LESSON 2

CULTURE OF NATIVE PLANTS

Aim
Determine cultural practices to maintain healthy native plants.

Australian Natives are generally easily cultivated under a wide variety of conditions within the garden. Species natural to any given area with usually perform better then those introduced from other areas.

The climate, soil, aspect and the characteristics of the plant should all be given consideration before choosing appropriate species. Once you have learnt to develop a good plan and also understand the growing conditions required, a native garden will provide you with years of beauty and pleasure

Galls on Acacias are often caused by wasps Treatment –remove and destroy damaged tissues.

CULTIVATION OF AUSTRALIAN PLANTS

There are three main things which affect the way a plant grows. They are **environmental factors** such as temperature, light or moisture; **nutrition** (ie. the supply of food to the plant and the influence of **pest and diseases** on the plant's health. You should strive to gain a broad appreciation of these three factors. With such an understanding comes the ability to make your own decisions about how to grow a particular plant in a particular place.

Environmental factors

Consider where the plant grows naturally.
This may give you some idea of its requirements (eg. Banskias tend to occur in well drained soils, indicating that they need good drainage; plants which grow above the snowline will probably tolerate very cold conditions, etc.). A plant which is grown outside of its natural environment can often still be grown successfully, but you may find that it will grow differently (eg. tropical plants which are grown in the southern states tend to be smaller in size; in other words the plants may need more protection than they do in the north).

- Consider light and temperature conditions.

Characteristics such as foliage colour, flowering, fruiting, rate of growth, etc. are largely controlled by temperature and light conditions. It is helpful to think of plants as having "optimum", "tolerable" and "intolerable" ranges of environmental conditions. For instance, for a particular Grevillea, optimum growth may be achieved if temperatures stay between 20 and 30 degrees centigrade. The same plant may tolerate temperatures as low as minus 5 degrees C. and perhaps as high as 50 degrees C., but above or below these extremes the plant will die. Many plants will lose the brilliant colour in their leaves if they do not get ample light. Flowering and subsequent fruit development will also be affected by low light levels for many plants.

- Similarly rainfall, wind, hail, frost, etc. will all affect plant growth.

Nutrition

- Both northern and southern rainforest species tend to require reasonably fertile soil conditions.
- A large number of Sclerophyll plants have evolved in relatively infertile soil conditions. Many of these plants will grow better in soil which is not overly fertile.

Pests and diseases

There are hundreds of pest and disease problems which commonly affect native plants. Many insect attacks occur in the natural environment as well as in cultivation. For example, many Eucalypt species often have anywhere from 15 to 50 percent of their foliage eaten by insects annually.

If the plant is healthy, most pests and diseases will not be of any great concern and will probably not need treatment. For example, wasps lay their eggs in the flowers and leaves of wattles causing abnormal swellings and distortions (ie. galls) as the grub develops. Although the galls are unsightly most plants will normally recover from the injury. For some plants, a severe gall infestation can however, eventually lead to death.

- The best way to fight pests and disease is to grow hardy and resistant species. When you propagate plants, discard the weaker growing ones. When you buy plants, buy the healthiest looking ones (even if they are smaller or more expensive).
- There are some diseases which are very damaging and almost impossible to combat. For example, *Phytophthora cinnamomi*, or Cinnamon fungus, is a soil- borne disease which attacks the roots of a wide variety of plants, causing a thinning of foliage and eventual die-back of the plant. The disease moves in the soil water and is more likely to occur if the ground is wet. It is virtually impossible to control: if you suspect that you have it, take a soil sample to your Department of Agriculture (or a University Botany Department) for analysis. If your fears are confirmed, all you can do is improve the drainage in your soil AND try to stick to plant varieties which are resistant to the fungus.
- Chemical sprays can be used in your native garden to control pests and diseases but you should be aware that:
  - Some chemicals will kill off the beneficial insects (ie. the insects which naturally eat your pest; worms which carry rotting material into the lower levels of the soil; bees which pollinate your flowers etc.)
  - Chemicals may harm wildlife (either through direct feeding of sprayed plants or insects or by contamination of water and soil).
  - Some chemicals are very dangerous to humans; others are much less of a problem! Know your chemical thoroughly before use it!

Sawfly larvae attacking a *Eucalypt*

Inkspot Disease
A common fungal problem on *Anigozanthus* leaves
The best control is to choose species or hybrid varieties which are more disease resistant

SOILS ARE THE KEY

A plant is only as good as the soil it grows in. Soil provides plants with their nutrients, it holds the plant firm in the ground, and it provides air and water. The soil's physical structure and biological and chemical nature are critical to good plant growth.

Soil physical structure
Soil is composed of

- Solids and
- Non-solids (pore-spaces containing air, water, etc.).

The solid component of soil is made up of four different types of particles in varying percentages.

- SAND and GRAVELS: particles between 0.02 and 2 mm diameter
- SILTS: particles between 0.02 and 0.002 mm diameter
- CLAYS: particles less than 0.002 mm diameter
- ORGANIC MATTER: in varying stages of decomposition.

The nature of a soil is mainly determined by how much of each of these 4 parts goes to make up the soil. This will help determine how much pore space is present in the soil. Too much or too little of any one of these components will cause the soil to have undesirable characteristics eg. soil with a large proportion of small particles will have poor drainage, whereas soil with a large proportion of large particles will have poor water retention. The physical structure of the soil can also be altered by human intervention for example heavy foot or machine traffic, or over cultivation can result in compaction of the soil causing a reduction in pore space between the soil particles.

Chemical nature of soil

- Plants obtain their food in the form of nutrients from the soil. There are around 50 different nutrients used by plants. Some are needed in large quantities (eg. Nitrogen, Potassium and Phosphorus), whilst others are only needed in small amounts.
- Nutrients must be in the right balance in the soil (ie. too much of one nutrient can stop another nutrient being used, even if it is there in an adequate quantity).
- The acidity of the soil can affect the plant's ability to use nutrients; thus the acidity (or pH) must be at the right level for the plant to perform at its best.
- Each type of plant has a different set of chemical conditions which are ideal for it (ie. what is best for one type of plant may not be best for another).

Soil profile
Topsoil generally has a higher percentage of organic material and more nutrients than the lower layers. Topsoil generally drains better than deeper soil. The change from the topsoil to deeper layers is normally gradual, allowing roots to adapt to changes as they grow deeper. Plants generally do not like sharp changes through the soil layers; compost, sand or topsoil which is added to the planting hole should be thoroughly mixed into the surrounding soil to avoid sudden changes in the soil layers.

Biological nature
Harmful or beneficial organisms in the soil can directly affect plant growth and health. For example organisms such as nematodes can directly attack plant roots, mycorrhiza may increase the availability of nutrients to plant roots, nitrogen fixing agents such as *Rhizobium* bacteria may help convert atmospheric nitrogen into a form suitable for uptake by plant roots, and earthworms will help improve soil structure and fertility by the digestion and movement of organic matter through the soil and by increasing pore space by the presence of their burrows.

What type of soil do you have?
Soil can be named by a simple test:

- Take a pinch or two of soil in the palm of your hand and add just enough water to make it stick together (not too wet or dry). If it doesn't stain the fingers and feels coarse, it is SANDY SOIL.
- If it can be rolled into a ball which holds together, while still feeling gritty, it is LOAMY SAND.
- If it can be rolled into a cylinder while still feeling gritty, but where the cylinder barely holds together it is SANDY LOAM.
- If the cylinder is more solid and doesn't crack or feel gritty, but doesn't bend without cracking, it is LOAM.
- If it is like a loam except it's also sticky, it is CLAY LOAM.
- If it is very sticky and when bent, the cylinder doesn't crack at all, it is CLAY.

IMPROVING SOIL STRUCTURE
Soils which have poor structure can be improved in the following ways:

Clay soils
- Add lime, gypsum and commercial preparations such as Multicrop Clay Breaker and Agrosol have the effect of causing soil particles to aggregate to form soil 'crumbs' (or 'peds') This makes the soil easier to dig, helps water to be absorbed, and assists earthworms and other small organisms to carry organic matter deeper into the soil.
- Organic matter can be incorporated into the soil.
- Sand can also be incorporated into the soil to help improve drainage, but generally large amounts of sand would be required, so it is rarely done.

Sandy soils:
- Adding clay and organic matter will aid water retention

In both cases the addition of organic matter has extra benefits, including raising the soil's fertility, encouraging small animals (eg. worms) and beneficial soil micro-organisms (eg. bacteria, fungi), and improving the soil's ability to resist ("buffering effect") sudden or extreme changes in soil temperature or chemistry.

Watch the soil acidity
Acidity affects how plants take up nutrients. Extremely acid or alkaline soils can prevent plants absorbing some types of nutrients. The plant will suffer from a nutrient deficiency, even though the required nutrient is in the soil. For example, in very acid soils all the major nutrients will be in short supply; in alkaline soils, phosphorus and some of the trace elements will be unavailable for plant growth.

Most plants prefer slightly acid to neutral soil, so check your soil with a pH kit (available from nurseries and garden centres). Apply lime if you have acidic soil, and use sulphur to lower the pH of alkaline soils.

Soil pH
pH is a measurement of the hydrogen ion concentration in a particular medium, such as soil. More simply it refers to the acidity or alkalinity of that medium.

The pH is measured on a logarithmic scale ranging from 0 to 14 with 7 being considered neutral, above 7 being considered alkaline, and below 7 as acid.
The pH of a growing media or a soil is important to plant growth. Each particular plant has a preferred pH range in which it grows. If a plant is subject to a pH outside its preferred range, its growth will at least be retarded, or it may even die. Very low pH (less than pH = 4.5) and very high pH conditions (above pH = 9) can directly damage plant roots.
Very high and low pH values can also affect plants as follows:

1. As the pH of a soil changes so does the availability of nutrients. The majority of nutrients are best available at a pH range of 6 to 7.5. Somewhere in this range is generally considered to be the ideal for growing the majority of plants, although there are plants that prefer higher or lower pH conditions. In some circumstances, particularly at very low or high pH conditions, some nutrients may become 'locked up' and unavailable to plants. Although the nutrients are present, the plants can't use them. At **very** low pH conditions, toxic levels of some nutrients, such as manganese and aluminium, may be released.

2. As the pH of some soil is raised, more negative charges are produced on some colloid (particle) surfaces, making them capable of holding more cations. This allows some soils to hold larger quantities of nutrients.
Soils and growing media that contain clays, or some of those derived from volcanic materials are most affected.

***CATION EXCHANGE CAPACITY**

Cations are atoms which have lost electrons. As such they are particles which have a positive charge. Many important plant nutrients occur in a soil or nutrient solution as cations (i.e. potassium, calcium and magnesium). These particles will be attracted to particles which have a negative charge. Thus they will remain in the soil, or the growing medium, and become available to the plant roots for a longer period of time.

Organic matter such as peat moss, and fine particles such as clay, have a lot more negative charges on their surface, hence a greater ability to hold cations (higher cation exchange capacity) than larger sand or gravel particles. Soil or growing media with a very low cation exchange capacity will require more frequent application of nutrients than ones with a higher cation exchange capacity. When a nutrient is applied to a soil (or growing medium) with a low cation exchange capacity, but high water holding capacity, the medium might remain moist, but many nutrients will be lost with drainage of excess irrigation water - so becoming leached more rapidly. A higher cation exchange capacity will reduce this tendency.

3. Like plants, micro-organisms have a preferred pH range in which they thrive. Altering the pH may severely affect the populations of both beneficial and detrimental micro-organisms. For example, the bacteria that convert ammonium to nitrogen prefer a pH above 6. Most mycorrhizal fungi prefer a pH range between 4 and 8.

Adjusting pH

On a new growing site, soil pH should always be tested. Commercial growing media should normally have a pH between 6 and 6.5 (though for some types of plants, the ideal pH is higher or lower than this).
If a soil's pH is either too high or too low, it can be changed to a certain extent. Slow-release lime will raise pH, and sulphur chips will reduce it. But this will always be a temporary amendment. It is far better to grow the plants that suit your soil, rather than have a constant, time and money consuming, fight with nature.

pH and Nutrient availability

The ease with which plants can take up nutrients is greatly affected by pH. Extremely acid or alkaline soils can often prevent plants using available nutrients. Nutrient deficiency can be caused by incorrect pH. The ideal pH is often slightly different for each nutrient. Iron and calcium differ more than most. The only answer is to compromise - go for a pH in the middle.

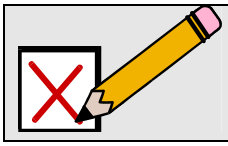
Optimum pH for nutrients:

Nitrogen	6 to 8	Calcium	7 to 8.5
Phosphorus	6 to 7.5	Potassium	6 to 10
Magnesium	7 to 8.5	Sulphur	6 to 10
Iron	4 to 6	Manganese	5 to 6.5
Boron	5 to 7	Copper & Zinc	5 to 7

***BUFFERING CAPACITY**

The soils ability to withstand rapid pH fluctuations is known as 'Buffering Capacity'.
The greater ability a soil has to withstand fluctuations the greater the amount of acid which must be incorporated with a material to alter the pH.

- Sandy soils that have little clay or organic matter have low buffering capacity
- Soils that have lots of mineral clay and organic matter have a high buffering capacity
- Soils with low buffering capacity need less lime to raise the pH then soils with a high buffering capacity.



SELF ASSESSMENT
Perform the self assessment test titled 'test 2.1.'
If you answer incorrectly, review the notes and try the test again.

Water and Air
The plant roots need water and air just as much as nutrients.

Water:
Nutrients (except carbon and oxygen) must be dissolved in water for plants to absorb them. Water itself is also needed by the plant for metabolism, where it is important in the processes of respiration and photosynthesis.

Air:
Soil air is essential! It is richer in carbon dioxide, and poorer in oxygen, than atmospheric air. Only a few plants (specifically water plants) can survive with very little air about the roots. The amount of soil air depends on the size of pore spaces between soil particles. Thus, water-logging will damage plants by depriving the roots of oxygen, not because there is too much water.

Soil temperature
The rate of absorption of water and nutrients is affected by the temperature of the soil. Too much heat or cold will slow the whole metabolism down. Soil temperature is not always the same as atmospheric temperature. Mulching a plant, or adding organic matter to the soil, will even out the fluctuations in soil temperature. As with most organisms, plant roots will grow within a particular range that varies between species.

