Guide to handling of tropical and subtropical forest seed

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SEED COLLECTION

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Other Chapters of the book Guide to Handling of Tropical and Sub-Tropical Forest Seed by Lars Schmidt soon available on www.dfsc.dk

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SEED COLLECTION

4.1 Introduction

A number of methods for the collection of fruits and seeds have been developed. The methods range from simple collection from the ground after natural seed fall to advanced methods using sophisticated and expensive equipment such as elevated platforms, mechanical shakers or even balloons or helicopters. The selection of the most appropriate method depends on a number of factors but is usually eventually determined by the economy. The most efficient method is the one in which the appropriate amount of seeds can be collected with the smallest possible cost without jeopardizing seed quality (physiological or genetic), safety of staff and possible future seed production.

Seed collection is often the most labour and cost intensive part of all the seed-handling operations and one may be tempted to cut down labour cost and choose the cheapest possible method. However, an optimal seed quality at the time of collection is a precondition for an overall high seed quality, i.e. viability and longevity. Further, as the seeds contain the genetic potential of the crop to be raised from them, choosing e.g. 'climber-friendly' seed trees with low branches and crooked crowns could lead to genetic deterioration (cf. section 3.3). Hence, saving cost on seed collection can easily be uneconomical in the long run.

Seed collection methods have been described in details by Yeatman and Nieman (1978), Blair (1995) plus a series of technical notes from Danida Forest Seed Centre, e.g. Barner and Olesen (1983 a and b), Barner and Olesen (1984 a and b), Stubsgaard (1987, 1997), Baadsgaard and Stubsgaard (1989), Robbins (1983a and b), Ochsner (1984), Mwitwa (1990). A major part of this chapter has been compiled from these sources.

4.2 Factors Influencing Choice of Collection Method

In practice, the choice of seed collection method is usually restricted by a number of factors, e.g. relating to location of seed source, condition of the stand, individual trees and type of fruits or seeds and their maturity.

4.2.1 Climate and weather conditions during collection

In seasonal climates, seeds normally mature during the late dry season or early rainy season. Dry weather conditions are usually the most ideal for seed collection; movement to as well as within the seed sources are easier both because of the dry ground with reduced risk of vehicles getting stuck and because of more open vegetation.

Collection from the ground may be possible during the dry season but impossible during rain. In dry areas, ground collection, whether directly from the ground or from spread out tarpaulins, may be ameliorated by controlled burning of grass vegetation under the seed trees.

Moist or wet weather is generally not suited for seed collection. Accessibility and movement may be hampered, camping difficult or unpleasant. The beginning of the rainy season, when many trees fruit, is often unpredictable. Heavy downpours often cause flooding because of constrained permeability of dry soil and because of inadequate vegetation to absorb moisture. Ground collection may later be hampered by growth of ground vegetation, muddy ground or early germination of fallen seeds. Releasing fruits and seeds by shaking is usually more difficult in moist weather. Climbing in wet weather is both more difficult and more risky; bark gets slippery when wet, often exacerbated by the growth of epiphytes, mosses or lichens. Humid conditions also impede drying and extraction of dry seeds in the field (cf. chapter 5).

High air humidity may in certain conditions be beneficial for collection of dry fruits and cones since seeds are less likely to be lost when the fruits or cones are moist (Seeber and Agpaoa 1976).

Temperature in itself may not be crucial for the choice of collection method, but it should be taken into account that extreme hot weather will negatively affect the efficiency of collection by climbing. Climbing under such conditions should be restricted to the relative cool morning and afternoon hours. On the other hand, in high altitude areas where frost occurs, at least climbing should be undertaken only during midday when frost has disappeared.

Windy conditions hinder almost all types of collection. Generally, the danger of falling branches or heavy fruits during strong wind makes any stay in the forest risky. Some operations get especially difficult: branchlets and wind-dispersed fruits released by e.g. shaking or cutting may be blown far away from tarpaulins placed beneath the tree. Handling of long extended pruners, advanced lines etc. is very difficult and climbing under strong windy conditions is risky and dangerous; it should be avoided.

4.2.2 Damage to trees

Collection from standing trees involving climbing by the aid of spurs and pruning of seed bearing branches will inevitably cause some damage, but on a moderate scale it rarely influences general health or future seed production (see below). Scars in the bark left by spurs, and the open end of pruned branches will normally be sealed with resin exuded from the bark and gradually recover completely. However, in some instances insects or diseases may use scars as entry points for attacks. Both damage and the ability to close wounds depends on species: species with thick bark and excessive resin (e.g. *Pinus merkusii)* are little prone to damage whilst species with thin bark and less resin are more easily damaged. Susceptibility or resistance to damage of individual species should be considered in connection with choice of collection method.

Damage to trees can be reduced by appropriate methods of climbing and pruning, e.g. appropriate cutting of branches rather than breaking to reduce the exposed surface and the risk of bark being stripped off (fig. 4.1).

National parks and other conservation areas often have restrictions on operations causing any damage to trees (cf. chapter 3). In these cases, less damaging methods must be used, e.g. collecting individual fruits rather than cutting branches and using ladders or advanced lines for climbing rather than spurs.

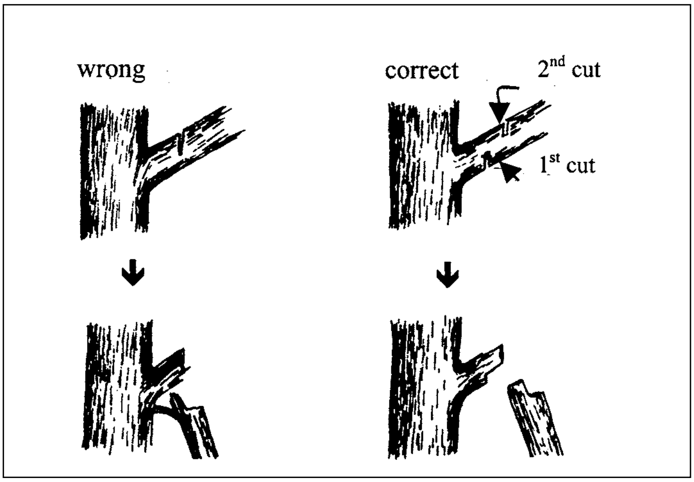


Figure 4.1.
Damage to trees can be reduced by correct cutting of branches during collection: to avoid bark being stripped off and leaving the sapwood exposed the branch should be cut from below before being cut from above.

4.2.3 Accessibility and terrain

Apart from managed seed sources, which have normally been established with a view of accessibility during seed collection, many seed sources are isolated and scarcely provided with roads. When vehicles cannot reach seed trees, equipment must be carried. Heavy and bulky equipment like ladders must often be left behind during expeditions far from roads and in hilly terrain.

Collection from trees growing on steep slopes can be difficult as cut-off branches and fruits may fall far downhill. However, slopes can sometimes ease the collection, e.g. by reaching fruit-bearing branches or placing lines over branches from an uphill position.

Stand density and understorey vegetation may restrict movement and ground collection as well as positioning of advanced lines, and reduce opportunities for shooting. Further, cut off branches may be prone to entanglement in dense crowns or understorey.

4.2.4 Shape and height of seed trees

Crowns of shorter trees may be reached by extended pruners or saws, or flexible saws or other equipment operated from the ground or the top of vehicles. Trees with long relatively straight clear boles of relatively small diameter can be climbed, up to the crown, by the help of spurs or a tree bicycle. Trees with large diameters, trees with large buttresses and overgrown by vines, climbers, stranglers or other large epiphytes, are very difficult to climb with spurs and a tree bicycle cannot be used. Here ladders, advanced lines or shooting are usually the only solutions. Large spreading umbrella-shaped crowns typical of many *Acacia* and *Albizia* species make the use of safety equipment very difficult and climbing of these trees may be excluded altogether. Methods of seed collection in relation to height and shape of trees are illustrated in fig. 4.2.

4.2.5 Type of fruit and seed

Small seeds from dehiscent fruits like eucalypts, casuarinas and conifers must be collected by picking the fruits from the tree before the fruits open. Pre-mature collection (chapter 3.2.6.) always involves direct harvest from the tree.

Large conspicuous seeds may be collected from the ground. However, those collected under the trees are often seeds that failed to be dispersed which may be only a fraction of the actual fruit production. It may suffice for small collections but usually not for bulk collections.

4.2.6 Special tree problems

In some species climbing within the crown can be subject to specific problems. Many dry zone species especially from Africa are extremely thorny and spiky and on e.g. *Acacia polyacantha* and many *Erythrina* spp. large thorns occur on the stems and main limbs. *Albizia*, *Paraserianthes*, *Pterocarpus* and many other Leguminoseae plus several *Cordia* spp. are often inhabited by extremely aggressive ants, which readily attack climbers. Tree crowns inhabited by wasps or bees may also present a real danger. It is advisable to examine the crowns with a pair of binoculars before climbing: if there are wasps or bees' nests, the trees should not be climbed.

4.2.7 Identity of mother tree

In tree breeding the identity of the mother trees often has to be known and this inevitably requires that collection is carried out directly from the parent tree and not from the ground, unless distance to other trees excludes alternative maternity. Collection from spread out tarpaulins after shaking individual branches of the mother tree in question may be applicable. However, the released seeds may be contaminated with seeds from neighbouring trees, e.g. if the branches of the canopy are somewhat entangled. Care should also be taken when collecting seeds directly from the crowns of trees with interlocked branches, as it can sometimes be difficult to see which branches belong to which tree.

4.2.8 Future seed crop

Damage to trees caused by cutting off branches may indirectly influence future seed crop by reducing the number of potential fruit bearing branches. Pruning may be directly detrimental to the next crop if young undeveloped fruits are removed together with mature fruits. This is a potential risk when fruit development takes more than one year, typical for most conifers (cf. section 2.3.1). However, moderate pruning may have a beneficial effect on future seed production as it promotes exposure to light of the remaining branches.

