.100	56.220	90.5	1975	

TREE SEED REGISTER
INVENTORY AND SEEDLING POTENTIAL FOR ALL ACTIVE SEEDLOTS
BY SEEDLOT

SEPT. 17, 1975

SEED LOT	GENETIC CLASS	N.T.G.	ELEV-ATION METRES	SP	SEED ZONE	LOCATION	MANAGE-MENT UNIT	DIST	AGENCY	COL-LECT YR	SEEDS /GRAM	% GERM	VIABLE SEEDS /GRAM	GRAMS IN STORAGE	NURSERY FACTOR	POTEN-TIAL M TREES
****	*******	*******	******	**	****	**********	******	****	******	****	*****	****	******	*******	*******	*******
2368	B3	92 G 05	1097	HM	1040	MT ELPHINS	QUADRA	V	BCFS	74	367	78.0	286.	3899.	0.333	372.
2369	B2	94 N 11	305	SW	7080	LIARD R	LIARD	G	BCFS	74	381	83.0	316.	15060.	0.330	1572.
2370	B3	82 M 10	1067	SE	3060	HIRAM CRK	TFL23	N	CCINT	74	412	76.0	313.	2555.	0.330	264.
2371	B3	82 G 15	1432	S	4030	HARMER CRK	FERNIE	N	BCFS	74	443	79.0	350.	10485.	0.330	1211.
2372	B3	82 G 15	1615	F	4030	HARMER CRK	FERNIE	N	BCFS	74	113	90.5	102.	64575.	0.515	3401.
2373	B3	92 O 16	1006	F	5020	TILL LAKE	STUM	C	BCFS	74	94	86.0	81.	68430.	0.515	2849.
2374	B2	82 F 13	1341	SE	3020	UPHODER CR	TFL03	N	TRIPAC	74	370	85.5	316.	2960.	0.330	309.
2375	B3	92 O 16	1006	F	5020	BECHER PRA	STUM	C	BCFS	74	98	79.0	77.	13990.	0.515	558.
2376	B3	32 J 11	1311	F	4030	PALLISER R	UKUOTE	N	BCFS	74	129	85.5	110.	14155.	0.515	804.
2377	B3	82 K 15	1219	F	4020	BOBBIE BUR	WINDER	N	BCFS	74	135	47.0	63.	10420.	0.515	340.
[illegible]	B2	82 N 02	975	F	4020	PARSON	TFL1[illegible]								.515	667.

CONE COLLECTING COSTS

N.B.: One sheet required for each Provisional Seedlot Number
(i.e. one for each species collected)

Provisional Seedlot No. N - 2 - 1 Species Douglas Fir

Forest District Nelson No. of ~~Bushels~~ 84.5 hectolitres

1. Indirect Costs (F.S. Personnel Wages)

   Pre Collecting Reconnaissance ½ day @ $35.00 = $ 17.50

   Supervision 10 days @ $35.00 = $350.00

   ~~(Reforestation Vehicle) 400 miles @ 30¢ = $120.00~~

   F.S. Transportation 640 miles @ 25¢ = $160.00

   TOTAL $647.50

2. Direct Costs (Non F.S. Personnel wages and all invoices)

   Wages, Foremen

   Fallers 750.00

   Pickers 1,860.00

   Hired Transportation

   Supplies 88.04

   Misc. Expenses

   TOTAL $2,698.04

3. Total Cost 1 and 2 above $3,345.54

4. Cost per ~~Bushel~~ Hectolitre (f.o.b. Ranger Station) $39.59

A F Tede
Supervisor

5. Added Shipping Costs

   From ______ to ______ $______

   From ______ to ______ $______

October 7, 1974
Date

Reforestation Officer

F.S. 736

Appendix IX
Selected Reading List

Allen, G.S. 1941. *A basis for forecasting seed crops of some coniferous trees.* Journal of Forestry 39: 1014-1016.

Allen, G.S. and J.N. Owens. 1972. *The life history of Douglas-fir.* Environment Canada, Forestry Service. 139 pages.

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Dobbs, R.C., D.G.W. Edwards, J. Konishi and D.P. Wallinger, 1974. *Cone Pickers Manual.* British Columbia Forest Service/ Canadian Forestry Service, Joint Report No. 1. 13 pages.

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Hedlin, A.F. 1974. *Cone and seed insects.* Environment Canada, Forestry Service, Report BC-X-90. 63 pages.

Kozak, A., O. Sziklai, B.G. Griffith and J.H.G. Smith. 1963. *Variation in cone and seed yield from young open grown Douglas-firs on the U.B.C. Research Forest.* University of British Columbia, Faculty of Forestry, Research Paper 57. 8 pages.

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Orr-Ewing, A.L. 1967. *A progeny test to demonstrate the importance of selection in forest practice.* British Columbia Forest Service, Research Note 43. 23 pages.

Orr-Ewing, A.L. 1974. *Good seed does not cost, it pays.* Forestalk (British Columbia Forest Service) 2(1): 17-19.

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Sources of photographs

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Figs. 4A-E, J-L; 5A; 6A, B; 8; 11; 12A-C; 13A-F; 14A, C, D; 15C, D; 16H; 17B, C, F; 19H, I, K, L; 21A, B, D, H; 23A-F; 26.

Canadian Forestry Service

Figs. 7; 9; 10; 12E; 15A, B; 16A-G; 17A, D, G; 19A, B, J, M; 21C, E-G, I; 24; 25.

Dr. J.N. Owens (University of Victoria)

Figs. 4F-I; 13G-I, K.

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Allen and Owens 1972

Figs. 5B-G; 6C-F; 12D.

Hedlin 1974

Fig. 17E; photo on page 5.

Orr-Ewing 1967

Fig. 14B

Orr-Ewing 1974

Fig. 14E, F.

Owens 1975

Fig. 19C-G.

Owens and Molder 1973. (Canadian Journal of Botany 51: 2223-2231.)

Fig. 13J.

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Fig. 13L.

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