Humus
Humus is organic matter that has decomposed into a stable, 'colloidal' form. A colloid is a solid that is held in suspension (like jelly). Because of its colloidal form, humus can retain nutrients and prevent them from leaching out of the soil. Plant roots can extract nutrients from humus.

Organic matter
The average soil contains around 2 to 4 percent organic matter. Organic content tends to drop in the course of normal cultivation therefore the addition organic matter to **any** soil-type will improve its quality. Only soils already exceptionally high in organic matter, such as peat soils, will not benefit from additional organic matter.

Organic matter benefits the soil in many ways, including:
- Adding valuable slow-release nutrients to the soil.
- Acting as a buffer against sudden chemical or temperature changes which can damage plant roots or adversely affect soil micro-organisms.
- Helping to improve soil structure.

Organic matter can be added in the following ways:
- Incorporate home-made garden compost during the growing season.
- Use organic mulches on top of the soil. Mulches such as leaf-mould; shredded pruning material; composted woody waste, and similar materials, are all ideal for the purpose. As material breaks down, particles will be worked into the soil. **Always mulch onto warm moist soil.**
- Leave crop plant roots in the soil, if possible, where they will decompose and increase the level of organic material.
- Incorporate well-rotted manure during the growing season.
- Grow green manures whenever crops are not growing, particularly during winter months. The green manures will protect the soil surface, as well as providing plenty of organic material to dig in.

Soils with good organic matter content are generally easily worked – that is, they have a 'good tilth'. If you squeeze a handful of soil into a ball in your hand and it remains in a hard lump, then it has a poor tilth - hard clods will probably result when it is cultivated. If it crumbles, then it is well granulated with a good tilth. Soils with good tilth are less subject to wind and water erosion.

SOIL AND WATER

Why is water important to plants?

Plants absorb more water then any other material, most of it entering the plants through its root system from the soil.

- Seeds require water to initiate enzyme activity required to activate germination
- Water is used in photosynthesis and all other metabolic processes associated with plant growth and development
- Lowers the temperature of the plant's leaves when water is dissipated through transpiration
- Water dissolves nutrients before they are up-taken by plants.
- Water functions as a transport system within the plant moving nutrients to sites where they are converted into products of photosynthesis, and then transports the synthesised materials to sites of storage or use within the plant

Infiltration and Water retention

Infiltration refers to process of water entry into the soil and is influenced by:

- Soil type and soil texture. Sandy soils generally have higher long term water penetration rates than clay soils.
- The condition of the surface soil. Water will enter faster if the soil surface is friable and open or is extensively and deeply cracked. Compacted or crusted soil with few cracks reduces infiltration.
- The stability of the surface soil. Low water stability means that the soil crumbs do not stay together when wetted. Low water stability results in slow water penetration unless the soil is sandy. Also, it often results in the formation of a surface crust as the soil dries which will reduce infiltration at the next irrigation.
- Depth of soil above an impermeable layer. For example, if a soil consists of light loamy topsoil over a clayey subsoil or parent material, any water up over the impermeable layer reduces water penetration.

Infiltration and retention of water into the soil can be improved by adding organic matter – it stabilises and strengthens aggregates improving soil structure, increases cohesion of sandy soils and decreases cohesion of clays. In both cases it creates a better range of pore sizes (tilth) for optimum root growth. Organic matter also decreases adhesion in most soils.

Suitable organic materials include:

- Manures
- Peat moss
- Straw
- Pine bark
- Mushroom compost
- Aged sawdust

When to water

Knowing when to water is extremely important for healthy plant growth. Over and under watering can be equally detrimental.

Under-watered plants will exhibit the following symptoms:

- Leaves wilt - especially new growth.
- Leaves turn yellow.
- Leaves burn and sometimes drop off the plant.
- Stunted growth, poor flower and fruit set – typical symptom of long-tem water deprivation.

Over watered plants will appear:

- Leggy, brittle stemmed and have lush, or even rank, new growth.
- Flowering will be reduced at the expense of leaf and stem growth.
- General plant health will be reduced as soil nutrients are leached from the soil
- Disease problems will increase, particularly root and leaf fungus.

Observing stress symptoms should be a last resort in deciding when to water.

A simple test that involves simply feeling a sample of soil can indicate soil moisture levels. The sample should be taken from the root zone of the plant:

Degree of moisture	Feel of soil	Amount of moisture
Dry	Powdery	none
Low	Crumbly, does not stick together	25% or less
Fair	Crumbly, but does hold together	25%-50%
Good	Will form a ball with some pressure	50-70%
Excellent	Pliable ball which sticks together readily; some clear water can be squeezed from it	75-100%
Too wet	Sticky ball which water can easily be squeezed from.	100%

Period of watering

- In sandy soils you can apply a lot of water quickly and it will be absorbed.
- In heavy clay soils you must water slowly over a long period (Heavy applications will not soak in, and a lot will be lost as run off).
- Deep rooted plants such as trees should be watered slowly over a long period, so as to wet the soil to a great depth.
- Deep rooted plants can be watered less often.
- Shallow rooted plants such as annual flowers and vegetables need frequent watering, but of a shorter duration at each watering.

Water-wise

- Wise usage of our water resources is very important. How often you water will depend on a variety of things including the types of plants you are growing; local climatic conditions such as the amount, frequency and timing of rainfall, winds, sunshine, etc.; and soil conditions. The following points should be considered when deciding when and how to water your natives.
- Minimise your water requirements by selecting plants to grow that require little or no watering.
- A good deep watering is more effective than a lot of shallow watering. It encourages roots to travel deeper into the soil, and reduces the development of extensive surface roots that require frequent watering. This is very important when establishing young plants.
- Water only when you need to. If there is moisture in the soil within 2- 3cm of the surface (poke your finger into the soil to check) then there is generally no need to water. If new growth on your plants appears healthy and there is no evidence of wilting, burning, etc. during the warmer times of the day, this also indicates that there is adequate moisture present in the soil.
- Try and group plants with similar watering requirements together. This helps reduce the likelihood of under watering or over watering particular plants.
- Avoid watering plants from areas of low rainfall during hot weather. Wait till conditions cool down. In particular avoid watering the foliage of these plants as high humidity levels can help the spread of disease.

HOW TO IMPROVE DIFFERENT TYPES OF SOILS PROBLEMS AT A GLANCE

Problem	Solution
Poor drainage	Lay drainage pipes Plant in raised garden beds Treat clay soil with soil conditioners such as organic matter, gypsum, or lime.
pH too low	Add lime or dolomite
pH too high	Add powdered sulphur Dig in manure or compost
Moss or algae growing on pots	Re-pot plants into better draining soil Don't fertilise so often Reduce watering Sprinkle a layer of coarse sand on the surface of the soil.
Soil getting too hot or cold	Mulch Water

Soil drying out too quickly	Mulch surface Water more regularly (eg. trickle systems)
Salt problems in pot plants (white cake on surface of the soil)	Leach out by ensuring good drainage and heavy watering.

IMPROVING DRAINAGE

Creating raised beds

Raised garden beds will enable many plants to be grown in areas where they would normally be difficult to grow. Beds which are raised to a height of around 0.5 m or more will have a significant effect on drainage. Raised beds and mounds will also add interest to an otherwise flat garden.
There are two common ways of building raised beds:

1. Shaping the earth
Raised mounds are created by moving soil (preferably with a machine) from other parts of the property and pushed into mounds. Mounded areas created this way are preferred because it tends to have less impact on the soil structure.
2. Building a wall
(Perhaps with railway sleepers or rocks), and filling in the area enclosed by the wall with imported soil (be sure to allow for drainage holes in the bottom of the wall).

Installing drains

Types of drains
An isolated patch of dampness or soggy soil which will suffocate plant roots can probably be corrected by making a simple soak way. Dig a hole about 1 metre wide and 1.2 metres deep in the damp spot - or just below it. Fill with coarse rubble (ie. rock, bricks, broken tiles etc. anything which will drain well) and replace the former topsoil. Drain holes such as this should be kept well away from buildings - they can damage foundations!

Another method of drainage is sand slitting. This involves digging a narrow trench through the area to be drained to a point at which water can be disposed of (eg. to a soak pit such as above - or to the storm-water drainage system). There should be a drop along the length of the drain (as with any drainage line). Water needs a fall of at least 2.5cm (1 inch) every 6m (20 feet) in length if it is to fall. Once the trench has been dug it is then filled with coarse sand. A thin layer of topsoil can be placed on top of the sand. The trench should usually be about 30-60cm (1-2ft) deep.

The most permanent type of drain consists of clay agricultural drainage pipes; or PVC drainage pipe laid underground with an outlet into a storm water drain, large soak way pit or sump pit. Trenches should be dug through the topsoil layer into the harder subsoil layer (often clay). There should be a reasonable gradient in the trench sloping towards the outlet. This should be at least 1 in 100, or in other words for every metre of pipe there should be a fall of 1 centimetre, so for a six metre length of pipe there would need to be a **minimum** fall of 6 centimetres. Trenches may penetrate the hard subsoil layers in places to achieve the required depth and slope. Trenches should be deep enough to allow a 10 cm cover over the pipes at least - they can be much deeper if you wish!

Once the trench is dug, lay a very thin layer of porous aggregate (eg. 1-2cm stones) in the bottom. This is to keep the pipes of the subsoil so that slot/holes that allow water entry into the pipe are not blocked by loose soil. Pipes can then be laid. These should then be covered to a depth at least equal to their diameter with coarse aggregate (ie. half or three quarter inch screenings). A layer of newspaper or cardboard can be placed on top of the screenings and top soil or sand placed on top of this layer. This will allow good water penetration, and the layer of newspaper/cardboard will prevent silt being washed into and blocking the pipe. The drain may be alternatively covered with coarse mulch (for aesthetic affect).

Limestone under-lay technique

This method was developed after observations showed that many difficult to cultivate plants occurred naturally in soils which have calcium or lime rich layers below the surface.

The method involves laying about a 15cm thickness of crushed limestone or limestone chips below about 30cm of topsoil.

It is particularly useful for growing Banksias, Dryandras and other plants from Western Australia which have proven difficult to cultivate outside that state.

Experiments at the Australian National Botanic Gardens (Canberra) have also shown that the technique may be useful in overcoming problems caused by Phytophthora cinnamommi, as the presence of calcium is thought to inhibit the growth of the fungus. At this stage the experiments have been inconclusive, but the indication is that it can be very helpful in growing such things as members of the Proteaceae family, the Darwinias and Verticordias.

IMPROVING SOILS - COMPOST

Compost is indeed the powerhouse in any growing system, but is particularly valuable in organic growing where chemical fertilisers are not used. Its benefits cannot be underestimated.

- It improves soil structure in all types of soil.
- It provides slow release nutrients for plants to use when required.
- It increases the level of soil micro organisms beyond measure.
- Composted soils produce plants more resistant to pest and disease attack
- Compost making is a environmentally sustainable method of recycling 'waste' material,
- Garden produced compost is effectively cost – free.

Compost bins

There is a wide range of compost containers now available from garden centres, local councils, hardware shops and via direct mail. They are usually made of plastic (often recycled), or wood. These are useful for composting small amounts of waste and for making compost in small gardens where you don't want to look out at an open heap of rotting waste. Fixed bins can be difficult to aerate, and are prone to becoming too dry or too wet. Rotating bins are more expensive but provide quicker, more reliable results.

It is equally possible to produce compost successfully in a heap without any container. Systems where large quantities of compost are made will often use this method. Always have the heap covered to prevent the material becoming either too dry or too wet.

Make sure that, wherever you have your compost area, it is accessible for all the equipment you're likely to be using. If you propose to turn the material using machinery, allow enough room to do so.

What can be composted?

Any organic material, if left long enough, will eventually rot down due to the action of micro-organisms. Composting is simply a way of harnessing and maximising this process. It speeds up the rate of decomposition, and minimizes nutrient losses.

The raw material for successful compost making is a mixture of organic materials, such as:

- lawn clippings
- weeds
- leaves
- paper/cardboard waste
- seaweed
- pruning material
- plant debris
- straw
- manure
- pre-meal kitchen waste

Ideally, the mixture should contain around 25 times woodier, carbon-rich material, than moist, nitrogen-rich material (grass clippings, kitchen scraps, green plants). This gives the best C/N ratio and results in effective composting.

What is the C/N ratio?

The micro-organisms that break down plant materials require food in the form of nitrogen, phosphorous and potassium. The most important requirement is the ratio of the percent carbon (C) in the materials, to the percent Nitrogen (N). This is called the carbon/nitrogen ratio.

Woody waste has 25 times as much carbon as it has nitrogen, so its C/N ratio is simply expressed as the number 25. A C/N ratio of around 30 is required for compost activity to take place at an optimum rate. To get a suitable C/N ratio it is necessary to mix materials with a high C/N ratio, such as wood shavings, with materials that have a low C/N ratio, such as green plant waste.

Materials to avoid in a compost heap:

- Protein-rich kitchen waste, such as meat or fish. It can attract vermin, and become putrid in hot weather.
- Roots of perennial weeds (unless the compost will heat up sufficiently – see below)
- Seed heads of annual weeds
- Too much of any one material in one layer. A large quantity of grass clippings should be added in layers not more than 4 – 6 cm deep.
- Layers of evergreen pruning material. These need to be managed differently (see below)
- Diseased plant material – particularly those diseases that are soil-borne, such as club-root (brassicas), white rot (onions), potato cyst eelworm.
- Material that has been sprayed with herbicides (such as lawn clippings).
- Thorny or spiky plant material. The thorns will not decompose sufficiently and can cause injury once the compost is spread on the soil.

Animal manures are a good addition to a compost heap. The most commonly used are sheep, cattle, poultry, horse and pig. Animal manures should be composted for a minimum of six weeks to prevent problems such as burning of leaves and roots from the presence of high levels of ammonium ions in the fresh manure. The ammonium ions are rapidly lost during composting. Large quantities of manure are best covered and composted separately.
If manure from an inorganic source is brought onto an organic system, check with your certification body to verify how long it must be composted before it can be used.