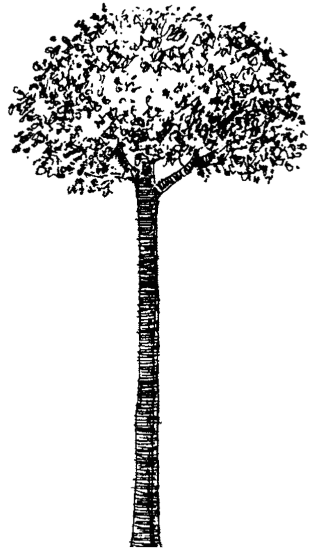
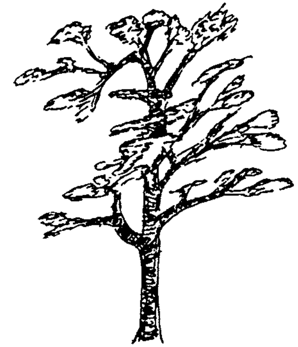
				
Characteristics	Long clear bole of small diameter with large crown with few large branches	Bole with large diameter, high buttresses and / or epiphytes, climbers, or vines	Long clear bole of small diameter. Small crown with many thin branches	Short clear bole, wide or narrow crown
Examples	Alnus nepalensis, Eucalyptus grandis, E. camaldulensis, Albizia spp.	Rain- or moist forest trees like *Agathis spp. Dipterocarps, Khaya spp.*	Conifers, e.g. pines, araucarias and cupresses Small broadleaves like *Alnus* and *Populus* spp.	Most young trees plus mature trees of low species e.g. acacias and erythrinas
Crown access method	Tree bicycle, spurs, advanced line	Advanced lines	Tree bicycle, spurs, ladder, (advanced line)	Ladder or spurs or directly operated from the ground
Harvesting technique	Within crown: movement w/ safety line Shaking or pruning of fruit bearing branches	Within crown: movement w/ safety line Shaking or pruning of fruit bearing branches	Free hand climbing w. safety line within crown. Pruning of branchlets or stripping off fruits with long handled tools	Flexible saws, extended pruners
Advanced methods	Balloon, shooting	Balloon, shooting	Net, elevated platforms, mechanical shakers	AElevated platforms, mechanical shakers, seed traps.

Figure 4.2 Seed collection methods as related to different tree shape.

4.2.9 Efficiency and labour costs

The easier and quicker the seeds can be collected, the lower is the collection cost. Collection from a heavily laden tree is obviously more efficient than collection of the same amount of seeds from several different parents. Any method involving climbing is likely to be fairly time consuming. Hence, once the climber has reached the crown, he should collect as much seed as possible.

Further processing costs should be considered in connection with choice of collection method. Collection methods in which much debris like soil particles, stalks or leaflets are mixed with the seed may make cleaning or other processing difficult (Turnbull and Martensz 1983).

In countries with high labour costs, advanced methods of collection with mechanical equipment, are justified in seed orchards, because seed production is high, spacing and terrain designed for easy movement, and the seed prices are high due to proven genetic superiority.

4.3 Collection from the Ground

Applicability. Species with large indehiscent fruits or large seeds. Most species will shed part of the fruits under the trees so that small quantities can usually be collected during the fruiting season. For larger collections the method prerequisites that a large number of fruits or seeds fall under the trees, and seeds are little prone to predation, dispersal, rapid germination or deterioration after fall. Mainly applicable to species with short duration of fruit maturation.

4.3.1 Collection after natural seed fall

Method. Collection is postponed until most fruits and seeds have matured and fallen to the ground. Many seeds normally fall during strong winds or heavy rain storms. If seeds easily deteriorate (recalcitrant seed), several collections may be necessary. Large or dense ground vegetation and debris may be removed a couple of weeks before seed fall in order to ease collection. Normally the fruits or seeds are simply picked up by hand or possibly by the aid of a pair of large pincers. If there is a large amount of fruits or seeds and the ground relatively free for debris, the fruits may be raked together. In seed orchards on flat terrain and with short ground vegetation natural fallen seeds may be collected by mechanical equipment using vacuum (light seeds) or rotating brushes (heavier seeds) (Hallman 1981), or collected from spread out ground covers (see below).

Advantages. The main advantage of the method is that time and labour can be saved by avoiding the labour-intensive collection from the crown. This is especially relevant for large trees where climbing is difficult. Untrained workers can collect the seed or fruit, e.g. casual labourers or schoolchildren. There is no damage to the trees and the collection is relatively independent of weather conditions.

Problems and limitations. For most species dispersal implies that the fruits and seeds are removed from the mother tree and dispatched some distance away. Hence, for those species, seeds that fall under the mother trees are those that fail to be dispersed, which is only a fraction of the total seed production. Seeds that fall close to the mother tree are especially prone to predation by insects or ground-foraging animals. For example, seeds of African acacias like *A. tortilis* are prone to heavy attack by bruchid beetles after fruit fall, and herds of wild or domestic herbivores rapidly remove the fruits (Coe and Coe 1987, Lamprey *et al.* 1974). In Costa Rica seeds of *Sterculia apetala* are attacked almost immediately after fall by cotton-stain bugs (*Dysdercus fasciatus*) (Janzen 1972), and in the Philippines rapid collection of seeds of *Anthocephalus chinensis* is necessary to avoid attack by ants (Seeber and Agpaoa 1976).

On moist forest floors, seeds with no dormancy germinate rapidly and are lost to the seed collector. Seeds that have imbibed moisture and initiated germination will normally not tolerate re-drying upon collection. Recalcitrant seeds impose a special problem since they will not remain viable for long. Such seeds that fail to germinate immediately after fall will rapidly deteriorate.

The maternal origin of seeds collected from the ground cannot usually be verified. In mixed stands of species with very similar fruits or seeds, there is a risk of contamination with seeds of other species that later during processing may be difficult to separate from each other. This is common in natural populations of e.g. dipterocarps, one of the species groups often collected from the ground after natural fruit fall. In cases of breeding, where the maternal origin must be known, the method is not normally applicable. An exception is those species that occur naturally dispersed in the forest and whose fruits naturally fall before they are dispersed by animals, e.g. *Artocarpus* spp. and *Durio zibethinus*.

Collection from the ground practically excludes all species with small or inconspicuous seeds. If the fruits and seeds are collected by raking the ground or by more sophisticated mechanical collection, there is a risk of collecting deteriorated seeds together with the good ones plus debris, and the cost of processing will often be increased. In addition, ground collected seeds may be prone to contamination with soil borne pathogens (Gray 1990).

Comments. Ground collection is conveniently used for large-fruited species like teak and *Gmelina* (fig. 4.3B) (Wasuwanich 1984). It is often applied in species with very high and inaccessible crowns such as many dipterocarps and other rain forest species. The latter are mostly species with recalcitrant seeds with short viability, hence collection must be done continuously during fruit fall. In some instances, however, dormant seeds accumulate in a soil seed bank year after year without germination and without considerable deterioration. This is often the case in hard-seeded legumes in arid or semi-arid environments where an accumulated seed crop may be extracted from soil under the mother trees. The procedure has been practised under *Robinia pseudoacacia* plantations in Hungary, where seeds were extracted from the upper 10 cm of the soil layer under the trees (Keresztesi 1980).

The problem of applying the method to relatively small seeds may be overcome by placing sheets, nets, funnels, or tarpaulins under the trees during the period of seed fall. Sheet funnels can be established under the crowns of relatively low and narrow crowned species (Doran *et al.* 1983, fig. 4.3A). Plastic sheets and tarpaulins placed on the ground have the disadvantage that water tends to collect with the seeds and may cause them to deteriorate. A prolonged cover may also damage the ground vegetation. These negative effects can be overcome by using fine-meshed nets rather than sheets or tarpaulins (Hallman 1993). Ground collection from nets is used in Denmark for collection of *Fagus sylvatica* seeds and in the United States for collection of seeds of a number of species.

Sheets, nets, tarpaulins and funnels are quite expensive, as they must cover a large ground area during the period of seed fall. They are, in most countries, only applicable in seed orchards, seed stands or for small samples for research purposes.

Figure 4.3. Collection after natural seed fall. A. Funnel mounted on a small tree for collecting acacia seeds during natural seed fall (from Doran *et al.* 1983). B. Mature fruits of *Gmelina arborea* on the ground.

4.3.2 Collection after shaking

Applicability. Relatively low trees with dehiscent large-seeded fruits or indehiscent mature fruits that easily separate from the branches, e.g. fleshy fruits and samaras. Usually species with a short maturation period.

Method. Fruit-bearing branches can be shaken from the ground by the aid of a hook mounted on a long thin pole or a rope thrown over the branches via the advance line technique (see section 4.7). Lines or hooks must be placed relatively distant to the stem where the branches are more flexible. Relatively low and young trees with a straight thin trunk like *Alnus*, *Betula* and many conifers may be shaken by placing the line over a high branch and then pulling the ends of the rope to one side and shaking sideways.

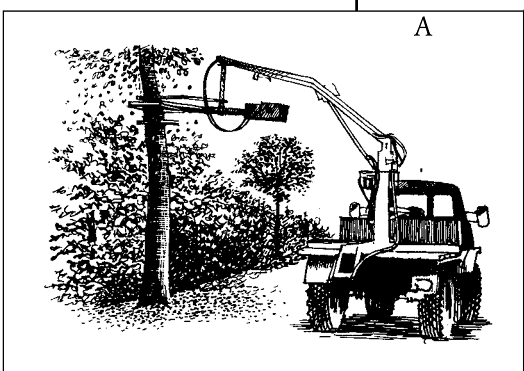
Because shaking is an operation of short duration, it is usually feasible to place tarpaulins or sheets under the trees before shaking to ease collection of the fallen fruits and seeds.

Special, powerful mechanical tree shakers have been constructed for use in intensive seed collection from seed orchards or other high-producing seed sources on flat terrain. Some types of shaker are mounted on the back of tractors or small trucks with automatic transmission, others are special vehicles designed to operate in seed orchards. During operation the tree shaker is clamped onto the trunk of the trees (Stein *et al.* 1974, Kmecza 1979). Even more sophisticated is the use of helicopters for creating turbulence to release the fruits and seeds (Vozzo *et al.* 1988).

Advantages. Shaking accelerates natural fruit or seed fall. A larger quantity of seeds can be collected than by awaiting natural fall, and the method reduces the loss to dispersal, ground predation, deterioration and germination. By using tarpaulins, smaller fruits and seeds can be collected by this method than after natural fall and there is less contamination from other seeds or debris. The identity of the seeds can be secured. There is normally no damage to trees by manual shaking; mechanical shaking requires some technical skill for operation without damage.

Problems and limitations. The method is restricted to a limited number of species (see applicability). For wind-dispersed seeds shaking must be done under calm wind conditions to avoid displacement of fruits or seeds. Mechanical shaking is restricted to areas accessible to vehicles. The equipment is expensive and in practice applicable only in seed orchards or similar high-producing seed sources.