The basic conditions needed in a compost heap:

- A good mixture of materials, as described above. Too much dry material will slow the process down, and too wet a mix will become smelly and slimy.
- Moisture - take a handful of the material from about 15 or 20cm deep in the heap, and squeeze it. It should be about as moist as a moderately squeezed wet sponge. If it is too dry add water, or plenty of fresh green waste (grass clippings are ideal). If it is too wet, drag out the material and mix with plenty of carbon-rich material. Junk mail and cardboard works well for this purpose. Put everything back into the container once it has been mixed. If mixing is not possible, use a spade to make slits or holes in the wet pile and push dry material into these gaps.
- Oxygen - this is incorporated by turning the mix occasionally. Decomposing micro-organisms require oxygen to survive. If turning the heap is not possible, then make sure that there is a good mixture of fine and coarse materials. This will create air spaces.
- Warmth – keep the heap covered at all times. The sides should not be slatted. Wind blowing through slats will dry out a heap. Rain sluicing through will cool materials down and wash nutrients away. In hot countries, composting is often done in pits or trenches in the soil, to prevent material from drying out.
- Temperature - if the temperature drops below 40C the rate of decomposition decreases, if it goes over 60C many of the micro-organisms causing decomposition will die. Temperature conditions will always vary from one part of a compost heap to another. Usually the centre of the heap is the warmest and, for this reason, decomposition is usually faster in the centre of the heap. So it is advisable to mix up the contents of a heap from time to time.

Hot heaps versus cold heaps

Much has been written about ‘the hot heap’. This is where a large quantity of compostable materials is piled together – a minimum of one cubic metre is the recommendation – and mixed well. Organisms in the materials become very volatile and active, which creates heat. Temperatures in a hot heap can soar to 80C and above. After a few days, the organisms start to die off, and the heap starts to cool. At this point, the heap is turned in order to incorporate more oxygen, and mix un-composted material from the sides, to the middle. The temperature will rise again. This turning process can be done several times, resulting in finished compost within a few weeks, even in winter. However, this is a time consuming process, and not always possible or practical.
Many compost heaps remain cool, as their volume is small, and material is added ‘little and often’.

If this is the case, compost will take much longer to mature – usually around 12 months. It is most important that this type of compost heap should not be overloaded with large quantities of one type of material, such as a huge pile of hedge clippings, or a thick layer of grass clippings. Always make sure that the balance of wet to dry material is correct. Remember, weed seeds in a cold heap will not be killed. Although a cold heap will take much longer to produce finished compost, both methods will produce an excellent product, rich in fertility for your farm or garden.

The benefits of a hot heap are:

- Compost produced quickly
- Weed seeds killed in the heat

The benefits of a cold heap are:

- No time spent turning the heap

How to build a compost heap

- The easiest way to build a compost heap is simply to pile materials in a heap, or in a container of some sort.
- Use a good mix of organic materials. Wet material should be in thin layers (no more than 3cm thick) covered by dry organic material, such as dry straw or shredded paper.
- If using a large amount of dry material such as straw, wood shavings or paper, add some manure to boost the levels of nitrogen in the composting material. To prevent sawdust from packing down in a solid layer, mix well with coarse material, such as chopped stalks, and plenty of green waste to add nitrogen.
- If possible, turn the heap with a garden fork weekly. Remember to keep the heap covered, especially in wet weather. In hot countries, or long spells of dry weather, it may be necessary to water the heap occasionally.
- In warm conditions, a heap that is regularly turned and aerated can be ready in around six weeks; in colder weather it can take several months.

A compost heap should be made on bare soil. If piled onto a solid base, such as concrete, liquid will soon start to seep from the waste material. This can cause contamination of drains and water courses. If you intend to produce large quantities of compost, make sure that you comply with your local environmental regulations covering management of leachate.

The Finished product

Compost is ready to use when:

- It is crumbly and generally an even texture. (Material such as straw, or flower stems might be still intact.)
- It should drain well, but still have good moisture holding capacity.
- It should be dark in colour.
- It should smell earthy and sweet, not of rotten eggs.
- Temperature should be air temperature. All heating/cooling should have finished if the hot heap method has been used.

How to use compost

- Compost can be used either as mulch spread on the surface of the ground, or spread a 2.5cm layer onto the soil and then dig in to the top 15-20cm. Coarser compost is the most suitable as mulch.
- Do not leave compost too long (particularly in warm weather) before using it, as nutrients can be lost over time.
- Don't plant in pure compost alone. Compost is good for most plants, but doesn't have everything a plant needs or may be too rich.

NO DIG TECHNIQUES

The ‘no-dig’ method involves building a slow working compost heap straight onto the surface of the soil as a "raised garden bed", and planting direct into the pile. In the home garden, no-dig gardens can be a very effective, easy growing method, once established the garden requires minimal maintenance. Esther Deans in Australia has promoted this style of gardening through her best-selling gardening book: ‘Esther Dean’s Gardening Book - Growing without Digging’ (no longer in print). The no-dig method has also been popularised by the permaculture movement.

There are many advantages to be had by using techniques which do not dig or cultivate the soil at all. Soil life is undisturbed, and as a result, develops a thriving, balanced community. Management techniques in a no-dig system include mulching for weed control and moisture retention. Organic material is spread on the surface and left for the abundant soil life to drag it down underground. Diseased plants, such as mint with rust spores, can be flamed off in spring.
No-dig systems are often set up with raised beds. This confers added benefits. All cultivation, digging, sowing, planting and so on, can be done from the sides, around the beds, without treading on the soil. Soil quality therefore is particularly good in such a system.

No dig raised beds - One method
Although timber edges can be used to construct no-dig beds and may help to keep beds intact, this is not really necessary. Beds can be layered straight on top of the soil, without the use of edging. Straw can also be placed between the beds to create weed free pathways. Over time the straw in the paths will decompose, this can then removed and replaced with new straw, the decomposed material is then used to top up the beds.

A typical no dig garden could be made as follows:
1. Weeds are removed first by mowing, physically removing, burning or some other method.
2. Very thick layers of newspaper (uncoloured) is laid on the surface to inhibit further weed growth (up to 50 sheets thick is not uncommon).
3. A layer of straw or lucerne hay (weed seed free) is placed on top of the newspaper (at least 10 cm thick). Other materials such as weed-free compost, grass clippings, or sawdust might also be used.
4. The straw or hay is covered with rotted manure to a thickness where the straw or hay can barely be seen.
5. A further 8-12 cm of lucerne hay is placed on top.
6. The surface is sprinkled with blood and bone fertiliser, or chicken manure pellets. Small quantities of these materials may also be mixed with the hay, sawdust or other materials.
7. Plants are planted direct into the top layer with a few handfuls of good quality compost around the roots of each when planted.
8. Once the plants are harvested, the materials will have decomposed, just add more layers on top and plant a new crop. Eventually you will have an amazingly fertile garden full of worms.

Building 'no dig bed' retainers.
Use timber to build four walls for each bed. Use a wood which will resist rotting such as red gum, jarrah (in Australia), oak (very expensive) larch, or sweet chestnut (in UK). Avoid recycled railway sleepers unless they are untreated. Old ones can contain high levels of creosote residue. Inexpensive pine can be used, but treat with one of the environmentally acceptable products now on the market. Check with your certification body to make sure that you are using an acceptable product.
The dimensions of the box can vary but commonly might be 20-30cm or more high, around 1.2 metres wide and 1-3 metres long. The box can be built straight on top of existing ground whether lawn, bare earth or even a gravel path. A slight slope is useful as it ensures good drainage. If the site is completely level, it may also be necessary to drill a few holes near the base of the timber walls to ensure water is not trapped. Weed growth under and around the box should be cleaned up before setting up the box. This may be done by, mowing, hand weeding, mulching, or a combination of techniques.

Once built, the box can be filled with good quality soil and commercial (organic) potting compost or some other soil substitute such as alternate layers of straw and compost from the compost heap. Another mix could be alternate layers of graded and composted pine bark, manure and soil. The growing medium must be friable, able to hold moisture, and free of disease and weeds (avoid materials such as grass, hay, or fresh manures that may hold large quantities of weed seeds).

A commonly used watering technique in these beds is to set a 2 litre plastic bottle (eg. soft drink or milk) into the centre of the bed below soil level. Cut the top out, and make holes in the side. This can be filled with water, which will then seep through the holes into the surrounding bed. Mulching the surface may be desirable to assist with controlling water loss and reducing weeds (Ref: Organic No Dig, No Weed Gardening by Raymond P. Poincelot - publisher Rodale Press 1986 ISBN 0878576118 – may no longer be in print)

FEEDING PLANTS

Most Australian natives will perform better if fertilised. As plants burst into spring growth, (in particular) they will draw heavily on nutrients in the soil. If inadequate nutrients are present, plant growth can become stunted. This effect is subtle and not usually noticed until it becomes severe. The nutrient level in the soil may drop as low as 30 percent below the optimum, before deficiency symptoms (such as discolouration) appear in the leaves. By this time, the overall growth rate and general health of the plant has been affected significantly.

What nutrients do plants need?

There are three major nutrients plants need for healthy growth: nitrogen (N), phosphorus (P) and potassium (K). Nitrogen is responsible for green leafy growth; phosphorus is needed for roots, shoots, flowers and seed development; potassium promotes stem growth and helps plants resist disease.

Plants also need smaller amounts of calcium, magnesium and sulphur, as well as minute quantities of a group of nutrients called trace elements (such as iron, zinc, magnesium and boron).

Every plant variety has its own unique set of nutrient requirements. Some plants need more iron and less phosphorus, others need more phosphorus and less potassium – there are tens of thousands of different "ideal" nutrient conditions – one for each type of plant.

Choosing the right fertiliser

There is a vast array of fertilisers available and every one is different. Using the wrong fertiliser or the right fertiliser at the wrong rate can create problems in your garden.

You can get concentrated, fast acting fertilisers (which will feed large amounts of nutrients to the plant quickly), or slower acting, long term fertilisers - there are many possibilities in between these two extremes. Avoid direct contact between the roots of a young plant and the stronger fertilisers. Usually a slower acting fertiliser is more appropriate with planting, particularly in sandy soils where nutrients can be leached out very quickly. Dynamic Lifter, Osmocote, Nutricote, or something similar is ideal for planting most plants. Be sure to check the phosphorus content of any fertilisers you intend to use, and avoid using large amounts of fertilisers containing more than a few percent of phosphorus. Commonly used fertilisers that have high phosphorus levels include super phosphate, hoof and horn, and blood and bone. The toxic effects of high phosphorus levels can be offset if balanced with high levels of nitrogen. Generally phosphorus toxicity is more of a problem in container grown plants than in the soil, where phosphorus is often immobile ("fixed") in the soil. The addition of fertilisers containing calcium (eg. gypsum, lime) can make soil phosphorus more readily available. This can sometimes create toxicity problems.

So how do you choose the right one? For a start, it is helpful to know what the various fertiliser terms mean:

Complete fertiliser – These contain a mixture of nitrogen, phosphorus and potassium. Some also contain calcium and sulphur, and trace elements. The formulations vary according to the plant groups for which they are designed, eg. flowers, fruit, large trees or lawns. They come in powdered, granular and water-soluble forms and are a convenient way to provide plants with all the nutrients they are likely to need.

NPK fertilisers – Another name for ‘complete’ fertilisers (N means it contains nitrogen. P means it contains phosphorus. K means it contains potassium).

Water-soluble fertilisers – These are powdered or liquid complete fertilisers that are applied as a dilute solution. They generally have high nitrogen content and also contain trace elements. They are useful for boosting plant growth but only have a short-term effect.

Slow-release or controlled-release fertilisers – These complete fertilisers are designed to release their nutrients slowly, often up to 12 months. Some are in the form of plant pills others are covered with a protective coating, eg. Osmocote and Nutricote. They are convenient, safe and easy to use but are more expensive than other NPK fertilisers. Some organic fertilisers such as blood and bone or rock phosphate also release nutrients over a long period of time.

Inorganic fertilisers – Artificially-made fertilisers; includes the NPK mixtures.

Organic fertilisers – A broad term for naturally-occurring fertilisers; includes animal manure and animal by-products such as blood and bone, mushroom and other composts, green manures, seaweed and worm casts. The nutrient content is variable, depending on the source of the fertiliser. Some commercially prepared organic fertilisers such as pelleted manure may have nutrient levels listed on the packet.

When you choose a fertiliser think about the following:

- Convenience and ease of use
- The type of plants you are fertilising and the time of year
- The soil type (clay soils hold fertilisers better than sandy soils)
- How quickly you want the plants to grow
- How much you're prepared to spend
- Whether you prefer to rely on organic fertilisers.

ORGANIC versus INORGANIC FERTILISERS – which is better?
It makes no difference to the plants whether you apply artificial or organic fertilisers. They simply absorb whatever nutrients are available in the soil.
BUT there are other important differences:

- Inorganic fertilisers release nutrients quickly, producing rapid plant growth
- Many inorganic fertilisers can burn plants if applied at high doses
- Many inorganic fertilisers have a short-term effect and need to be applied frequently to maintain growth
- Inorganic fertilisers can leave undesirable chemical residues in the soil
- Most organic fertilisers are safe to use and won't burn the plants (except some fresh manures which should be aged before use)
- Most organic fertilisers improve the texture and structure of the soil, thereby improving air and water uptake (exceptions are powdered organic fertilisers such as blood and bone)
- Some organic fertilisers don't contain many nutrients – their main value is as a soil-improver
- Most organic fertilisers if supplied on their own will not supply the complete range of nutrients essential for plant growth.

Roots start growing before the shoots so feeding should ideally start a few weeks before the foliage growth spurt.

How much fertiliser to apply
Some Australian native plants are well adapted to poor soils, and may be sensitive to strong fertilisers. As such it is always better to apply too little than too much. You can always add more, but you can't take it out of the soil and put it back in the bag! In particular, many proteaceae plants are highly sensitive to phosphorus.

Always read the instructions on fertiliser packets. If applying fertiliser to young plants or less hardy plants (eg. ferns and some indoor plants) you are better to put on less fertiliser.

There are a large number of ready made 'native' fertilisers available from your nursery, garden supplies, or chain store. Check the labels on the packets or containers to see what the N. P. K. ratios are before deciding which one/s to use.

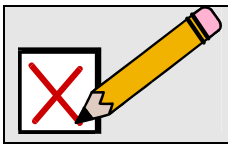
Suitable Application Times for Established Natives (these times do not apply to natives grown outside of Australia – but will vary in accordance with your local climate and seasons.

AREA	TIME
East Coast	August
Tasmania	September/October
W.A.	March/April
Tablelands	September

Fertiliser problems
Problems may be caused in gardens where native plants are growing in or around lawns. Lawns need regular feeding with fertilisers containing phosphorus, but the natives may be adversely affected by the high concentration of phosphorus.

In such situations:

- Be prepared to have a poor quality lawn
- Use lawn fertilisers sparingly and be prepared for some deterioration in plant health.
- Use lawn fertilisers which contain rock phosphate instead of superphosphate. This is not as damaging to natives. It should still only be used sparingly.



SELF ASSESSMENT
Perform the self assessment test titled 'test 2.2.'
If you answer incorrectly, review the notes and try the test again.

NATIVES ON LOW FERTILITY SOILS

Plants from the following genera have often been recorded growing successfully on low fertility soils (ie. low in nutrients) in NSW and South West Western Australia. This can be a useful guide in helping you to select plants for areas with low fertility soils, or in helping you decide how much to fertilise particular plants. (NOTE: some species from these genera may grow just as well or better on fertile soils).

From the Myrtaceae family
Actinodium, Agonis, Angophora, Astartea, Baeckea, Beaufortia, Callistemon, Calothamnus, Calytrix, Chamelaucium, Darwinia, Eremaea, Hypocalymma, Kunzea, Leptospermum, Melaleuca, Micromyrtus, Regelia, Thryptomene and Verticordia.

From the Proteaceae Family
Banksia, Conospermum, Dryandra, Franklandia, Grevillea, Hakea, Isopogon, Lambertia, Lomatia, Persoonia, Petrophile, Stirlingia and Telopea.

From the Rutaceae Family
Astrolasia, Boronia, Correa, Crowea, Eriostemon, Phebalium and Zieria.

From the Fabaceae Family
Bossiaea, Brachysema, Burtonia, Chorizema, Daviesia, Dillwynia, Eutaxia, Gompholobium, Goodia, Hardenbergia, Hovea, Jacksonia, Kennedya, Mirbelia, Pultenaea, Templetonia and Viminaria.

From the Epacridaceae Family
Astroloma, Epacris and Leucopogon.

PRUNING AUSTRALIAN NATIVES

Though not critical; many Australian natives will benefit from pruning. Some, like many Boronias, will live and flower for significantly longer if pruned annually. Others can be rejuvenated and the foliage kept denser and healthy if routinely pruned.

Remove dead tissue will improve both their appearance and health.
Infections (eg. bacteria, fungal diseases; and even insects) attack and gain a foothold in dead (or weakened) plant tissues with relative ease; then once established, are able to multiply and spread much more easily into the healthy parts of the plants. Regular pruning can thus be a major way of controlling diseases in your plants.

Wood rots
Wood rots are a sign that the plant has an infection. Typical signs are soft, crumbling or splitting bark, and branch dieback. A healthy tree will use its own defence mechanisms to prevent the disease spreading, but where feasible, it is better to cut off the dead or diseased wood as soon as you notice the problem.

Dead heading
Some plants drop their flowers while they're still fresh; others hold on to the spent flowers for weeks, even months. Deadheading, the process of cutting off dead flowers from the bush - is beneficial for garden plants:

- When you cut off the dead flowers, you are cutting off dead tissue which could be harbouring diseases

- The pruning cuts encourage side shoots to grow so the plant will produce more flowers

- You are removing unsightly withered flowers, improving the plant's appearance

- By removing the flowers, you are preventing seeds (and fruits) developing, so the plant has more energy for growth and flower production.

Most flowering plants will benefit from deadheading, including soft wooded plants (eg. daisies). The more frequent the deadheading the better, as it encourages more flowers and can reduce the risk of disease.

Is annual pruning enough?
In most cases, an annual prune is sufficient for healthy plants. For most plants, up to one-third of the growth can be removed at the annual pruning without stressing the plant. (NB. Many plants can tolerate much more severe pruning – even to ground level; others won't recover and are best given frequent light trims.)

At the time of the annual pruning, you should remove any remaining dead flowers and seed heads, as well as any dead or diseased wood.

In some cases more frequent pruning is beneficial to the plant. For example, although many people prune roses only once a year, others also give a lighter prune in summer to encourage more flowers and to cut out any dead or diseased wood.

The same principal applies to all other plants – if the plant is carrying dead wood or showing signs of disease, don't wait until the annual pruning to remove the affected parts. Remember, the longer the diseased or dead wood remains on the plant, the greater the risk of the infection spreading.

Pruning tools should be sharp and clean. Wipe the blades with methylated spirits before and after use to reduce the risk of spreading disease.

PRUNING TREES and SHRUBS
Native trees are generally similar to most other trees in the way they should be pruned.

- Native trees are best pruned when they are young so as to establish well balanced forms which will be strong when they reach maturity. For many trees there should be one main stem/trunk with other major branches coming off that, and for others, the habit may involve multi-trunks. Be sure you know the appropriate growth habit for the tree you are pruning.
- Branching should not be at narrow (ie. sharp) angles. When two branches join at a sharp angle, the join is a weak union and there is a greater likelihood that a split will develop at some stage in the future, resulting in one branch falling. (If this type of forking is seen on an established tree, then one side of the tree should be removed. Even if this looks unattractive n the short term, it will grow back into balance and the tree will be much stronger for the operation).
- When a branch is cut from a tree, the cut should be made along a very precise line to minimize the chance of wood rots developing.
- Avoid heavy pruning of Eucalypts. Pruning stimulates dormant buds (ie. epicormic buds) to shoot; these shoots grow quickly but are only weakly attached to the main trunk or branches. They can eventually become a problem (ie. falling branches).

How to cut a branch from a tree

- 1st Identify the branch bark ridge (ie. the swelling or area of folding on the inside of the crotch where the two branches join).
- 2nd Identify the collar of the branch which is to be removed (ie. a swelling at the base of the branch on the underside).
- 3rd Make a cut on the underside, 300 mm or so above the collar, 30% of the way through the branch.
- 4th Make a cut on the top, 400 mm or so above the collar. Keep cutting until the branch drops, leaving only a stub.
- 5th Now make a final cut to remove the remaining stub, cutting from a point on the outside of the branch bark ridge, to a point on the outside edge of the collar.

What is compartmentalisation?

The tissue of a tree is made up of groups of cells forming compartments. Between each compartment; there is a natural barrier to rot – if the plant is vigorous and healthy, the rot tends to spread through the compartment, then stop - but if the tree is weak, it may move into the next compartment.
By keeping plants well fed and watered, and ridding them of pests and diseases, you are encouraging the plants to compartmentalise the spread of disease.

What about wound treatments?

Fungicide treatments painted over a wound may in theory deter the growth of disease. Scientific advice seems to suggest that wounds do not become more infected if you don't paint them - dark paints, however, can make the wound less obvious.

SHRUBS

Some native shrubs will take relatively hard cutting back, but many will not. If you don't know a plant, you may be taking a grave risk by heavily pruning it.

- Many wattles tend to die back if pruned too heavily, though sometimes the same variety will re-grow rapidly after a heavy cut. You cannot always predict if the plant will take a heavy pruning.
- In nature, shrubs tend to be "nibbled" constantly by native animals. Similarly, most natives respond well to frequent light pruning. The safest way to prune native shrubs is frequent light tip pruning, rather than occasional heavy pruning.
- There are exceptions. Some natives respond to heavy pruning. Red boronia (B. heterophylla) will actually live longer if flowers are harvested in a heavy pruning every spring.

TEMPERATURE REQUIREMENTS

Requirements are diverse, and there are Australian natives that will grow out doors in most populated parts of the world from cool temperate zones to the tropics. If you live in a colder climate the following list may provide some guide as to what could be worth trying out.

Frost hardy native plants

Acacia baileyana, cultriformis, dealbata, floribunda, pravissima
Allocasuarina cunninghamiana, glauca, stricta, torulosa
Banksia ericifolia, marginata, media, spinulosa
Bauera rubioides, sessiliflora
Boronia filifolia, megastigma, muelleri, pinnata
Brachyscome multifida
Callistemon citrinus, pallidus, paludosus, rigidus, salignus
Callitris oblonga
Cassia artemisioides, sturtii
Correa alba, decumbens, manni, reflexa
Epacris impressa, microphylla, pulchella
Eremophila glabra, maculata
Eriostemon myoporoides, verrucosus
Eucalyptus cinerea, cladocalyx, crenulata, gunnii, leucoxylon, macrandra, melliodora, nicholii, pauciflora, polyanthemos, sideroxylon, stellulata.
Grevillea alpina, aquifolium, baueri, capitellata, confertifolia, juniperina, lanigera, lavandulaceae, Poorinda hybrids, rosmarinifolia, sericea, steiglitziana, tridentifera
Hakea elliptica, nodosa, petiolaris, purpurea, salicifolia, sericea
Helichrysum apiculatum, baxteri, bracteatum

Indigofera australis
Kunzea capitata, parvifolia, pomifera
Leptospermum flavescens, humifusum, juniperinum, lanigerum, scoparium
Melaleuca decussata, elliptica, incana, pungens, squarrosa, stypheloides, thymifolia, uncinata, wilsonii
Myoporum parvifolium
Pandorea pandorana
Pittosporum phyllyraeoides
Prostanthera aspalathioides, crenulata, lasianthos, nivea, rotundifolia
Telopea oreades, speciosissima
Thryptomene calycina, saxicola
Westringia fruticosa

HOW TO PLANT AN AUSTRALIAN NATIVE PLANT
The first step is to prepare the soil and to remove any weeds (see sections on improving soils and weed control).

Basic planting procedure
Plant most containerized plants as follows:

1. Thoroughly soak the plant in the pot, to help the plant come out of the pot easier; and allow it to drain. (Ideally, immerse the root ball in water until air bubbles stop rising eg. dip it in a bucket or tub of water).

2. Dig a hole one and a half times the depth of the pot, and in hard soils, break up the soil well at the bottom and sides of the hole.

3. Place a small amount of slow release fertiliser in the hole.

4. Fill in one third of the hole and mix the fertiliser with the back filled soil.

5. Take the plant out of the pot. Turn upside down and tap on the side of a wall or other hard object: and it will slide out easily.

6. Loosen any exposed roots. (ie. if most of the roots are inside the soil ball, you might not need to do much. If there is a tight mass of roots on the outside of the soil ball you may need to break a centimetre or so into the ball all over). Free any roots circling the bottom of the container.

7. Place the plant in the hole and cover with soil. Firm down but don't compact to a hard impenetrable surface. Make sure that the surface of the potting mix is at the same level as the ground surface. Don't bury the trunk/stem, as this can affect the success of some plants.

8. Make a lip of soil around the base of the plant to hold water.

9. Soak thoroughly with water.

10. Mulch with a suitable material. In hot or dry conditions mulch should be thick enough, and extend far enough from the base of the plant to keep roots cool, and minimise evaporation from the soil.

Time of planting
Planting is best timed to allow plants to settle in and establish before facing the harshest time of the year. The harshest time of year will vary from place to place, and may also vary according to the plant species being planted.

In temperate climates, planting may be done at any time of the year providing the plant will receive adequate water. In well maintained gardens, planting may be done when growing conditions are optimal ie. in the southern states planting is best done in autumn or spring when rainfall is high, and there is adequate warmth in the soil to stimulate root growth.

In tropical or sub-tropical climates planting may be better carried out after the hottest part of the year, but while the ground is still moist.

In areas with severe frosts planting may be best carried out in spring after the threat of frost has passed. This will give the plant time to establish before the following winter.

Always avoid planting on hot or windy days - plants are more likely to dry out in these conditions.
Always avoid planting just prior to severe storms which may damage young plants.

Staking
Staking is not always necessary. It can in some cases do more harm than good. When movement of a plant in the wind is stopped completely, it may not develop sufficient strength in the trunk (known as "reaction wood") to withstand the wind when the stake is finally removed.
Plants SHOULD be staked if they are likely to fall over (ie. because they are exposed to severe winds), or if they are likely to suffer from vandalism or unintentional damage. A tree guard may alternatively be used (surrounding the plant with a tube or wall), to protect it from wind, vandalism, or foraging animals.

When you do tie a plant to a stake, the tie should be loose allowing the plant to move about in the wind. If movement is restricted, the tree may never develop proper strength in its join between the roots and trunk. Be sure to check as the plant grows that the tie is not restricting the growth of the plant.

Stakes can also be used simply as a marker (without ties) for small plants that may overgrown by grass, before they have had a chance to get established and put on a spurt of growth. This makes them easy to locate when you are mowing, trimming, etc.

Mulching
Mulching has several advantages as follows:
- Helps control weeds.
- Conserves soil moisture (helps prevent drying out).
- Improves soil structure.
- Adds nutrients to the soil.
- Reduces fluctuation in soil temperature.
- Can promote earth worms.
- Can reduce soil erosion.

Almost anything organic can be used as a mulch. Here are just a few examples: wood-shavings, sawdust, tan bark, pine bark, leaf mould, paper, old rags, compost, straw, pruning material, weeds, lawn clippings, leather, cardboard, etc. There are even some inorganic materials which are useful as mulches, including gravel, scoria, blue metal, coarse sand, and river pebbles.

Wind can be a problem, blowing away some fine mulch when they are first delivered, or laid down (eg. wood shavings). Once thoroughly wet and settled however, even these mulches tend to stay where they are.

All too often, the desired benefits of the mulches are not achieved.

Some common mistakes are:
- Mulch is not thick enough. Different types of mulches should be applied at different thicknesses ie. 30mm for fine mulch and 60-80mm for coarse mulch
- Black plastic placed under mulch will create an impermeable layer, causing plants to suffer from water stress. Sweating underneath may cause water to stagnate, creating foul smells and promotion of root diseases.
- Weeds need to be eradicated BEFORE the mulch is laid. Weeds can be removed by hand or a non-selective, non-residual weedicide eg. Roundup (Zero) can be sprayed several weeks before laying the mulch.
- Maintenance is often ignored. Top up organic mulches regularly; remove weeds before they develop seed heads.
- Wood-shavings (and some other mulch) need to be kept moist for the first month or two. This will allow the mulch to "settle" and prevent the wind blowing away large amounts of material.