Comments. Shaking down fruits or seeds is a commonly used technique for most large-fruited or seeded species, and shaking is also used in connection with climbing. Since the stalks most readily break off when dry, shaking is most efficient during low air humidity, e.g. midday. That has to be balanced against the risk of increased horizontal displacement by wind when the fruits/seeds are very dry.



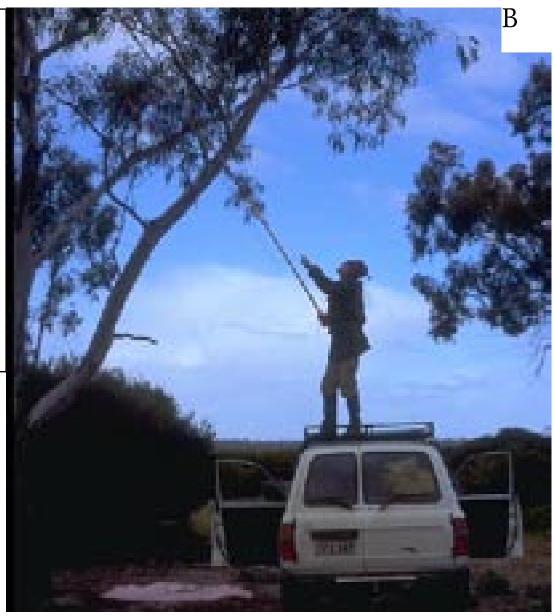


Figure 4.4.
Collection after shaking.
A. Mechanical shaker used in seed orchards.
B. Branches may be shaken or cut down by the help of telescopic poles or extended pruners. Higher branches can be reached from the top of landrovers or vans.

4.4. Collection from the Crown of Felled Trees

Applicability. Mainly bulk collection from large plantation species where collection can be combined with logging operation.

Method. Individual trees with good phenotypes are preferably marked as seed trees before logging. Fruits are harvested from the crowns as quickly as possible after cutting. Large fruits are picked individually, small fruits are collected from cut-off fruit-bearing branches. For small fruits it may be an advantage to release the fruit by pulling the branchlets through a stationary rake device (see fig. 4.5).

Advantages. The main advantage is that seed can be collected directly from the crowns of large identified trees without climbing them. Untrained or casual workers can collect a large amount of seed in a very short time, and the collection is relatively independent of weather conditions.

Problems and limitations. Logging is obviously destructive to the seed source and the method should only be used when trees are to be cut anyway; trees should never be felled just for seed collection. The time is often very critical; fruits should be mature or almost mature but not too close to dispersal, otherwise a lot of fruits may be lost when the trees fall. In some species felling in the early morning hours when the crowns are relatively moist may reduce loss.

Because water supply to the fruits stops soon after felling, fruits are likely to dry out more quickly than if the tree was still alive. Accordingly, dehiscence and abscission normally take place soon after felling. Immature fruits may mature forcibly which may result in poor seed quality. Hence, it is important that felling is scheduled so as to assure the optimal quantity and quality of seed. In species where seeds remain long time within the mature fruits, e.g. several pines and eucalypts (section 3.2.5), timing is obviously less critical.

Comments. Because of the great reduction in collection costs, seed collection in connection with cutting is widely used in plantation species where sufficient improved seed from seed orchards is not available. In New South Wales, Australia, most *Callitris* seed is acquired that way (Schaw 1996), and the method is widely used in West Africa, e.g. for *Triplochiton scleroxylon*, *Terminalia ivorensis* and *Khaya ivorensis* (Brookman-Amissah 1973). In species with regular abundant fruiting, seed

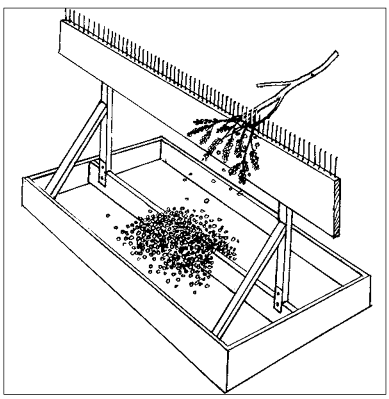


Figure 4.5.
A stationary rake device used for pulling off small fruits from branches. The branches are pulled through the teeth of the 'rake'.

availability can be assured by scheduling logging at the best time for seed collection. Further, sale of seed may yield an additional income, and seed availability can be announced a long time in advance (see fig. 15. 2).

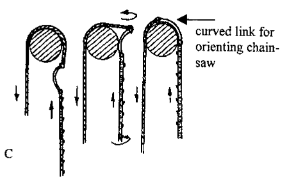
4.5 Collection from Standing Trees

Applicability. Relatively low trees or lower branches of larger trees before fruit dehiscence or dispersal.

4.5.1 Collection with access from the ground or low vehicles

Method. Low branches can be reached from the ground or from the top of vehicles where the terrain allows access for vehicles. Special platforms can be mounted on the load of pick-ups or small trucks (Willcocks 1974, Turnbull 1975). Higher branches are reached by long-handled equipment like pruners, saws or hooks to cut or pull down fruit-bearing branches. In the latter case the fruits are picked by hand or cut off by secateurs. Telescopic poles or bamboo poles can reach heights of max 6-8 meters, plus additional 1½-3 m if operated from the top of vehicles (fig. 4.4B). Extended pruners (secateurs) can cut branches up to 5 cm diameter, saws somewhat thicker, up to 10-15 cm.

Higher branches may be cut by the aid of a flexible saw, attached to a rope at each end. The saw is placed over the target branch by the advanced line technique (see section 4.7). By alternating pulling down the two rope ends the saw will cut through the branch. The flexible saw may be operated by one person only standing under the branch and using alternating hands for pulling. But, in addition to the irritation of falling saw dust, the operator runs the risk of being hit by both the falling branch and the saw once it is through. The saw should rather be operated by two persons standing a distance from each other and outside the range of the falling branch and saw. Several models of flexible saws are available. Thin wire saws may cut thin branches <5 cm diameter, but are not good for resin-rich species like conifers and *Pterocarpus* since the cutting edges easily get stuck with resin, after which the saw is no longer useful. Chains of chain saws or 'commando saws' can cut branches more than 15 cm diam. Most flexible saws are designed to orient themselves with the cutting edge down, in others a short curved link must be inserted just before the cable to orient the saw properly (fig 4.6).



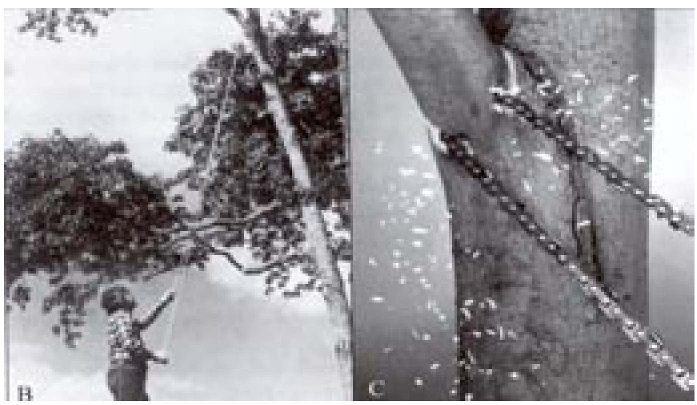


Figure 4.6.
A. The flexible saw in operation.
B. Close up of the flexible saw.
C. Curved link in connection with the flexible saw orients the cutting edge down.

Problems and limitations. Pulling or bending down branches implies a risk of breaking them and hence damage the trees. In addition, care should be exerted as hooks may easily slip off with the danger of hitting other collectors with the hook or back-swinging branches.

Cutting down branches inevitably causes some damage to trees and may be subject to restrictions in some seed sources (chapter 3). Operation of extended tools and placement of advanced lines are not easy under windy conditions. The length of the poles sets the height limits of operation. However, with increased length the tools get very difficult to handle especially in a non-vertical position.

There is in principle no height limit for the operation of the flexible saw other than the length of the rope, as long as the advanced line can be placed properly. However, cut-off branches easily get caught in the canopy of the tree itself or neighbouring trees. Especially when operated by only one person, the saw easily gets stuck if the cutting angle is not appropriate and the branch bends before it has been cut through.

4.5.2 Shooting down branches

Applicability. Very tall trees with heavy crop of small seeds, or collection of small quantities of seeds for e.g. research purposes.

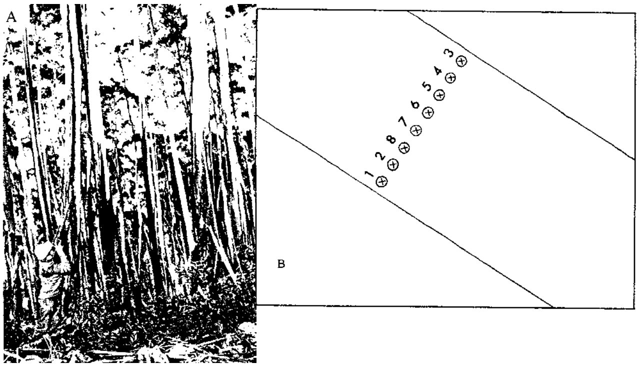
Method. A large-calibre rifle (.222, .243 or .308) with telescopic sight and 'pointed soft point' ammunition is used. Branches up to 15-20 cm diam can be brought down from the highest trees by 5-15 well-placed shots (Boland *et al.* 1980, ATSC 1995, Green and Williams 1969, Kleinschmidt 1989). Horizontal branches are the easiest ones to bring down, and shooting at a right angle to the branch is the most effective. A clear line to the branch is necessary and resting the gun on a fixed object like a tree or a vehicle facilitates precision. The first shot is placed at the down part of the branch to cut the underbark and hence avoid hanging of the branch or pulling off the bark of the remaining branch end when the branch falls. The second shot is placed at the upper part and the remaining shots at intervals across the branch (fig 4.7B).

Advantages. The method is quick and safe as compared to climbing. Guns and cartridges are light in weight compared to much climbing equipment and collection can be done by one person only.

Problems and limitations. The method is subject to the general rules and restrictions on use of firearms, *viz.* safety measures, licence requirement and prohibited use near populated areas or in wildlife conservation areas. The noise exerted may be annoying to people and disturbing to wildlife (the shooter and other members of the collection team should use earmuffs for protection). Branches of some species with stringy bark (e.g. *Eucalyptus globoidea*) can be difficult to dislodge by the method. Shooting can only be done under relatively calm wind conditions, as it is very hard to hit a moving branch. Use of the method requires a relatively open crown and stand, both to assure a clear shooting line and to secure branches falling freely after dislodgement. The price of ammunition may be limiting in many countries.