- As organic materials decompose, they draw on nitrogen from the soil. Plants which are grown in mulches made from shavings, wood chips, and paper may show nitrogen deficiency symptoms (ie. the leaves will turn yellow). To counteract this, apply a small nitrogenous fertiliser.
- Mulch has not been thoroughly wet when first laid down. Many organic materials actually repel water when they are dry. If it is not moistened through when used, rain can run off the surface to the sides of the plants.

NATIVES AT A GLANCE

The following points are general comments about natives and shouldn't be considered iron clad rules. (There are exceptions.)

- Don't feed natives with fertilisers which contain a high percentage of phosphorus (including super-phosphates).
- Don't break the tap root on native trees when planting them.
- Tall native shrubs and trees do not transplant well.
- Many natives require good drainage (it is a good idea to plant them on a raised mound of soil).
- Mulching is generally desirable, to keep roots cool and minimize water loss in summer.

To grow plants is more than just planting and standing back! Even our so called "hardy natives" require ongoing care if you want to get the best from them.

SPECIAL PLANTING TECHNIQUES

Most home gardeners shouldn't have too much difficulty in establishing new plants. In some areas, however, problems such as severe soil erosion, arid climate, etc. will mean that special techniques are needed to enable the plant to establish in its new environment.

Pocket planting

This is simply establishing a pocket or basin on a slope, with the soil excavated from the pocket being used to form a wall enclosing the pocket, particularly on the down slope side. The wall will then retain water and help prevent soil erosion occurring. An overflow spillway in the wall will prevent the pocket from being washed away in heavy rains. The pocket may need to be reformed every now and then, until the plant is established.

Slope serration

Sloping sites can be terraced to enable plant establishment and reduce erosion. Slopes are cut into steps which measure approx. 1 m wide, with the steps sloping back towards the hill to retain water. Over time, the steps will erode however the plants will usually have become established by then. The loose soil from the eroded steps also provides favourable germination sites for seed which is dropped from other nearby plants.

Wattling

This technique relies on the use of bunches of branches placed on slopes to prevent erosion. Bundles of long, slender branches are tied into bundles and are partially buried in contoured trenches which have been cut across the slope, or cut branches and dried brush are simply spread across the surface of the slope. 'Chicken wire mesh' or strands of fencing wire are sometimes pegged down on top of the branches to hold them in position. (Some types of wire mesh can lead to zinc toxicity, particularly on moist soils). Layers of straw or commercially available synthetic matting can be used to similar effect.

This technique has been more commonly used overseas, although it can be used here on badly degraded sites to enable native species to regenerate. In Australia, dried brush is more commonly used. This type of brush material: eg. Leptospermum often contains large quantities of capsules that release seed; which will often readily germinate on the newly stabilised slope.

Planting arid sites
Plant establishment in un-irrigated, arid sites can be extremely difficult. Mulching, controlling competing weed growth, wide spacing of plants and creating saucers of soil to retain water, are simple ways of overcoming the water shortage problem. Smaller sized plants also have a better chance of becoming established.

Condensation traps have also been used with some success in areas with clear night skies. One simple method of trapping the moisture from condensation is to construct a 1.5 m diameter planting basin with a depth of 30 cm. The plant is placed on a mound in the centre and polythene sheeting is arranged to collect evaporating soil moisture, which condenses on the sheet and drips back to the ground.

Direct seeding
Direct seeding is a low cost method of re-establishing vegetation, although the results are less predictable than transplanting established nursery- grown plants.

The most important factor is to eliminate weed growth before seeding to remove competition from the germinating seeds. An initial spray with chemical herbicides will give the best results; alternatively cultivation can be used to encourage dormant weed seeds to germinate which can then be sprayed. A light cultivation of the soil will also provide favourable germination conditions for the seed. Seed can then be broadcast either by hand on small sites, or by direct drilling or mechanical hoppers for larger areas. Fencing the site and follow-up weed control may also be required. Irrigation or timing of seeding to make the best use of rainfall will help germinating seeds to get a good start.

In areas where there is an existing cover of native vegetation, natural regeneration can give good results. The site should be fenced off, and the weeds on the windward side of the tree (where seeds are most likely to drop) should be removed.

NATIVES FOR SHADED AREAS

Shade can cause a range of different problems for plants and gardens:

- Reduced light can restrict plant growth. Many plants in shaded areas will appear weak and leggy, with poor flowering.
- Shaded areas are cooler than adjacent open areas. Whilst this is generally a benefit to the garden, growth in shaded areas may be slow in cool climates (eg. this may be more of a problem in Hobart than Sydney).
- Shade encourages the growth of moss and algae on the ground (including paths), making them slippery.
- Water in shaded areas does not dry up so readily.
- Roots from large shade trees compete with smaller plants growing below them.
- Soil under trees can be quite dry, as the overhanging leaf canopy prevents water penetration.
- Foliage from some trees (eg. conifers) may be toxic to plants below.
- Roots of some trees may give off toxins which inhibit growth of other plants (eg. Eucalyptus trees).
- Leaf or branch drop from trees may smother or damage low-growing plants below.
- Trees restrict ventilation (ie. air movement), which may encourage disease problems in shaded areas.

Plants suited to full shade

Boronia mollis	*Dampiera diversifolia*	*Epacris impressa*
Kennedia prostrata	*Thryptomene spp.*	

Other shade tolerant natives

Acacia mitchellii	*Acacia myrtifolia*
Acacia terminalis	*Calytrix spp.*
Dryandra spp.	*Eriostemon (most varieties)*
Eucalyptus camaldulensis	*Eucalyptus globulus*
E. gompocephyla	*E. polyanthemes*
E. radiata	

Rainforest plants
Rainforest trees and under-storey plants are well adapted to low light situations. For these reasons, many are used as indoor plants when young then planted out when too large for the home.
Some rainforest species that tolerate dark conditions include:

Agathis robusta	*Ardisia pachyrrhachis*
Castanospermum australe	*Cissus antartica*
Cissus hypoglauca	*Cordyline spp.*
Cryptocarya erthroxylon	*Davidsonia pruriens*
Dracaena angustifolia	*Eupomatia laurina*
Ficus spp.	*Harpullia rhyticarpa*
Phaleria octandra	*Podocarpus elatus*
Randia fitzalanii	*Schefflera actinophylla*
Stenocarpus sinuatus	*Wilkiea angustifolia*

Palms
Many Australian rainforest palms will handle low light positions but will do better if provided with dappled light. Archontophoenix species are hardy in dark situations but grow better in bright light to full sun when mature.

Ferns
Ferns are ideal for growing in shady areas as they are naturally adapted to growing in conditions of low light. Different varieties can tolerate different levels of shade and soil moisture, so use the following lists to choose ferns which suit your particular problem area.

Hardy with some shading in the hottest part of the day:

Davallia trichomanoides,	*Pellaea (most species),*	*Pteris cretica,*
Doodia media,	*Platycerium (most species),*	*Pteris vittata*
Dryopteris erythrosora,	*Polypodium aureum,*	*Nephrolepsis cordifolia,*
	Polystichum polyblepharum	*Todea barbara.*

CONTROLLING WEEDS
There are 2 different types of weeds; annuals and perennials.

ANNUAL WEEDS grow from a seed to full maturity within 12 months. If you can stop seed being produced, then the old plant dies and there are no seeds for new plants to grow from.

PERENNIAL WEEDS persist from year to year, if you kill off the top but not the root, they might very well re-grow from the root.

Weed control methods
Although weed populations and density can be reduced through weed prevention, it will not completely eliminate them. A weed control program should be used in conjunction with the preventative measures outlined above including

- Mulching – smothers weeds (covered earlier this lesson).

- Cultivation **–** hand cultivation through hoeing or hand pulling although time consuming is reasonably effective. Mechanical cultivation should be minimised in an organic system to prevent destruction of soil structure and spread of perennial weeds propagated readily from roots

If native grasses or groundcovers can be established under a canopy, weed growth can be suppressed

- Mowing - cutting the tops from the weeds regularly depletes the weeds food reserves. Mowing should be carried out before seed set in both annual and perennial weed species. The cut foliage should be left to rot and return nutrients back into the ground. If the weeds are tall when cut, the foliage will act as mulch, slowing re-growth of weeds.
- Solarisation - large sheets of clear plastic are spread over the surface of the ground in warm weather. Heat generated under the plastic can be great enough to kill many types of weeds. The plastic can then be removed (perhaps after a couple of weeks) and the area planted. This technique will also often kill other pest and disease organisms. Note that this method is only suited to warm climates that can depend on two or so weeks of continuous sunshine.
- Flame Weeding – flaming is only effective on annual weed species and weed seeds beneath the soil surface are rarely killed. May be effective way to control weeds along fence lines (with care) or on pathways and gravelled areas.
- By chemical methods - some chemicals (eg. Weedex) will burn off the top but not kill the weeds. Some chemicals move throughout the sap system of the weed, killing every part of the plant (eg. Zero). This type of chemical needs to be used with particular care as it will kill plants you want to keep if you let it touch them. Some chemicals kill one only type of plant (eg. broad-leaved weeds in lawns) without killing other types of plants (eg. grasses).
- By competition - if the desired plant is healthy and vigorous, it will naturally compete with the weeds.
- By biological control - using living organisms to attack or eat the weeds (eg. grazing animals, certain insects).

Weed control before planting

All weed growth should be removed before planting to reduce competition while new plants are establishing. In particular all parts of creeping plants such as couch, kikuyu, bent and buffalo grasses and bulbous plants such as oxalis should be carefully removed by hand or killed with a trans-located weedicide (moves through all parts of the weed including roots) such as Zero. Chemical control should be done prior to disturbing the soil so that broken off sections of weeds are not buried in the disturbed soil where they might strike as new plants.

Weed control after planting

Weed control after planting is best achieved by non-chemical means, unless the problem is really extensive, as you run the risk of damaging your natives. Heavy mulches, or weed mat laid down at the time of planting and regularly maintained will greatly reduce the likelihood of weeds becoming established. Maintaining plants in a healthy condition through good fertilising, watering, pruning, etc. practices will allow them to out compete any weed growth. As weeds develop hand weeding, slashing, mowing, etc. can be used.

PROPAGATION OF AUSTRALIAN PLANTS

Life of seeds

Some seed remains viable for years other seeds keep for very little time at all.

- *Banksia* seed will keep longer if left in the cone (provided cones are treated to kill insects which might cause damage). In the cone, *Banksia* seed lasts up to 6 years, out of the cone it lasts only 3 years.
- Eucalypt seed keeps much longer if stored with the chaff. When cleaned, the lifespan decreases
- Seed stored in glass or metal is better than that stored in plastic.
- Plastic containers give off ethylene gas which is an inhibitor to germination.

Sexual versus - Asexual propagation methods

There are various reasons for choosing sexual propagation instead of asexual methods and vice versa.

Sexual propagation is often used for the following reasons:

- When plants cannot readily be grown by asexual methods.
- Production by seed is a lot cheaper, and often quicker than by asexual methods.
- Seed of a particular plant may be plentiful, while cutting material is not.
- Seed propagation is important in maintaining genetic diversity.
- Seed propagation is used to breed new varieties.

Asexual propagation methods are often used for the following reasons:

- To produce plants with the identical genetic characteristics as the parent plant (eg. flower colour, variegation). Some plants do not produce viable seed, or their seed may be difficult to germinate, or the seed may be unavailable at the time you are in the area collecting propagation material, or that you need to produce that plant (you have orders from a customer) when seed is not available, or is perhaps too costly.
- Plants produced by asexual methods from a plant that has already flowered will usually flower quicker than plants grown from seed.
- Budding/grafting methods can be used to establish selected plants onto selected rootstocks (eg. resistant to particular soil conditions or pests and diseases, or to create standard or weeping plants).

Seed sources

It is absolutely vital that any source of seed for propagation is:

- Totally reliable - you must know where it comes from, that the collector knows what they are doing.
- From plants which are not likely to have hybridised.

Consider: Variation within a species

- A form of *Myoporum insulare* native to the coast may tolerate a pH of 9
- Another form of *M. insulare* from the inland may only tolerate a pH of 7.5
- There are red flowering forms of *Eucalyptus ficifolia* (also known as *Corymbia ficifolia*) growing in south west Western Australia which produce flowers virtually every month of the year. The time of flowering on the plants grown will vary according to where the seed came from.
- *Eucalyptus calophylla* occurs in the wild on the W.A. coast from 1600km to 450 km south of the Tropic of Capricorn. The plants which occur in the north would produce seed more adapted to warmer climates, while seed collected in the south would grow plants more suited to cooler climates.

If you buy seed, do you know where it came from, and what sort of plants it is likely to produce?

Where can you get your seed from? This is very important in terms of:

a. Quality

- Some seed suppliers do not supply pure seed (rubbish or weed seeds can be mixed with the seed).
- Some seeds have not been harvested at the right time, hence % viability is lower.
- Some seeds have not come from strong and healthy plants hence the vigour of the seed may be less.
- The seed may have been stored poorly (eg. allowed to dry out), and hence the percentage of viability is reduced.
- The seed may be infested with diseases or pests (eg. insects eating seed).

b/ Gene pool

The place which a particular plant originated from gives it a range of characteristics which are very specific to that plant (eg. *Eucalyptus camaldulensis* seed from one stand of trees might be very tolerant of salt, while seed from another stand of *Eucalyptus camaldulensis* might not tolerate salt at all). Seed sourced from local plants will enable you to produce plants that are adapted to local conditions (eg. soil, climate).

There are four main sources of seed:

1. Seed collected from the wild

Seed collected from plants growing in their natural habitat is less likely to be cross-pollinated, and you can be more certain of where it came from and how it will grow than if you had purchased it. This can be a cheap method of getting your seeds if you don't have to far to travel, and have the time to spare. Many people get great satisfaction out of collecting their own seed. This may also be the only way to get some particular species. Permission should be sought from landowners of privately owned properties, or from the relevant state authority for public land. In Victoria this is the Dept. of Natural Resources and Environment (Contact them)

2. Seed exchanges/Seed banks

Many Botanic gardens operate seed exchange programs, where they produce annual seed lists, and swap seed with others who involve themselves with the program.

Such programs are particularly valuable as a source of more scarce varieties of plants. Some associations and societies (eg. Society for Growing Australian Plants, Greening Australia, Landcare, Community Environmental Groups and Nurseries) also participate in exchange programs, or maintain seed banks for members and groups involved in re-vegetation programs. For example, the Victorian Branch of Greening Australia hold the "Melbourne Indigenous Seed Bank".

3. Commercial seed suppliers

There are many hundreds of seed companies operating throughout the world. Some breed new varieties of plants and grow seed crops to harvest. Others buy seed from collectors (who collect from the wild or from gardens). Major problems of using this source include:

- Collectors identifying seed source plants incorrectly.
- Unreliable supply (if they can't supply, it's too late for you to collect for yourself).
- Uncertainty about the quality.
- Developing a dependence on the supplier.

Major advantages of using this source include:

- Convenience
- Obtaining a seed source for plants which do not set seed well locally.
- Savings on labour costs.

4. Collecting seed yourself locally

You or your representative might collect seed from plants on your property, or on other nearby properties as it matures throughout the year.

They might also be collected from public parks and gardens or private gardens (with permission). The major advantages of this source are:

- You have a great deal of control over collection, storage and treatment.
- You can be sure you have got exactly what you want.
- You learn a lot more about the plants you are growing, because you see them in their mature state.
- You can save on the cost of purchasing seed, though collecting can be time consuming, particularly if you have to travel to collection sites.

Why do plants produce so much seed?

Much of the seed produced by plants gets eaten before it has a chance to germinate.

A lot of the seed produced will not end up in conditions suitable for germination.

Some of the seed will not germinate readily, even if it is in good conditions for germination due to dormancy factors within the seed.

Some seed will form a "Seed Bank" that may survive for many years in the soil until conditions are suitable for germination. A good example is the reappearance of species not seen in decades in areas where the Rabbit Calicivirus Disease (RCD) has had a big impact on rabbit populations.

By providing suitable conditions we can generally get much higher rates of germination than would naturally occur in the wild.

Collecting and harvesting seed – Guidelines

Always seek permission before collecting seed from private or public land.

- Find a site: this may be as simple as keeping your eyes open or by seeking advice from local forestry or conservation bodies or departments.
- Take necessary equipment: plastic bags; writing equipment, labels, or small cards to write collection details on. For larger scale collecting you might need handsaws, long handled loppers, tarpaulins, a step ladder and more.
- For tall plants you are best to obtain seed from commercial collectors. They generally use equipment such as cherry pickers, climbing equipment, or even high-powered rifles to shoot down branches from high in trees.
- Use gloves when harvesting. Many native plants have prickly or thorny foliage, some (eg. Grevilleas) can cause skin allergies many will have resident populations of spiders, ants, etc. Use common sense when choosing which clothes you are going to wear. Long trousers, long sleeved shirts, and tough durable footwear are recommended. Safety helmets might be necessary if there is a risk of heavy limbs falling.
- While many seed pods can be readily picked off the parent plant without damaging the plant some are a lot tougher to remove. Avoid pulling or ripping these off. Use sharp secateurs or similar hand tools. This will reduce the likelihood of damage to the parent plants.

- Always use sharp, and sterilised (pest and disease free) hand tools. A small container of a disinfectant (eg. bleach, methylated spirits) can be carried to dip or wash tools in regularly.
- Avoid harvesting seed pods when they are wet. This will reduce the likelihood of losses due to fungal problems.
- Avoid damaging other plants. In your desire to get to a particular plant you could easily trample on, or break branches off other plants. Be observant, take your time, and carefully pick where you place your feet, and you will minimise the likelihood of causing damage to other plants.
- Always label each batch of seed you collect, when you collect it. Information should include such things as the species collected, the date collected, who collected it, where it was collected. This will enable others who use the seed at a later date to be sure of what seed you have, how old it is, where to go if you want more, and who to ask if you want more information.

Selecting plants to collect from

- Collect your seeds from healthy, vigorous trees of desirable form, or having desirable characteristics (eg. flower size and colour).
- Where possible avoid collecting from isolated specimens, as self-pollination generally yields seed of low vigour, and a limited gene pool.
- To promote biodiversity take roughly equal amounts of seed from a variety of well spaced, desirable plants. Ideally only harvest a little from each plant, particularly when there are lots of that particular species available. As a rough guide no more than 10percent of available seed should be taken from each plant. This will ensure that plenty of seed is left on the plant to maximise the survival of the species locally, and helps ensure you have as wide a gene pool as possible in the seed you have collected.
- If you are quite sure that all of the plants you have collected from in a particular location are from the same species then you can mix all of that seed together. If you are not sure then keep each batch of seed separate (and separately labelled).

Timing

Knowing when to harvest seed is one of the most difficult tasks you will face when collecting seeds. The time taken for seed to reach a harvestable stage from flowering will vary considerably from species to species, and can range from a month or two up to several years.

Experience plays a very important role. Regular observation of plants you are interested in harvesting from can often be critical, particularly for those plants whose seed ripens over a short period of time and are not retained for long on the plant. Obtaining advice from others familiar with the plants you wish to collect can be very worthwhile, as can research from relevant publications.

For many species the fruits are mature when they reach their full size and turn darker in colour and become woody. Once mature many (eg. capsules, pods) will split open allowing their seed to be dispersed. Some species will shed all of their seed within a few weeks of maturity (eg. *Acacia*). Some species will retain their seed for a long time (eg. many *Banksia, Hakea*, some *Eucalyptus*.).

The seed of some plants will ripen over an extended period, while others will mature all around the same time.

Fleshy fruits, common amongst rainforest species, will usually soften, and often change colour when mature. These fruits are commonly eaten by birds and other animals, and the seed excreted from the animals, and so dispersed away from the parent plant.

Methods of collecting

- *Natural seed fall*

Large seeds or fruit can be collected from the ground. This method is most commonly used for rainforest plants.

- *From low growing plants or branches*

Readily detachable fruit or seeds can easily be handpicked. A tarpaulin or plastic sheet can be placed under the plant and the plant is shaken, or branches are knocked with a stick to dislodge seed and/or seeds. Some fruit might not be readily handpicked, but can be carefully pulled away from the parent plant with a little effort, making sure to minimise any damage to the parent plant. Other fruit might need to be cleanly cut away from the plant with a sharp knife or pair of secateurs.

- *From higher branches*

Long handled saws, loppers or pruners can be used to remove selected branches. A rope saw can be thrown over a branch, and the saw drawn backwards and forwards to cut the branch. Ladders can be used (carefully), but they are cumbersome to carry around in the bush. A rope with a weighted end can be swung around and thrown up into a tall plant to either wrap around a branch so that it can be carefully pulled down within reach, or to dislodge fruit or seed so they fall to the ground. A rifle with a telescopic sight is sometimes used to shoot through branches causing them to fall. This should only be done by qualified (and licensed) people. Expert climbers with suitable equipment can climb tall trees and cut down selected branches.

Ideally safety helmets should be worn when harvesting using any of these overhead methods to reduce the likelihood of injury from falling objects such as branches or large, hard fruits.

- *Felled trees*

If a tree has been cut down for harvesting then it may be possible to collect seeds from it. Trees should not be cut down just to harvest seeds.

Removing seeds

The mature fruits of many natives normally need to be dried before seed will be released. They can be spread loosely on sheets of plastic or a tarpaulin. They should ideally be exposed to the sun, in a site protected from wind, or placed in a well ventilated site under cover. Check regularly for pests (eg. spiders, insects, birds, mice), and turn the fruits regularly. The outer pulp of fleshy fruit should be removed prior to drying.

Drying may only take a few days in warm, dry weather, but may take weeks or even longer in cooler weather.

Fruit of some rainforest species should not be dried.

Extracting the seed

Some seed is readily separated from the fruit (eg. *Acacias, Hoveas, Hardenbergias*), some is actually dispelled as the fruit matures.

Seed held in hard woody fruits (eg. *Hakeas, Eucalypts, Callistemons, Melaleucas,* Leptospermums, Kunzeas) generally open naturally over time, once removed from the parent plant. The fruits may need to be banged to dislodge some of the seed.

Some seed however, might need a little help in being released. Many Banksias, for example, will retain seed in their fruit (technically called multiple woody follicles - more commonly called "cobs") for many years. The fruit generally require exposure to heat before they will open. This can be done in a variety of ways including:

Throwing the *Banksia* cobs onto a BBQ for a short time (eg. a couple of minutes); this will burn off any residual dried floral parts, and will often result in the follicles opening as the cob cools.

Putting the cobs in an oven at around 180 degrees C for about 15-20 minutes; remove them and allow them to cool naturally, or dip them in cool water.

Once the follicles have opened, the seed can often be easily removed by banging the cob onto something hard which will hopefully dislodge many of the seeds. There will often be two (winged) seeds per follicle. Some seeds may need to be removed carefully using a pair of flat pronged tweezers.

Seeds with fleshy coverings should have the outer fleshy layer removed carefully using your fingers, or a knife, and water. Alternatively the fruits can be pulped and seeds carefully strained off then dried.

Cleaning seed

Any chaff (infertile ovules in with the actual seed), leaf litter, old seed pod material, insects, spiders, etc. should be carefully removed, making sure you don't damage the seed. For heavier seed such debris can often be blown away carefully by blowing on them, or even with a hair drier held at a suitable distance away. Some seeds can be separated from other material through a wire mesh sieve.

Storing seed
Seeds are alive and like any living thing they can be harmed by adverse conditions. Seeds of some species do not store for very long at all...propagation should be done with fresh seed only. Most seeds however will store for at least 6 months without loss of viability, provided the environmental conditions of their storage are right.

Dusting seeds with an insecticide in powder form (eg. Carbaryl) can be effective in minimising damage due to insect pests. Make sure when handling such pesticides, and seed treated with them, that you use suitable rubber protective gloves. Also avoid breathing in any of the powder. Always wash exposed skin after handling seeds treated in this manner.

The seed of many natives, particularly those from drier regions, and including many of the *Eucalypts, Acacias, Cassias, Melaleucas, Casaurinas, Callistemons, Kunzeas, Leptospermums, Hoveas, and Hardenbergias* are ideally kept under low humidity and temperature conditions with little fluctuation in these factors. The seeds are commonly stored in airtight, re-sealable glass, plastic or metal containers. Alternatively snap-lock plastic bags can be used. Keep the containers in a cool, dark spot where they are safe from vermin.

Seed from many of the fleshy fruited species has a short life span, and should be sown as soon as possible.

At all times seed batches should be properly identified (ie. labelled).

DIFFICULT SEEDS
Some types of seeds are much more difficult to germinate than others. In their natural state most species have adopted mechanisms which allow germination to occur with relative ease. For many "difficult to germinate seeds", it is possible to carry out some type of pre-germination treatment which will increase the chances of success:

Germination treatments
Seed of many native species will germinate readily if suitable conditions are supplied however the seed of some species have built in dormancies that prevent them germinating immediately. This is an adaptation that promotes survival. Such seeds will often germinate only after fire has passed through the area, or after an extended period of time. To get such seeds to germinate they need to be treated in some manner.

Typical treatments include:

- Scarification is any process of breaking, scratching, mechanically altering or softening hard seed coverings to make them more permeable to water. These treatments are commonly used on species from the following genera: *Acacia, Hovea, Hardenbergia, Pultenaea, Kennedya*. Three types of treatments are commonly used to scarify seeds. These are mechanical, chemical and hot water:
- Mechanical Scarification involves such methods as rubbing them with sandpaper to thin the seed covering, filing through the seed coat, nicking the seed covering with a sharp knife, cracking the seed coat with a hammer or a vice. With each technique it is important to avoid damage to the internal parts of the seed (and to yourself!). These techniques are used for larger seeds (easier to handle), and where the amount of seed to be treated is small.
- Acid Scarification is where dry seeds are placed in containers and covered with concentrated sulphuric acid in the ratio of about one part seeds to two parts acid. Suitable acid resistant containers should be used and great care taken in handling the acid (eg. chemical safety gloves and face masks used). Time of treatment will vary from as little as ten minutes up to six hours depending on the species.

Soaking in boiling water
1. Place seed in a jar/cup/container.
2. Pour water which has been brought to the boil over the seed.
   Cover the seed generously.
3. Stir gently.
4. Leave soaking for 24 hours (Water is allowed to cool. Do not keep it boiling).
5. Remove and discard any floating seeds after the 24 hrs (the floating seed will not usually germinate).

6. Any seed that has not swelled (but has sunk to the bottom of the container) can be re-treated in this manner.
7. Sow the remaining (swollen) seed.
Species to be treated this way include those from the genera *Acacia, Hardenbergia, Cassia*, *Kennedya, and Hovea*. A few wattles have softer seed coats and can be damaged by this treatment (ie. *Acacia harpophylla, A. stenophylla).* These types can usually be determined by pushing the coat of the seed with your fingernail. Soft coated Acacias should be sown without any treatment.

Stratification (Moist chilling)
This is a method of handling seeds, which require a period of after chilling to mature the embryo. The following is one method of stratification that can be used:

- Mix seed with slightly moistened peat moss, sphagnum or vermiculite (1 part seed to two parts medium).
- Place the mix in a polythene bag, label and tie. It is important that you use polythene as it is much more permeable to oxygen than some other plastics, but will retain moisture preventing the seeds from drying out. The seeds can be dusted with a fungicide powder to help protect them.
- Place the bag in the bottom of a refrigerator (not the freezer). The temperature should be in the range of 1 – 5 degrees C.
- Check periodically to ensure the mix remains moist.
- At the end of the required period remove seed and sow.

Species that may respond to this type of treatment include those from alpine and sub-alpine regions such as the Mt Kosciusko area, for example, *Eucalyptus regnans, E. delagatensis, E. stellulata, E. kybeanensis, E. nitens and E. pauciflora. Banksia canei, B. saxicola*. Most require at least 3 weeks, while some such as *Eucalyptus regnans* need 6 to 10 weeks.
This method has also been used successfully for non-alpine plants such as *Anigozanthos* species.