Comments. Collection by shooting is commonly used in Australia mainly for large eucalypts, where it may be the only method applicable (Boland *et al.* 1980, ATSC 1995). Despite the cost of ammunition it may be far more economical than climbing, especially where labour costs are high. A 15 cm diameter heavily fruited upper branch of e.g. *Eucalyptus camaldulensis* may yield some 100 grams of seed. With a current price of some US$500 per kg for high quality seed, 100 gram would be worth US$50 from which should be deducted the price of ammunition which in Australia is approx. US$ 4-5 for 10 cartridges.

Figure 4.7.
A. Practice of shooting (Australian Tree Seed Centre).
B. Positioning the shots through a branch.



4.5.3 Collection by climbing

Climbing has to be used when trees are tall and the fruits or fruit-bearing branches cannot be reached by long handled tools from the ground. This applies to the same fruit and seed types and the same fruiting behaviour as those collected from the crown with access from the ground (small fruits/seeds, heavy and early predation or dispersal, delayed abscission etc.). Climbing is arduous, time consuming and implies (even with the best safety measures) a certain risk, and is used only where there is no other alternative, - which is in fact quite common, especially for bulk collection of large plantation species.

Native forest dwellers are often extremely good climbers and able to climb tall trees bare-footed sometimes with the aid of a short rope tied between the feet (Willan 1985) or via smaller trees and then on to taller ones (Marzalina *et al.* 1993). These methods are, however, both strenuous and potentially dangerous. In forest seed collection safety should have high priority and climbing only be undertaken by trained climbers using appropriate safety measures (section 4.9). This always includes the use of safety belt or harness connected to a safety line or safety strop. Efficiency in climbing depends on the tree form, the climbing technique, the seed crop, and the climber. In Thailand it has been reported that a climber can climb 6 medium size *Pinus kesiya* trees per day, harvesting about 4-6 kg. of cones per tree, i.e. a total of 25-30 kg (Sirikul 1994). Tree climbing includes two techniques, 1. access to the crown by vertical climbing of the straight often branchless bole, and 2. climbing within the crown involving both vertical and horizontal climbing where the branches are the main support.

4.5.3.1 Climbing the bole

Applicability. Trees with a relatively straight and long clear bole of relatively small diameter (< 1 m) without buttresses and without overgrowth by epiphytes, climbers or vines.

Method. There are two methods using two different types of equipment *viz.* spurs (spikes) and the tree bicycle.

Climbing spurs are tied with leather or nylon belt straps to the inner side of the climber's feet and lower leg (fig. 4.9). During climbing the climber walks his way up the stem by alternating kicking the spurs into the bark and outer sapwood of the tree in short steps. He is secured to the tree by a safety strop going around the trunk and fastened to a safety belt or harness with a karabiner. The safety strop is moved upwards by the hands as the climber ascends. Many types of spurs are available some of which have changeable gaffs which can then be adjusted to different tree species. Some thick-barked pine species requires, for instance, longer spurs than the 'standard'.

The **tree bicycle** or 'baumvelo' is a Swiss designed device consisting of two parts, one for each leg, of different length. Each part consists of a ring attached to a pedal. The rings are placed around the bole, adjusted to the diameter so that they can move up and down freely, and locked. The longer part is placed above the shorter one so that the pedals are in level. The climber ascends by alternately lifting up and stepping down the pedals so that the two rings move alternating upwards. A safety strop is used in the same way as for spurs.

As the trunk tapers with increasing height, the safety strop gets too long and the rings of the bicycle too loose; both must be adjusted during ascent to fit the tree circumference. Branches are an obstacle for both the safety strop and the rings of the tree bicycle. Lower dead branches and small live lower branches may be broken off or cut, e.g. with the aid of a small saw pruner. Larger branches must be passed. When a large permanent branch is reached, a second safety strop must be fastened above the branch before the lower strop is detached (beware that the right strop is detached!). Passing side branches with the tree bicycle is quite arduous and the device is usually parked below the branch while the climber ascends into the crown using free-hand climbing with safety line (see section 4.5.3.4).

If the tree has a clear bole above buttresses it is sometimes possible to climb the lower part via a ladder and then proceed with spurs or tree bicycle above the buttresses.

Advantages. Both spurs and tree bicycle are quick ways of ascending compared to e.g. advanced line technique. The tree bicycle is less strenuous than the spurs as there is no risk of slipping. The main advantage of the spurs is that they are relatively cheap, have a very wide use in terms of tree types, and are easy to carry.

Problems and limitations. The tree bicycle can be used up to a trunk diameter of about 80 cm, which is the maximum circumference of the rings. For spurs the length of the safety strop normally determines diameter limit. Very large tree diameters hinder upward movement of the strop. A relatively stiff broad strap or belt is easier to move upwards than a rope strop. For very large diameters a steel wire strop is preferable. Overgrowth of climbers, stranglers, epiphytes or epicormic branches makes climbing by the way of the bole with either type equipment very difficult, but especially the tree bicycle.

The main limitation of the tree bicycle is the problem faced in passing side branches and forks, hence restricting its use to tree types where a long clear bole is followed by a branch-rich crown, e.g. most conifers. It is also difficult to use if the stem has any fluting. The tree bicycle is in limited use both because of these physical limitations and because of its relatively high price (Stubsgaard 1997).

The use of spurs requires a relatively thick bark and soft wood; thin bark and hard wood make slipping a potential risk. Holes left in the bark by spurs may be entry points for e.g. fungi. This is rarely a problem in conifers as wounds in these species close quickly through exudation of resin, but may be problematic in thin-barked hardwood species.

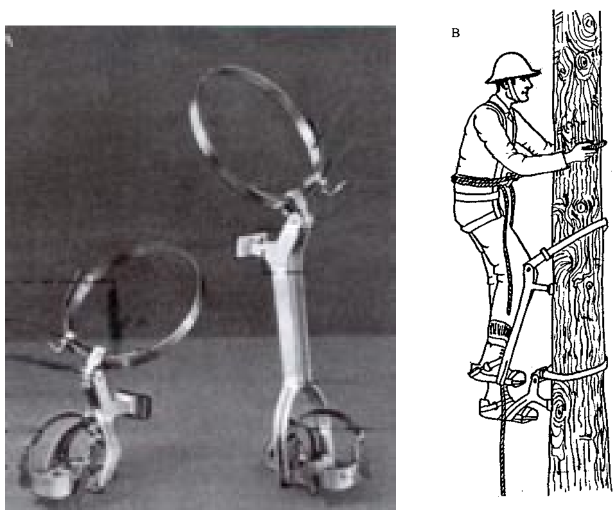


Figure 4.8.
A. The two parts of the tree bicycle.
B. Practical use of the tree bicycle.

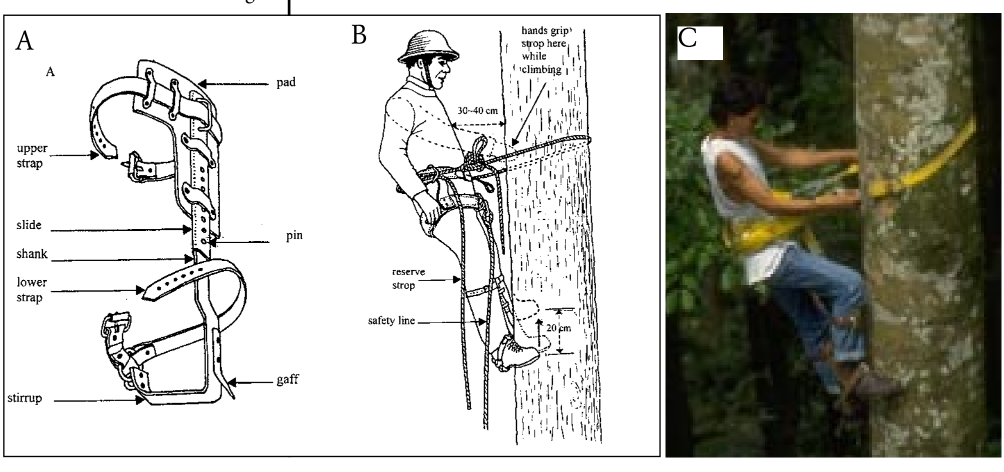


Figure 4.9.
Climbing with spurs.
A. Single spur showing different parts.
B. Use of safety line and safety strop in connection with climbing.
C. Practical use of spurs in climbing.

4.5.3.2 Access to the crown via ladders

Applicability. Low to medium size trees.

Method. Several types of ladder are available which may be used for tree climbing in connection with seed collection. The three main types are:

1. General-purpose fixed length wooden or light metal ladders of 4-8 meters.
2. General-purpose two legged wooden or light metal ladders consisting of 2-3 connected sections, each of 3-4 metres giving an extension capacity of 6-12 meters.
3. One or two-legged sectional ladders of 3-4 m's length per section which can be extended to indefinite length by adding additional sections on top.

General purpose fixed length or extendable ladders are raised in position from the ground, leaning towards the main stem or a stout branch (make sure that the ladder does not slip off or under!).

Sectional ladders are raised vertically, each section being tied to the bole with a strop or a chain. Since the flexibility of the ladder is limited and it is strongest in a straight vertical position, it is advisable to choose a side of the tree where collision with large branches can be avoided. When the lower part of the first section has been fastened around the bole, the climber secures himself with a safety strop around the tree and climbs to the top of the section where he fastens the upper part (long one-legged sectional ladders are usually also fastened at half-way points). The ground helper ties or clips the second section to the tool line attached to the climber's harness. The climber pulls up the section and places it on the top of the first section. He then climbs up and fastens the upper end (still secured by the safety strop while climbing). The third section is then hoisted up, placed, climbed and fastened and so on to the last section. When passing a side branch the climber secures himself with a safety strop above the branch before he releases the one under the branch in the same way as used with climbing spurs. The procedure is repeated in opposite order when the ladder is taken apart on the way down.

It should be noted that the standard straps or chains to tie the ladders to the bole usually only fit stems less than 50 cm in diameter. On larger trees some extension must be added.

Advantages. Ladders do no damage to the tree and climbing can be done when spurs are not suitable (e.g. thin bark or with some overgrowth). Climbing with ladders is quick and not exhausting; it is easy to move up and down. General-purpose ladders are relatively easy to move around in low crowns in which case they save much time and energy for climbing on branches.