Fire
Some seeds often germinate best after a fire has passed over them (eg. *Actinotus helianthi*). This effect can be recreated on a small scale by sowing the seeds in a fireproof container such as terracotta pot and covering the propagation media with a small heap of leaf litter. Ideally this litter should be derived from species associated with the area from which the particular seeds you have sown are native to. The flame should be maintained for 2-3 minutes then put out. The ash is allowed to cool, and the pot is watered and treated as for other seed trays.

Smoke has been shown in recent times to enhance the seed germination of many species, in particular, many Australian natives from fire prone areas, such as species from the following genera: *Calytrix, Conostylis, Dianella, Eriostemon, Geleznowia, Lechenaultia, Philotheca, Pimelea, Stylidium, Verticordia).*

Much of this knowledge is based on research done at Kings Park Botanic Gardens in Perth. They have isolated many of the individual components of smoke, with the aim of producing commercial preparations that can be added to water, and simply watered into trays of suitable seed to increase germination rates. One method they have used is to soak seeds for twelve hours in a 9:1 water:smoke - water solution. The smoke-water can be made by bubbling smoke through a container of water for around an hour and then frozen until it is needed.

Leaching seeds
Some seeds have a chemical inhibitor that prevents or delays germination. This can sometimes be removed by leaching the chemical out of the seed by placing such seeds in muslin bags or similar material in running water for 1-2 weeks.

SOWING YOUR SEEDS
When to sow
Some natives can be successfully germinated at anytime of the year, however most are best germinated during the warmer months. If you are using greenhouses or other facilities where higher temperatures are being maintained then you can extend the time you can readily germinate particular species. For many species temperatures need to reach above 20 degrees C each day. For those from cooler climates the daily temperature may only need to reach 15 degrees C, while for plants from tropical areas the daily temperatures may need to reach 25 degrees C or more.

Seed from many of the fleshy fruited species needs to be sown as soon as possible after harvesting.

Propagation medias
Most native plant seeds, particularly those plants that naturally inhabit drier regions, prefer a propagation media that provides good drainage and aeration. Commercially prepared seed raising mixes are readily available from nurseries, garden supplies, etc. Alternatively you can make your own mix. A simply prepared propagation mix that can be used is:

- 1 part moist, finely sieved peat moss to 3 parts of coarse washed river sand (which is commonly sold as propagation sand).

- The ratio of peat to sand can be altered to suit the seed being sown for example seeds that prefer a little more moisture can be sown in a mix of one part peat to two parts sand.

NOTE: Peat is becoming more and more expensive, and its harvesting causes a lot of environmental damage. An alternative for peat is hammered coconut fibre which is readily available.

Another way in which the mix can be altered to suit your particular requirements is the addition of perlite, a product created by heating the mineral mica to a high temperature. It is light-weight, inert, and helps improve drainage and aeration in a growing media.

One example of such a mix is:

- 1 part coarse washed river sand: 1 part sieved peat moss: 1 part perlite

Avoid the use of soils where possible. These are a major source of pest and disease problems. In addition they often become sticky when wet, or stay waterlogged, or dry to form hard crusts.

All media ingredients should be thoroughly mixed, and the mix ideally pre-moistened prior to use, ensuring all parts of the mix are moist.

Containers for sowing seed
Suitable containers for seed propagation should have the following properties:
- Ideally be inert so that they don't release any toxic chemicals (some wood preservatives for example can be very toxic), or salts.
- Not be made of to porous a material that results in moisture being absorbed from the propagation media into the walls of the container.
- Have sufficient drainage holes to allow good drainage.
- Be able to retain the propagation media without it washing out of the bottom (i.e. through overly large drainage holes).
- Have sufficient depth to allow for good root development of the germinating seeds.

Seed sown into trays
Seed is commonly sown into plastic trays, for example standard size propagation trays. Other plastic containers such as butter or margarine containers can be used but make sure you make sufficient drainage holes.
Any containers used should be thoroughly cleaned first. Wash off any dirt, debris, etc. in warm soapy water. Then soak them in a solution of household bleach (20ml of the concentrate to 1 litre of water). Wash off any disinfectant of soap with clean water.

Sowing directly into pots
Seed of quick germinating and growing species, and whose seed is big enough to easily handle, can be sown directly into small pots (commonly 50mm diameter tubes). Generally two or three seeds are placed in each pot, depending on how much seed you have. When the seeds are germinated the strongest seedling is left and the others removed.

How to sow your seeds
The selected container should be filled with propagation media until it is nearly full. The container can be lightly bumped to consolidate the mix. The surface of the mix can be levelled using a flat piece of wood. Firm lightly but not too hard. Water carefully, to minimise any disturbance of the soil. Let the container sit for a while to allow excess water to drain.

The seeds can then be sown evenly over the surface of the tray. Try not to waste seeds by missing the container, and be careful that seed doesn't blow into, or get accidentally sown into other containers you may have prepared, and have standing nearby. Avoid sowing too densely as this encourages disease, and seedlings don't have sufficient room to grow strongly.

Seed can be sown directly from the hand, or out of a small containers such as a pepper pot (good for small seeds), mixed with fine white sand (so you can see the seeds and where you have sown the mixture).

Once the seed is sown it should be lightly covered with fine sand, propagation mix, or fine sieved vermiculite. Only cover to a depth equivalent to the thickness of the seed. Make sure that the container is labelled showing what type of seed was sown, when it was sown, where it was collected from, etc.

Carefully water the tray with a fine mist from above, or place the tray into another container with water in it so that when the seed tray is sitting on the bottom of the other container the level of water in the larger container is only a couple of centimetres deep. Leave the seed tray sitting there until you see water rising to the top of the propagation mix. Carefully lift the tray out and place it on a bench so that excess water quickly drains away.

The trays can then be placed in a suitable position, such as on a bench in a greenhouse, in a cold frame, in a spot covered by shade-cloth, underneath shrubs that provide filtered sunlight and light breezes, or in a protected position on a veranda. Make sure they are not exposed to bright, direct light (ideally 50-80% shade), and exposure to drying winds. Avoid placing seed trays directly on soil as this increases the likelihood of diseases problems.

Also make sure moisture levels in the propagation mix are suitable. This will vary according to the species sown but most natives prefer a mix that is always moist, but excess water can freely drain away. Do not let the mix dry out. Most trays will need watering at least once a day, more on hot days. Water using the bottom tray method: or overhead using a fine mist. In cooler conditions reduce watering to prevent over-watering.

The major cause of losses of germinating seeds and new seedlings are fungal diseases. They might appear as rotting stems, as small patches of dead seedlings, and as leaf spots. Good hygiene throughout propagation is the best way to reduce the likelihood of such diseases occurring. If you do see evidence of fungal problems they must be treated urgently, as they can rapidly spread. Drenching with a fungicide such as Benlate or Fongarid will often help (these products may not be registered for use in your country). Other methods are to increase ventilation around the plants, reduce watering, avoid watering later in the day, dispose of infected trays before the infection spreads, or a combination of these things. If you find you are repeatedly suffering from these problems then you may need to alter your potting mix to improve its drainage, and thoroughly drench your propagation areas with a disinfectant such as bleach (sodium hypochlorite) or a quaternary ammonia solution.

Fertilising is not generally necessary, but dilute applications of liquid fertilisers can be misted onto to the seedlings (this can be done during normal watering) about once a week, once the seedlings appear.

The Bog method

This method is often used to germinate the very fine seed produced by *Callistemon, Melaleuca, Kunzea,* and *Leptospermum* species. Seed of these species will usually germinate easily, but the small seedlings are easily damaged by overhead watering, or if the propagation mix is allowed to dry. With this method a seed tray is sown normally, but the seed are not covered. The tray is then stood in an ice-cream or similar plastic or glass container. Water is slowly added to the larger container until the level reaches about halfway up the side of the tray. Leave the seed tray standing in the larger container, and cover both trays with a large polythene bag (you might need to make a simple wire frame to place it over). Top up the water every day or two.

About a month after germination remove the seed tray from the water and allow it to drain. Then treat the tray of seedlings as for other trays grown in the normal manner, but making sure the tray is watered from the bottom. If disease problems arise treat with a suitable fungicide (ie. Benlate, Fongarid) and remove the plastic bag.

Transplanting
Also known as "pricking out" this is the transfer of the young seedling out of the seed tray into individual containers.

When a seed first germinates the first leaves (actually seed-leaves not true leaves) are known as cotyledons. Most trees and shrubs have a pair of cotyledons (this type of plants are known as dicotyledons), while grasses, lilies, grass trees, orchids, and many other smaller plants only produce one cotyledon (these are known as monocotyledons).

For dicotyledon types when the plant continues to grow it produces its first pair of true leaves, then a second pair, then a small shoot. At this stage the seedling is ready to transplant into an individual container. Casuarinas, which have a different growth habit, can be pricked out when they are about 15-20mm tall.
Great care should be taken when pricking out seedlings. The mix can be loosened, and the seedlings carefully lifted up using your hand, or a flat narrow tool such as a knife, or a dibble stick. Then gently pick up the individual seedling by the leaf, being careful not to squeeze it. The seedling can then be placed into position in a partly filled container and potting mix gently filled in around it. Try to ensure that roots are not twisted, or bunched up during this process. This is particularly important for plants that have a strong tap root system. The potting mix can be consolidated by gently tapping the pot onto a hard surface. The transplanted seedlings should be watered as soon as possible.

Suitable potting mixes are best purchased from a reputable commercial supplier. A suitable fertiliser mix will need to be added. Alternatively a coarse washed river sand and peat or peat substitute can be made up at home. Generally a combination of a quick release soluble fertiliser and a slow release one (eg. Osmocote, Nutricote) is used. Be careful using fertilisers with more than about 2 or 3 percent phosphorus content as many natives are adapted to soils with low phosphorus levels (eg. *Banksias, Hakeas, Dryandras, Grevilleas*). Look for specially prepared “Native” fertilisers such as ‘Osmocote for Natives’. Many natives are also prone to iron deficiencies – look for pale yellow new foliage, particularly in members of the Proteaceae family.

Common containers used for the first potting up are:
50mm diameter x 75mm deep round plastic tubes: (commonly used for slower growers and fibrous rooted types).
50mm diameter x 150mm deep square forestry tubes: (commonly used for quick growers with tap root systems (eg. *Eucalypts, Acacias*).

Aftercare
The transplanted seedlings can be placed in a tray (or other suitable container such as a polystyrene fruit box), and placed in a protected position out of direct sunlight. Watering is still critical. The seedlings can gradually be exposed to more light as they grow and ‘harden up’. The seedlings should be ready to pot up into larger containers or into the ground in 1-3 months

Keep a close eye out for pest and disease problems, and if sighted treat with a suitable control method as soon as possible,

ASEXUAL PROPAGATION
A cutting is a piece of vegetative growth (non-sexual - not the flower or fruit) which is detached from a plant and treated in a way so as to stimulate it to grow roots, stems and leaves; hence producing another new plant. Cutting propagation is most commonly used for shrubs, indoor plants and many herbaceous perennials. It is the most common method of asexual reproduction used by horticulturalists. As a general rule, it is rarely used to propagate most types of trees.

When a plant is grown from a cutting it is genetically identical to the parent plant. This is not necessarily so when plants are grown from seed. Cuttings are the most widely used technique for reproducing "true to type" plants. This ensures that the unique characteristics of the parent plant are passed on to the progeny.

Cuttings can often be used to propagate plants that:
- Don't produce viable seed, or produce seed at irregular times,
- Have seed that is difficult to germinate

- Have seed that is difficult to collect, for example, plants that have seed pods that burst open dispersing the seeds widely
- Produce their seed at a time when seed cannot be collected, or collection would require a further trip to the area (often very difficult for remote areas), or can only be collected with difficulty (e.g. plants whose seed matures during wet seasons when access may be limited).

Cuttings can be useful as they may avoid the problem of juvenility in the newly propagated plants. Most plants grown from seeds go through a juvenile stage, in which flowering, and hence seed production does not occur. Some plants may take 5, 10 or even more years before they commence flowering. Once a plant has flowered, plants propagated from that plant by cuttings will avoid the juvenile stage and flower early, often within months of the cutting having struck.

Many plants also have undesirable growth forms when they are young. These include very vigorous growth, thorniness, or unattractive foliage or form. By taking cuttings from adult plants these undesirable characteristics can be avoided.
In some cases the juvenile form of a plant may have characteristics that are more desirable than those of the adult form.

You may take cuttings from plants growing in gardens, pots, parks or in the wild; and you may successfully produce new plants from cuttings taken from any source; however, you will always get much better results if you carefully choose your source of cuttings.
- If you know the cultivar name of the plant, you can be more certain of how to propagate it, and be confident of the characteristics that will be demonstrated by the new plants.
- If you take cuttings from healthy plants; they are more likely to develop roots faster, and produce healthier plants quicker.

Why cuttings?

Despite all the difficulties that can be experienced with various techniques to propagate a plant, the cutting technique still remains one of the easiest and cost effective techniques to produce a number of new plants, whether that is for commercial or domestic production.

The home gardener will find that cuttings are easy, time effective and cheap; the rewards in watching a plant produce roots and develop into a new plant encourages them to propagate even more plants, and share them with friends etc.
Commercial production nurseries know the benefits of the cutting technique. Their profit and existence relies upon using the right technique for the right plant. Improving their techniques can increase production and hence increase profit.
Growing plants by cuttings can be a very rewarding exercise, and for commercial propagators may be the most economically viable method for many plants.

How to propagate a cutting

Most cuttings are pieces of stem, often with some leaves left at the top of the stem. Some plants can be grown from cuttings of other tissue (eg. a piece of leaf, or section of root, or even part of a bulb, with no stem at all).

Cuttings are usually planted into a mix of materials such as sand, peat moss, perlite, rockwool or vermiculite. Part of the tissue is usually below the surface of the mix, and some exposed above the surface.

The cuttings should then be kept moist and other conditions such as light, temperature, humidity and hygiene should be kept appropriate to the requirements of the variety of plant being grown.