Problems and limitations. There are two related main limitations *viz.* weight and length. Although light metal (aluminium) ladders weighing a fraction of wooden ladders are available, carrying long or several sections of ladder through adverse terrain and bush is arduous. In practice ladders are mainly used near vehicle access or at short walking distance. General-purpose ladders normally have a maximum length of 4-9 m. Longer ladders may be available but they are difficult to raise and manoeuvre. In addition to their being heavy they are thus potentially more dangerous to use.

Sectional ladders have no length limit as long as additional sections are available. They are, however, fairly dependent on a straight stem, although one-legged ladders have a certain flexibility. The diameter of the tree must not be too large both because of the problem of tying the sections around the stem and because of difficulties in moving the safety strop.

Metal ladders should never be used near transmission lines.

Comments. Rope ladders are used in connection with advanced line techniques and are mentioned in section 4.5.3.3. A special application of direct harvesting from ladders is the climbing net, a strong triangular rope net mounted outside the tree crown via a connection point at the top of the tree (fig. 4.10). The climber saves time climbing up and down the stem and out on the branches since he has immediate access to the fruit-bearing branchlets (Morandini 1962). The climbing net is only applicable to conifer types of crown in open stands, i.e. dense conical crowns, since in most broad-leaved species the net will get tangled in the branches. Its main advantage is that it is possible to harvest small fruits of e.g. thuja, callitris and cypresses without cutting off branchlets. However, because of its restricted applicability to open exposed conifers and the laborious way of raising the net it is not very much used.

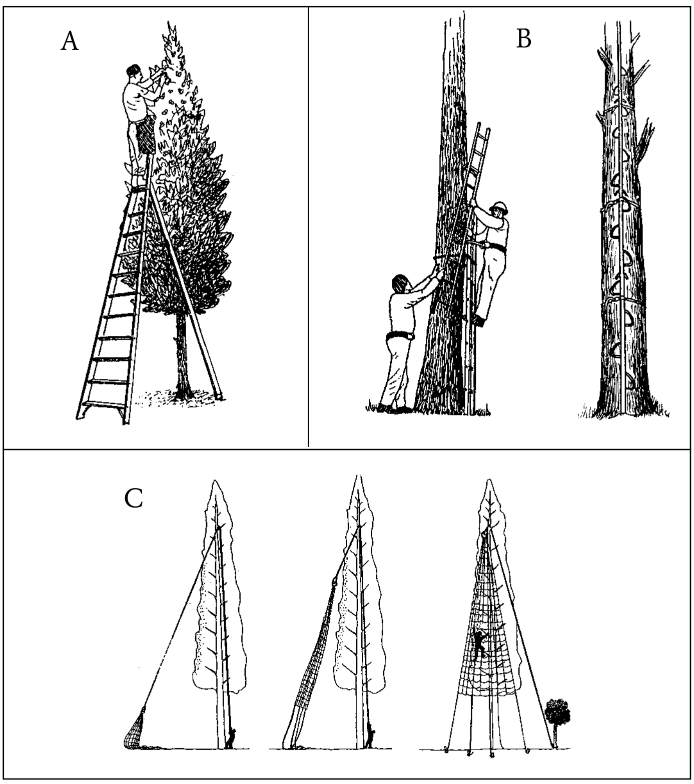


Figure 4.10. Ladder types used for seed collection. A. General purpose ladder. B. Sectional ladder. C. Triangular rope net for collection of small conifer cones.

4.5.3.3 Ascending via advanced lines

The technique of placing advanced lines is described and discussed in a special section (4.7) as it is used in several aspects of seed collection.

Applicability. Intermediate to tall or very tall trees and trees with stems unfit for climbing.

Methods. Ascending by advanced lines can be used in two ways, 1) where the climber ascends himself via a rope or a rope-ladder, and 2) where the climber is pulled up by one or two helpers on the ground by the aid of a pulley (block and tackle system).

Free rope climbing is physically exhausting and needs a fairly thick and rough rope; the normal rope used for lifeline is usually too thin and too smooth to climb without a rope-lock devise. Alternatively, the advanced line can pull up rope ladders; a rope ladder is easy to climb.

A special system for climbing one rope has been developed for mountaineering and modified for tree climbing (Perry 1978, Perry and Williams 1981). The system uses a special fitted rope-lock system, one connected to the safety belt/harness, another attached to a loop in which the climber places his feet. The climber raises his body resting on the foot loop, and pushes the upper lock upwards. He then rests on the safety harness and upper lock, while the legs push up the lower lock. The climber ascends this way by alternating moving upwards the upper and lower lock. The ground end of the rope must be held down so that the leg lock can be pulled up smoothly. Experienced climbers sometimes use only one lock for the hands, while the free end of the lock is held tightly between the feet by a special foot-lock technique.

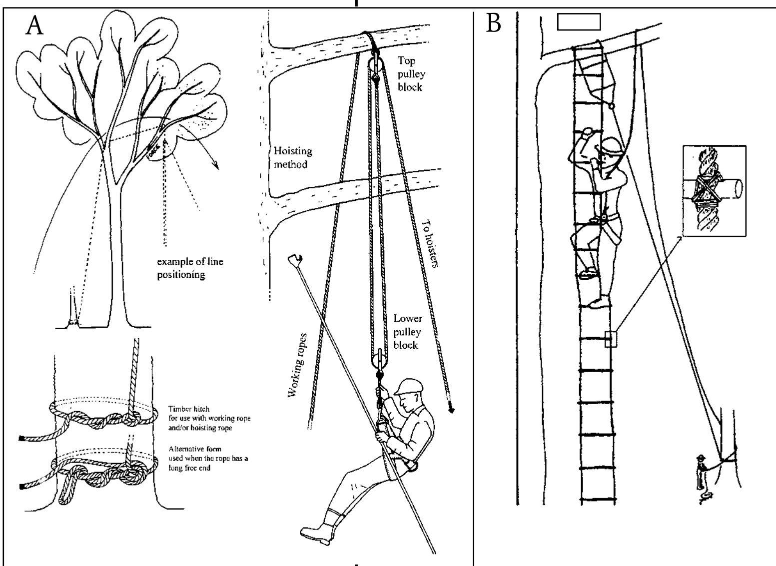
The block and tackle system uses a two-pulley system. The first pulley is attached to the advanced line and pulled up to branch level. The second pulley is attached to the harness of the climber. A rope is fastened to the eye of the first pulley, goes through the second pulley of the climber's harness and back up through the wheel of the first pulley (fig. 4.11). The connection must obviously be established before the first pulley is pulled up. When the first pulley has been pulled up, the end of the rope is firmly tied to a tree (fig. 4.11Ad). One or two persons then use the other rope to pull up the collector. By using two pulleys and the double line system (fig 4.11Ab) the power to pull up the climber is reduced.

Advantages. Advanced line climbing does not harm the tree and can be used where other methods are not applicable, e.g. rain forest trees with large diameters, high buttresses and overgrowth by epiphytes or climbers. The block and tackle system has the advantage that the climber saves energy as the ground men provide the energy for the exhausting ascent.

Problems and limitations. All the methods are quite arduous and time consuming because of the positioning of the advanced line system. Free hand climbing is exhausting and not very safe. Rope ladders are quite bulky and it is difficult to use safety devices while climbing in such ladders.

The block and tackle system is quite cumbersome, as it requires at least one helper. Its safety has been questioned since the climber is out of control while he is hoisted up. Electrical or other mechanical powered winches to pull up the climber are absolutely banned because of safety reasons: if a powered winch is not stopped immediately when the climber is up, a serious accident is inevitable. The rope lock system is the most convenient, safe and quick way of ascending but the locks normally require a special rope type, which is quite expensive and easily gets worn by the locks and hence needs regular replacement.

Comments. In rope climbing the climber relies completely on the safety of one support, the line he is climbing on. That introduces a special requirement for safety measures. Climbing via ropes has been used extensively for mountain and rock climbing. The techniques used for rock climbing are not, however, necessarily the same as for tree climbing. Rope climbing in trees has been further extended to include techniques for the establishment of ropeway systems used for floral studies (Perry and Williams 1981).



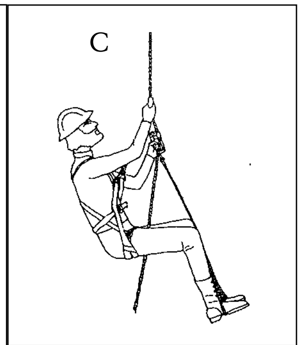


Figure 4.11.
Climbing via advanced lines.
A. Block and tackle system.
B. Rope ladder.
C. Ascending via one rope using rope-lock system.

4.5.3.4 Climbing within the crown

Vertical climbing is much easier than horizontal climbing of branches since in the latter case there is no natural support for the hands. Yet, fruits are normally borne on the outermost branches and it is sometimes necessary to climb or walk on horizontal branches.

A number of techniques and safety measures for climbing within the crown have been described in Yeatman and Nieman (1978), Stubsgaard (1987, 1997), Ochsner (1984); reference is given to these papers for details. The techniques should be introduced by training at low heights under appropriate instruction and supervision. Some general approaches are outlined here.

While working in the crown the climber should always be secured by a safety or life line which will arrest any possible fall (see section 4.9). The safety line may also be used for support and balance during climbing and as an ascent or a descent line. The safety line may be placed by the advanced line technique (section 4.7) or, for spur or tree bicycle climbing, be placed by the climber as he ascends. The safety line is placed as high as possible over a stout branch on the main stem, which will hold the weight of the climber and not break in case of a fall. A safety line is at least double the length of the height above the ground of the branch over which it is placed. One end is tied to the climber's harness by a karabiner, then the rope is looped over a branch, and attached again to the climber by a figure of 8 or a prussic loop. The rope end to which the climber is tied by the prussic loop hangs freely. The prussic loop is easily loosened but will grip firmly in case of a fall (Ochsner 1984).

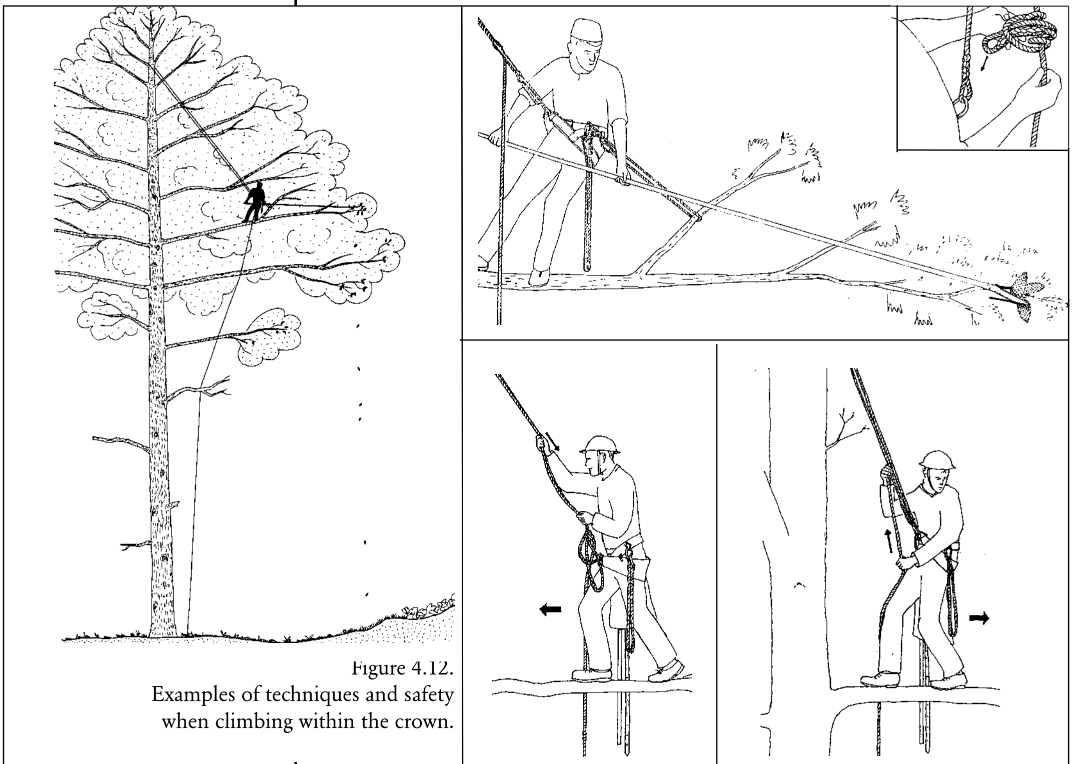


Figure 4.12.
Examples of techniques and safety when climbing within the crown.

4.5.3.5 Harvesting seeds from the crown

Several methods and accessories are available for harvesting fruits from the crown, some of them are the same as those used for harvesting with access from the ground (section 4.5.1). Sketch drawings of some of the equipment used appear in appendix A4.1.

The method selected depends on fruit type, maturity stage and tree morphology. Four methods are used:

1. Picking individual fruits into bags carried by the climber. The method is applicable if the fruits are prone to lose their seeds if thrown down, or ground collection for other reasons is difficult e.g. rough terrain or vegetation. For example, dry dehiscent fruits like cones of araucarias, agathis and temperate abies are often collected directly in bags because they easily disintegrate upon fall. The collector carries the bag attached to his belt. Filled bags

are lowered down by a tool line and emptied by the ground personnel.

2. Shaking. If the fruits are relatively large and easily loosened by shaking, individual branches may be shaken by hands or by a hook attached to a long pole (cf. section 4.3.2). Tarpaulins or sheets placed under the trees facilitate picking from the ground. It should be noted that wind-dispersed fruits may easily fall far away from the tree when released from height, even with only a slight wind.

3. Stripping off individual fruits. Large fruits that do not separate by shaking and do not dehisce during fall may be stripped off the crown with the aid of cone cutters or rakes (appendix A4.1). This method is used for most early mature large fruits plus for several fully mature but unopened cone types e.g. *Pinus oocarpa, P. patula* and *P. caribaea*.

4. Cutting down fruit-bearing branches. Very small fruits, e.g. eucalypts and cypresses, are usually borne on thin inaccessible branches and in this case the fruit-bearing branches are normally cut by secateurs or saw pruners, sometimes mounted on long handles. If the fruits or seeds are likely to shed during their fall, the loss can be reduced by placing tarpaulins or sheets where the branches fall or by carefully lowering them with the tool line. Special care should be taken in this operation: the line that holds the branch should be attached and later lowered via an anchor point above the climber, it should never be attached to the climber, otherwise he may be pulled down.

Fruits are stripped off the branches on the ground manually, by secateurs or by pulling the branches through a stationary rake device (fig. 4.5).

Pruning or stripping of fruits may occasionally be detrimental to future seed crops, especially where fruits of a younger development stage are present, e.g. in many conifers (see chapter 3).

4.6 Collection after Dispersal

Most seeds are lost to the seed collector once they have been dispersed. That holds generally for wind dispersed species with no directional dispersal, i.e. seeds are likely to be deposited at random over a large area (chapter 2). The fairly large seeds of some animal-dispersed species may in some instances be deposited in concentrations that make post-dispersal collection feasible. In temperate regions squirrels often collect cones and nuts in special food stores. These so-called caches have been used for collection of *Pseudotsuga menziesii* in North America (Stein *et al.* 1974, Dobbs *et al.* 1976). Some birds like hornbills often have particular resting trees under which large amounts of regurgitated seeds or stones are concentrated, e. g. of *Maesopsis eminii* in East Africa. Such stones have been cleared of fruit flesh and through being transported away from the mother tree they are less likely to be attacked by insects (cf. Janzen 1972).

Faeces of fruit-eating animals often contain a large quantity of seed but are usually too widely dispersed to be used for seed collection. However, in Africa goat and cattle enclosures often contain manure with a large concentration of acacia seeds, e.g. *A. tortilis*. Such seeds are usually free from bruchid attack and the hard seed-coat dormancy is more or less broken by the influence of the digestive juice (Coe and Coe 1987, Lamprey *et al.* 1974).

4.7 Advanced Line Technique

Applicability. The technique is used in several different aspects of seed collection *viz*.

1. Placement of safety lines
2. Positioning of ascending line, rope ladder, or net
3. Placement of flexible saws
4. Pulling down branches

Advanced lines are used for intermediate to tall trees. Positioning of the line requires a relatively open crown and a reasonable distance between the trees in order to give a good sight and to avoid entangling of weight and line in the canopy.

Method. The principle of the method is that a rope is positioned over a high branch by throwing a heavy (10-50 g) object attached to a thin line (e.g. fishing line) over the branch. The thin line may then be used for pulling up a stronger and heavier intermediate line, which may again be used to pull up e.g. a working/safety/lifeline or rope ladder. The intermediate line can, however, often be omitted by using a relatively strong line attached to the throwing weight.
Relatively low branches of say 5-8 m. can be reached by throwing the weight (e.g. a small bag of sand) by hand. Manual throwing is also applicable when using advanced lines in various connections while working in the crown. Advanced lines to be placed over higher branches require some ballistic accessories, e.g. catapult, bow, crossbow, or a gun (fig. 4.14). No matter which type is used, placing the line implies two main problems: 1. Placement over the right branch, 2. Avoiding the weight and line getting entangled in the branches.

In the ideal shot the weight passes just over the target branch and falls down on the other side, pulling up the thin line as it falls freely to the ground. That shot is quite difficult to make and one should choose a branch and a shooting angle allowing as much space as possible above and around the branch. If the weight is fired far beyond the target branch, which is often the case if the shooting power cannot easily be adjusted, a relatively vertical shot gives the best result. The weight must be sufficiently heavy to easily pull up the thin line as it falls to the ground, i.e. overcome weight and friction of the line, but sufficiently light to be thrown or fired the required height. Friction of the line during firing or throwing may affect both throwing distance and precision. Therefore the line should unwind freely, e.g. from a fishing reel. If an arrow or steel rod is used, the line is preferably tied to the base since that affects the precision least.

Problems and limitations. Guns may be small rifles with blank cartridges or air guns. In both cases a heavy arrow or steel rod is fired. Since the rod fills up the barrel, the line must be fastened at the top end of the rod, which may affect the precision negatively. A crossbow uses a short heavy arrow in which the line is attached to the bottom end. Both guns and crossbows have a good sighting mechanism and high precision but normally do not permit adjustment of the firing power with the consequence that the arrow or rod may pass far beyond the target branch and may get entangled in branches above.

Precise shots with ordinary bows require a bit more skill and experience but by adjusting the pull on the bow the distance can be adjusted to just pass the target branch. A problem with bows is that they need relatively long arrows, which get entangled more easily than the short crossbow arrows.

Stubsgaard (1987) designed a special catapult (fig 4.14) for placing advanced lines in connection with seed collection. The catapult has two major advantages: 1. Distance of the shot can easily be adjusted to the height of the target branch, 2. It uses a small lead weight, which does not easily get entangled in branches.

The density of the canopy may limit the use of advanced lines. Dense canopies with thin branches like many conifers are very difficult to place a line in without the line getting entangled in other branches. In dense stands, especially with understorey, it is difficult to find a good angle for shooting or throwing.

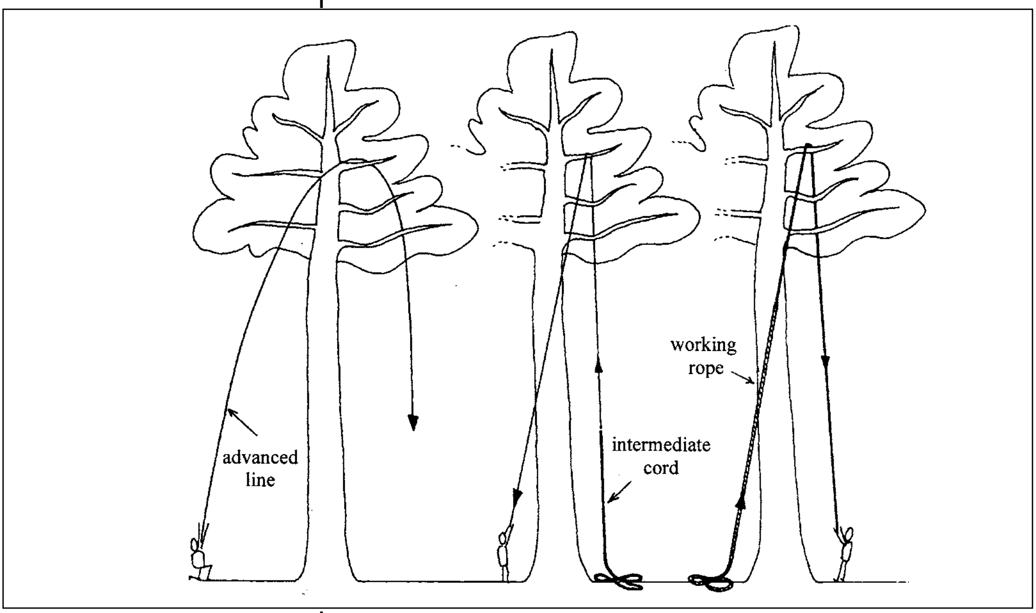
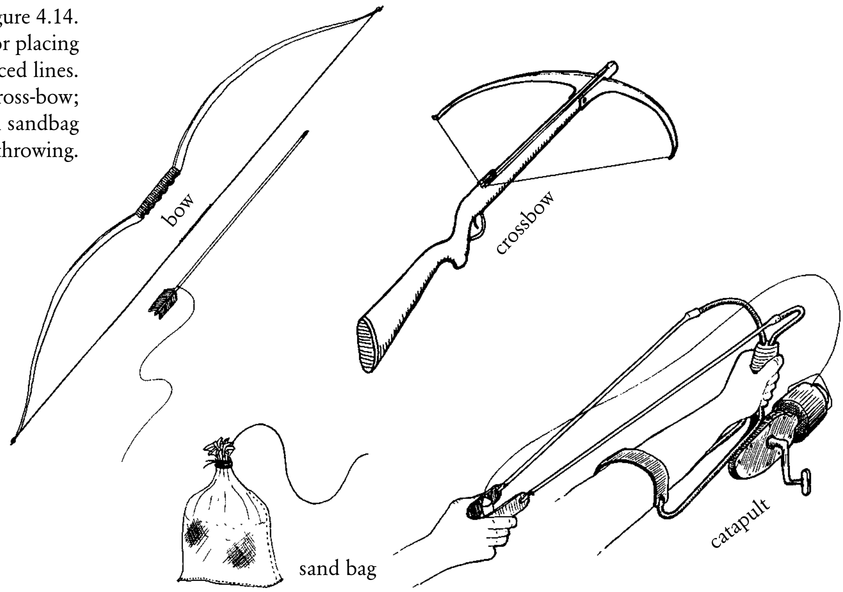


Figure 4.13. Practical use of advanced lines.

Figure 4.14.
Devices for placing advanced lines.
Bow and arrow; cross-bow; catapult; small sandbag for throwing.



4.8 Bags and Containers for Collection and Field Storage

If fruits are to be collected from the crown directly, the climber normally carries a small cone bag attached to his belt. When the bag is full, it is lowered via the tool line and emptied into a large bag. Normally only dry fruits are collected that way. Fruits or seeds collected from the ground, directly or from pruned branches, are preferably collected in open containers such as baskets, buckets, tarpaulins or canvas sheets. Baskets are used for relatively large fruits and seeds. Baskets can be made of wire, rattan, bamboo or the like. Wire baskets are usually preferred since they are easier to clean and stack, but they are only usable for large fruits. Buckets are used for fleshy fruits. Metal buckets are preferred because they are stronger than plastic ones and can be repaired.

Tarpaulins can be used for most fruit types. After collection the fruits are raked or swept together and put into the storage container. Care must be exerted not to perforate the tarpaulin by stepping on it as twigs or other sharp material will readily perforate it.

Canvas sheets are convenient for quantities of small and dry fruits and seeds like eucalypts and casuarinas. The sheets (approx. 2x2 m) are spread on the ground and fruits and fruit-bearing branchlets collected on the sheet. When the work is finished and the sample labelled with a number corresponding to the seed collection form, the sheet can be folded together and tied carefully corner to corner. The sheets can easily be opened to expose the fruits to drying when required.

If large quantities of fruits are collected, collection containers may preferably be emptied into sacks, barrels or other larger containers.

Collection containers or sheets as well as those used for bulk storage should be tight and cleared of all seeds and debris from previous collections. This is especially important for small seeds like eucalypts and casuarinas whose seeds easily slip out of small holes, and leftover seeds may be stuck in corners or canvas with a risk of contamination. Fruits are preferably removed from the twigs before being put into the sacks as twigs may easily perforate the material. Storage containers should not be too large, both for convenience of carrying, and because aeration may be insufficient in large containers.

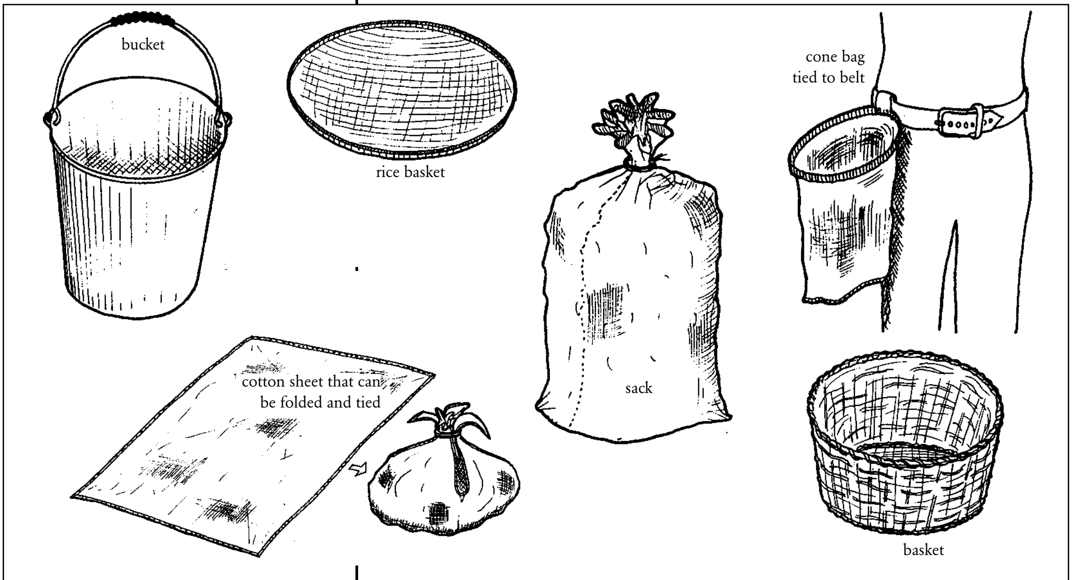


Figure 4.15.
Some types of container used during collection and temporary field storage.

4.9 Safety in Seed Collection

Collection from the ground does obviously not imply many safety hazards. Use of e.g long handled tools increases the risk, and climbing may be dangerous both for the climber and for the ground staff. Some risk factors and safety measures have already been mentioned under the individual collection methods; in this section some general rules and precautions are stressed and discussed. Seed collection often takes place in remote places, usually well away from qualified medical assistance. Even relatively minor accidents can therefore have severe consequences.

It can probably not be overemphasized that in dangerous operations like e.g. tree-climbing safety must not be sacrificed to save time, money or other short-term convenience. In fact, appropriate safety measures are likely to make collection more efficient. Risk of injuries cannot be eliminated but greatly reduced by exerting the appropriate safety measures. As in most other work functions, most accidents happen to beginners and very experienced staff. The former because of insufficient practice, the latter because they may be disposed to take short cuts because the work has become routine.

Safety precautions should be enforced particularly in relation to the following points:

1. Use of ground operated equipment
2. Collection near transmission lines
3. Danger of falling objects

4. Maintenance and careful use of climbing equipment
5. Personal fitness
6. Personal clothing
7. Tree defects / weaknesses
8. Insects
9. Equipment when climbing

Re. 1. Although minor cutting injuries happen to users of e.g. secateurs and saws, there is probably a higher risk of being injured by others (and of injuring others) than of injuring oneself. Long-handled tools like extended pruners and hooks to pull down branches can be perilous as the user often miscalculates the weight when the tools are held in a non-vertical position.

Bows, crossbows, catapults etc. used in advanced line techniques are potential weapons and should be treated with the safety measures weapons deserve, i.e. assembled and available only when in use, with fellow workers safely behind the person shooting, and safe aiming (not at people - not even for fun!). For firearms, special rules and safety measures apply for use and storage of both gun and ammunition; these should be known and complied with by the licensed holder.

In a group of more than three people it is difficult to keep track of the position of all the others during operation. Therefore large teams should be avoided.

Re. 2. Climbing or collecting seed from trees growing close to transmission lines should generally be avoided. If collection has to be done from such trees, metal equipment such as ladders and long handled pruners should not be used. Tree climbers should keep a safe distance from such lines.

Re. 3. Some fruits are heavy. A heavy durian fruit falling from 25-30 meters can easily kill a person. The direction of falling branches is often unpredictable as they may be diverted by wind or other branches. Climbers may easily break off branches and heavy fruits and accidentally drop equipment like secateurs or hand pruners. Hand tools should be attached to the climber by a string, which both protects ground staff and avoids the annoyance of losing the equipment. Both climber and ground staff should observe safety precautions. The climber should be aware of the position of the ground staff who in turn should never place themselves under a climber. Ground staff should be notified when e.g. bags of fruits are thrown down. In addition it is advisable that ground staff use safety helmets/hard hats.

Re. 4. Climbing implies the obvious risk of falling, and a fall may easily be fatal. Safety precautions for climbers imply correct use of safety equipment such as safety belt, harness and safety line. Safety devices should be manufactured from high quality materials, preferably acknowledged brands. Special attention should be paid to locally manufactured ropes, which do not always reach the standard required for tree climbing. Safety equipment should be inspected regularly, i.e. before each climbing, and possible damage should be repaired before use. If necessary, the equipment must be replaced. Special attention should be paid to the sewing of e.g. safety belts, and fibre damage of belts and ropes. Because nylon ropes do not rot, their durability is often over-estimated. Nylon rope is easily damaged by heat created by friction, and long exposure to sunlight weakens the material.

Leather is prone to rotting especially under humid conditions. Tearing and rotting often starts near the holes of rivets, which must therefore be examined particularly carefully. Longevity of leather is improved if it is kept dry and possibly preserved by leather grease when not in use.

Karabiners are used to fasten safety strops and safety lines in D-rings of the harness. The karabiners should be easy to open and close, and should have a safe lock system.

Use of safety equipment during climbing comprises a number of special techniques which should be known and carefully observed. For details reference is made to Yeatman and Nieman 1978, and technical notes from DFSC (e.g. Stubsgaard 1997). A few points are emphasized here.

Safety belts or harnesses are always used during tree climbing. The safety belt consists of a broad belt fastened around waist, and a saddle. A harness is provided with shoulder strops. D-rings of the safety belt serve to connect safety strops, safety lines, working rope, tool line and equipment.

The safety strop (or strap if it is a belt) is used during vertical ascent. It is connected to the safety harness with karabiners and goes around the bole. When a branch or a fork is passed, the strop has to be disconnected. Therefore, a second strop is connected above the branch to be passed before the lower one is disconnected.

Safety lines are used during ascending, horizontal climbing and descending. A safety line is connected to the climber's harness/safety belt, then looped above the climber at an anchor point, and attached to the climber again by a prussic loop (fig. 4.12). The connection to the safety line is adjusted so that it does not impede the free movement of the climber, but is simultaneously tight enough to suspend a possible fall within 2-3 meters. Care must be observed that appropriate safe knots are used.

Re. 5. Climbers should be physically fit, have a good sense of balance, fast reaction and not suffer from height dizziness (acrophobia). A climber who does not feel well, or who is recovering from debilitating illness e.g. malaria, should not be allowed to climb. Obviously drugs, alcohol or hangover should be banned in connection with climbing.

Re. 6. Clothing should be strong and fit well without being tight, and be without loose straps, belts, pockets or other appendices that might get entangled in branches. Climbing in tropical temperatures can be physically exhausting and very hot, and the clothing must allow adequate ventilation. Climbing trees with myriads of aggressive ants is a nuisance; well-fitting clothing with zippers rather than buttons and elastics around wrist and ankles yields some protection. Footwear should be strong and well-fitting with high-friction soles. If climbing spurs are used the best footwear is boots which protect the shins. They should be provided with a marked heel to avoid the spur slipping off. Gloves may be advisable to protect the hands and increase the friction when ropes are used.

Re. 7. Trees differ in the physical strength of their branches, some species have very brittle branches. The tree climber should be familiar with the strength of the species he is climbing. Lower branches are normally self-pruned by abscission from the tree. Therefore, there are often several dead branches below the crown which are not safe and cannot carry a person. The climber should also observe any disease in branches which could make them weak. When climbing in branches the climber should have three points of support at all time, i.e. one hand and two feet or two hands and one foot, moving one limb at a time.

Re. 8. Although ants may be an extreme nuisance during climbing in some trees, they rarely impose a real danger other than that of taking a certain amount of attention. However, bees and wasps can be really dangerous. It is advisable to examine crowns with binoculars before ascending: trees with bees or wasps' nests should never be climbed.

Re. 9. Any excess weight or projection is an obstacle to safe and smooth climbing as it may get tangled in the branches and be dangerous in case of a fall. While climbing up and down, the climber should be free of any excess equipment. Especially dangerous is anything tied around the neck. A pair of secateurs and a folded pruning saw are practical for removing obstacles when climbing. All other equipment is preferably left on the ground and hoisted up via a thin tool line once the climber is in place, connected to the anchor point and ready to start the collection. The equipment is lowered before the climber descends.

Rope and sharp equipment is a potential dangerous combination. Great care should be exerted when using secateurs, saws or the like near cutable material. Also climbing spurs can cause damage to ropes.

It is mandatory that climbers have received appropriate training in techniques and safety precautions before they start climbing, and that very difficult tasks are carried out by experienced climbers only. Safety training for climbers should include rescue operation from the crowns in case a climber is not able to get down by himself. Accordingly, two sets of climbing equipment should always be available at a climbing site, and at least two trained climbers should be in a collection team. Further, the staff should be trained in basic first aid and the team should be provided with a first-aid kit.

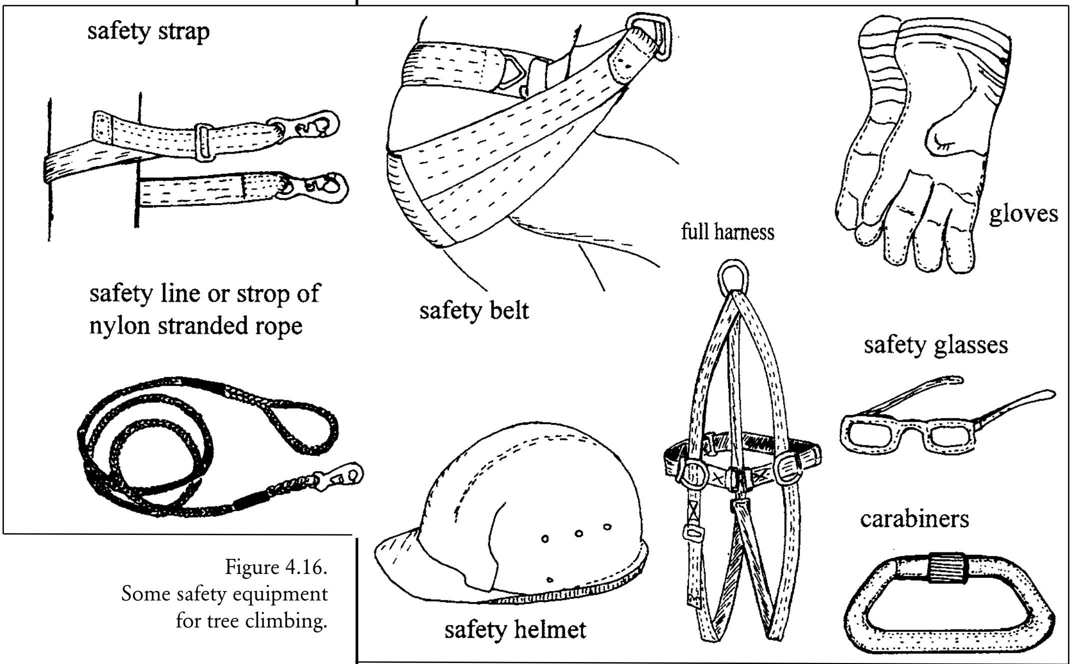


Figure 4.16. Some safety equipment for tree climbing.

4.10 Field Records and Sampling

The seed documentation system is described in chapter 14. Documentation starts in the field and follows the seed lot during processing, storage and testing to distribution. The following information should be recorded during collection:

1. Species (+ subspecies or variety). If there is any doubt of the species identification, herbarium material should be collected together with the seeds for later botanical identification. The material should preferably include flowers (if any are left at the time of seed collection), leaves and intact fruits. It is important that the material is preserved appropriately in a plant press, and labelled so that it can be related to the seed lot (individual tree).

2. Location. Geographical coordinates should include, as precisely as possible, the site of the actual collection. Geographical coordinates are found on large-scale maps, e.g. 1: 25,000 or 1:50,000. A recently developed system, geographical positioning system (GPS), uses the position of satellites for geographical coordinate finding (ATSC 1995). The system is quite exact but needs special, and still relatively expensive, equipment (the prices are going down). Altitude is indicated in meters above sea level (m.a.s.l.), which can be found on topographical maps (notice that some older maps and some countries indicate feet), or with the aid of an altimeter. The altimeter works on the principle of decreasing atmospheric

pressure with increasing altitude. Since the pressure varies with weather conditions, there is always a certain (but rarely important) error in altimeter indications. Adjusting the altimeter at a point of known altitude reduces the error. In hilly areas an appropriate altitude range (e.g. 400-600 m.a.s.l.) is recorded.

3. Soil samples may be taken for analysis and documentation of soil type. Alternatively, simple analysis such as pH and structure may be undertaken on site.

4. The number of parent trees, from which seed is collected, should always be recorded for documentation of genetic diversity.

Labelling

Appropriate labelling goes hand in hand with seed documentation. Maintaining the identity of the seed lot is especially important for single-tree collections where the identity of the mother tree must be known. Each seed lot is labelled with a number that serves as a preliminary identification number. The number on the label corresponds to the number appearing on the seed collection form (chapter 14). The label must be written with non-water-soluble ink on weatherproof labels, and safeguarded from blowing away or otherwise getting lost during handling. While the seed collection form is normally kept safely with the seed collector, the seed labels are prone to getting lost during seed handling, after which the identity is lost. It is advisable to put duplicate labels inside as well as outside each fruit container.

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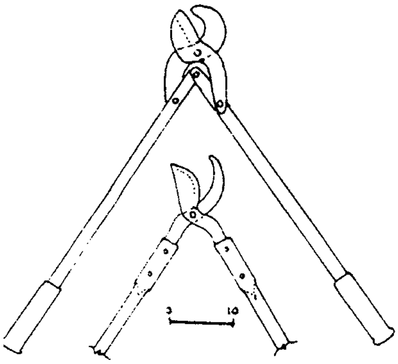
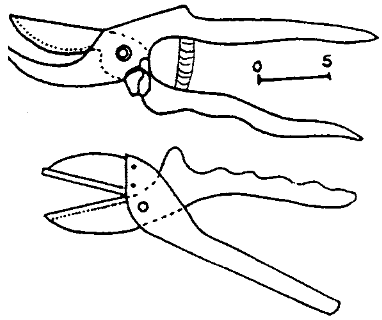
Appendix A4.1 Tools for harvesting tree seed.

1. Pruning shears

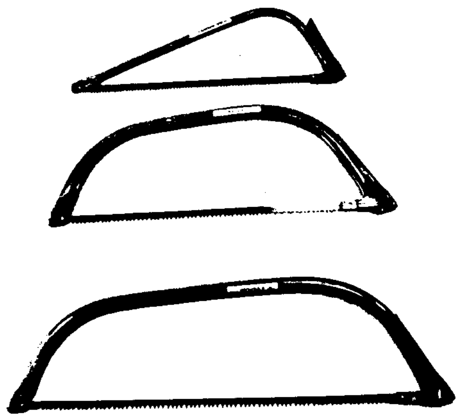


2. Secateurs (hand pruners)

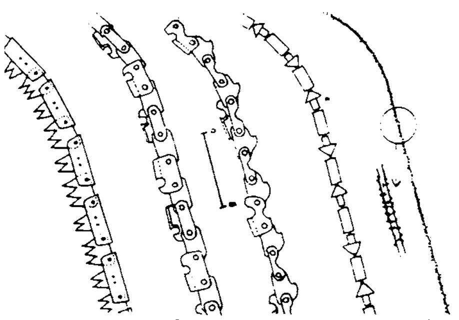


3. Pruning saws

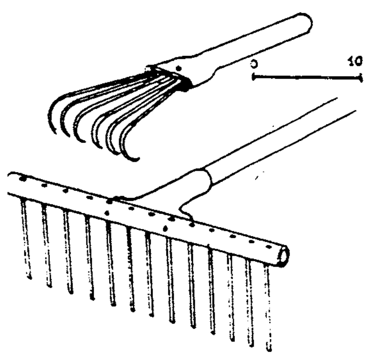
4. Bow saws



5. Flexible saws



6. Rakes



7. Pole pruners