Other things that can be done to enhance development of the cutting will either speed the rate of growth or improve the percentage of cuttings that succeed.
Chemical hormones may be applied to stimulate the formation of either roots, or foliage/shoot growth. Pesticides or disinfectants may be used to prevent diseases or pests. Heating may be used to warm the root zone (ie. bottom heat), to encourage faster growth of roots; or periodic misting of the foliage to cool the top of the plant, or prevent dehydration of the foliage.
If you want to get the best results from your cutting propagation, you really need to pay attention to selecting the appropriate technique for the time of year, and type of plant you are growing. Different types of plant tissues have varying abilities to sprout roots and shoots and turn into a new plant.

The ease with which particular tissue can grow as a cutting depends upon the chemical and physical make up of that tissue. These physical and chemical properties can be extremely variable at different times of the year, under different environmental conditions, and even between different varieties of the same plant species; let alone from one part of a plant to another. To become more and more successful at cutting propagation; you need to try and understand these subtle differences. In time, a good cutting propagator can develop an ability to make informed guesses as how to propagate a wide range of different plants.

Classification of cuttings types
Cuttings are commonly classified broadly in two different ways:

- *According to the type of plant tissue used.*

Example: a leaf cutting is a cutting made from just a leaf, or part of a leaf; and a stem cutting is made from a piece of stem.

- *According to the age (or tenderness) of the tissue used*.

Example: softwood cuttings come from tissue that is soft; whereas hardwood cuttings come from harder wood, which is older. The age of the wood is generally related to seasonal growth characteristics, for example, softwood cuttings are commonly taken in spring after the first flush of new spring growth, however they also be taken at other times of the year if suitable plant growth is available.

The classification of cuttings is not always the same from country to country, or even place to place within a country. Terms used in one place are sometimes different to those used elsewhere. The term **"tip"** cutting, for example, is often used to describe a cutting taken from the end of a stem. This in effect is normally, but not always, the same as a softwood cutting.

Some cuttings might contain different types of tissue in the one cutting. A heel cutting, for example, can contain wood that has grown recently at the top (still soft); wood that is semi -hard in the middle, and a small section of hard wood (from last years growth) attached at the bottom.

TYPES OF CUTTINGS
A section of stem usually (but not always), with some leaves left on the top, but lower leaves removed. There should generally be a node (this is a point at which a bud emerges) at the bottom of the cutting and at least another node at the top of the cutting. There may be one or several nodes in between.
The techniques of softwood, hardwood, semi-hardwood and root cuttings are covered in more detail later in this section. Only these are covered in more detail, due to the significance of these techniques to commercial practices.
Stem cuttings are usually classified as softwood, semi-hardwood or hardwood.

Variations
Stem cuttings can be taken from different parts of a stem. They might be taken from the very tip, with the terminal (end) bud left attached (or in some cases removed). They might be taken from sections of stem lower down, with the soft growing tip removed. In this case, several cuttings might be made from one single section of stem.

Another alternative is to pull a short side shoot, from a stem, with some older tissue still attached to the base. This older tissue is called a heel.

Some plants will even grow from sections of old stem (ie. wood that is 2 or more years old).

Softwood cuttings
These are sometimes also called soft-tip cuttings. They are stem cuttings taken from new growth that is soft. This commonly occurs during spring, but may occur at other times of the year if suitable material is available. The genus and species in conjunction with the climate can alter the time period. Pruning techniques used on mother stock plants can also govern when softwood cuttings are taken.
Common softwood cuttings include: *Baeckia, Banksia, Bauera, Billardiera, Boronia, Brachyscome, Brachysema, Bracteantha, Callistemon, Calothamnus, Cassia, Correa. Crowea, Dampiera, Dillwynia, Dododea, Epacris, Eremophila, Eriostemon (Philatheca), Grevillea, Hakea, Hardenbergia, Isopogon, Kennedia, Kunzea, Lambertia, Lechenaultia, Leptospermum, Melaleuca, Melia, Myoporum, Olearia,*

Pandorea, Persoonia, Phebalium, Pimelea, Prostanthera, Scaevola, Sollya, Syzygium, Telopea, Thryptomene, Verticordia, Westringia, Zieria.
Note: Semi-softwood cuttings are taken from tissue that is in the process of changing from soft to semi hardwood.

More on softwood cuttings:
The emerging shoots of plants used for softwood cuttings are tender and weak, and prone to quick death if allowed to dry out after being removed from the plant. For this reason when the plant material is taken, it is usually removed from the plant early in the day and placed immediately in a cool moist environment (ie. a bucket of water, or moistened and placed in a sealed polythene bag stored in a cool shady position until ready for preparation). The plant material taken is generally larger than what is needed – it is later cut to size during the softwood cutting process.

Soft plant tissue is easily bruised so careful handling and harvesting is essential. Extremely soft tissue that wilts the moment it is cut from the plant is not recommended as the success is often low and it often rots on the propagation bench.

Softwood cuttings are traditionally taken about 50-120mm long (2-5inches) with several nodes. With misting, fogging and base heating equipment, softwood cuttings are now taken even shorter at around 30-40mm (about 1.5 inches).

A weak concentration (1000-3000ppm) of rooting hormone in a quick dip is used which increases the success rate.

The tug test (a careful tug made near the lower part of the exposed part of the cutting) is used to indicate when the cutting has formed roots. This is when a gentle tug upwards of the cuttings is performed – if the cutting offers some resistance then the cutting has roots; if no resistance then no roots.

After rooting has occurred, watering (misting, etc) is usually reduced progressively.

Taking softwood cuttings
a. take a cutting (new growth) from the parent plant about 30-50mm long with several leaves attached
a. cut the stem with a clean sloping cut below a node
b. remove 2 or 3 of the lower leaves
c. treat with propagating mix
d. set into damp media
e. water
f. label and place in a humid environment ie. glass-house or cover with plastic

Semi-hardwood cuttings
These are sometimes called half-ripe cuttings, semi-ripe or green wood cuttings.
Semi-hardwood cuttings are usually taken in late summer or early autumn, when recent spring growth is in the process of hardening. Many commonly grown shrubs are propagated this way, including; *Auracauria, Boronia, Darwinia, Hibbertia, Grevillea, Pittosporum, Prostanthera, Pultanea etc.* and also climbers such as *Pandorea and Hardenbergia.*

More on semi-hardwood cuttings
Very soft tips of these semi-hardwood cuttings are generally removed as this soft tissue can desiccate during the rooting period and increase chances of disease. Additionally this limp soft tip may interfere with water penetration to the rooting media.

Cuttings are usually taken 80 -150mm (3-6 inches) long with the lower leaves (half to two thirds of leaves) removed.
Top leaves can be trimmed to reduce water loss, or to facilitate handling, but conflicting evidence indicates no clear benefit to this practice.

Hormone treatment is recommended to maximise root uniformity and success. Concentration will be dependant on the species being propagated. (See later listings for different plants).

Taking semi hardwood cuttings
a. Take a cutting (firmer growth without woody bark, test: cutting should snap like a bean when bent) from the parent plant up to 200mm long (depending on species, each cutting should have at least 3 nodes on the stem)
b. Remove the soft growing tip
c. Cut the base just below a node
d. Remove half to a third of the leaves
e. Treat the bottom 15mm with rooting hormone
f. Set in damp propagating mix
g. Water
h. Label and place in a humid environment ie. glasshouse or cover with plastic

Nodal cuttings
This is a stem cutting without a heel, where the base of the cutting is made as a cut, just below a node (ie. where the leaf joins the stem). A single node cutting (also called leaf bud cutting) utilises a single node and a leaf as part of the cutting. The node may have one or two buds depending on the species being propagated.

Examples of plants grown by single bud node cuttings include: Double bud nodes plants include: *Clematis and Pandorea.*

Double node cuttings are made from plants where two leaves emerge at the same point along the stems length, but on opposite sides of the stem. The cutting retains two pairs of buds that are opposite each other. Double node cuttings are popular for climbing plants in that if one bud fails to shoot, the other might succeed. *Clematis* are commonly propagated by these methods.

Basal cuttings
Stem cutting where the base of the cutting is made at the point where the young shoot joins the older branch. At this point there is often some swelling in the stem. The basal cutting does not necessarily contain any older wood, as does the heel cutting.

Cane cuttings
A small section of cane from the plant, containing only one or two nodes, and no leaves is inserted horizontally (instead of vertically - like most cuttings are normally done); with a bud showing just above the surface of the media. This is used with plants such as *Cordyline*, *Dracaena* and *Diffenbachia* where it is difficult to obtain large quantities of cutting material. Heating and misting are usually essential for commercial success.

Other cuttings
A range of other types of cuttings are used for various types of plants, though in general, these are uncommon for the vast majority of plants you are likely to grow. They include leaf cuttings, root cuttings, and some others.

How to take cuttings at a glance:
1. Collect cuttings of appropriate wood from parent plant
2. Label the cutting wood you have collected
3. Fill a container with propagating media and water
4. Make a cutting
5. Treat cutting with rooting hormone (dip into water first if using powder, shake of excess)
6. Make hole in cutting media with a dibbler and insert cutting firmly
7. Water gently to settle cuttings
8. Label and date
9. Cover with plastic or place into controlled greenhouse environment with misting

- See diagram “how to Take Stem Cuttings” - following page.

Division of orchids
During the dormant growing season some types of orchids can be cut with a sharp knife, each section containing four or five pseudobulbs. These sections are then potted; each developing into a new plant (eg. *Cattleya, Odontoglossum* etc).

Dividing and separating perennials (herbaceous and non herbaceous)
Plants with modified stems or roots: ie. rhizomes, tubers, corms and bulbs can be easily separated or divided by digging up and separating during the dormant period after the foliage has died back. Some perennials such as grasses and plants are simply such as the *Viola hederaceae,* (native violet) *Brachyscome, (Swan River daisy) Aslpenium* - are lifted and split into smaller clumps in early spring late autumn.
Use a sharp knife to cut into smaller (disease and weed free) clumps alternatively use two garden forks centred into the crown (back to back) then ease the forks into opposite direction to the outside of the crown. Most herbaceous plants divide easily using this method. After trimming back any damaged roots, the separated portions can then be re-planted straight into a well composted, moist garden bed or potted up into appropriate sized pots.
For non herbaceous type plants it is usually necessary to cut back the foliage by at least half to prevent too much moisture loss and transplant shock.

STOCK PLANTS
Stock plants are those plants which you take your cuttings from. Stock plants are frequently the most under rated aspect of HEALTHY cutting production. "YOUR CUTTINGS ARE ONLY EVER AS GOOD AS THE PLANTS THEY COME FROM"

If your stock plants are in poor condition:
- Your cuttings may have a lower rate of success.
- Your cuttings may be slower to form roots.
- You may transmit pest or disease problems from your stock plants to other plants in your propagation bed or greenhouse.
- Your cuttings may not develop as strong a growth as it might otherwise.

Selecting stock plants
Only use:
- Plants free of disease and pests.
- Plants which are true to type. The stock plants need to be correctly identified and clearly labelled.
- Plants which have been grown under preferred conditions.
- Plants which have been growing well.
- Plants which have been adequately fed, and are free from signs of any nutrient deficiency or leaf burn.

WAYS OF GETTING ROOTS ON DIFFICULT TO ROOT CUTTINGS

1. *Hormone treatments*
- This involves applying chemicals which stimulate root development. Such chemicals can be applied in powder, gelatinous or liquid forms, and at varying concentrations

2. Obtaining the correct type of material
The stage of growth of the cutting material is often critical.
- Juvenile material will often strike
- Healthy material is important

3. Etoliation and Banding
- Banding involves wrapping a band around the stem (frequently Velcro is used). This stops light getting to that section of stem.
- If the base of the cutting has been banded for a period it may produce roots more easily.
- Etiolation involves covering a section (or all) of a plant and keeping it in darkness for a period. Growth which develops in darkness becomes elongated between the nodes. This etiolated growth is often easier to strike as cuttings.

4. Cutting grafts
- A cutting is grafted onto a piece of root. This helps the cutting take more easily. This method works well with *Bougainvillea, and Liriodendron, Brachychiton.*

- Some types of plants have too much sap in the tissue to be grafted when in an active growth state. If grafted when in an active growth state a greater proportion of grafted cuttings may fail with rapid growing plants.

5. *Misting/Fogging*

- Misting involves applying small droplets of water in an intermittent mist, to the cuttings. This both keeps the cutting from drying out, and provides control over high temperatures. Mist droplets are big enough to get into the root media though and can lead to water-logging.
- Fogging applies water in superfine sized particles, much smaller than mist. -Water droplets are too small to get into the media and cause water-logging.

6. Temperature treatments

Nuytsia (the West-Australian Christmas tree) is difficult to strike from cuttings. Some success has been achieved with cuttings taken from suckers however they usually die, because mucilage oozing from the cutting promotes development of bacteria which kill the young cutting. Cutting material which is chilled has less oozing of mucilage and less of a problem with bacteria.

7*. Light treatments (on stock plants).*

- Increasing light intensity for a period before taking cuttings will decrease rooting of cuttings taken from many different types of plants (but not all).
- The same treatment will decrease rooting for some plants though and have no affect on others.
- For most plants, moderate light conditions for stock plants is more ikely to produce better rooting cuttings than low or high light conditions. Reference: Hansen J. 1987 "Stock plant lighting and adventitious root formation" published in Hortscience.

8. *Bacterial treatments*

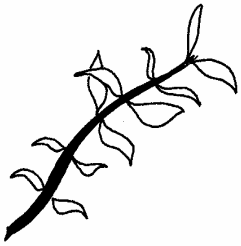
- Inoculation with a bacteria (*Agrobacterium rhizogenes*) has been successful in promoting root initiation on difficult to root species.

WARNING: This fungus can over stimulate root production to the point where it leads to infection. It this should only be used with difficult to root species. Ref: Patena, Suter and Dandekar in Acta Hortic. 1988

9. *Combination of treatments*

Banding is sometimes used with hormone treatments (ie. IBA is put on a velcro band, the velcro hooks scratch/break the bark and transfer hormone into the plant tissue.

HOW TO TAKE STEM CUTTINGS

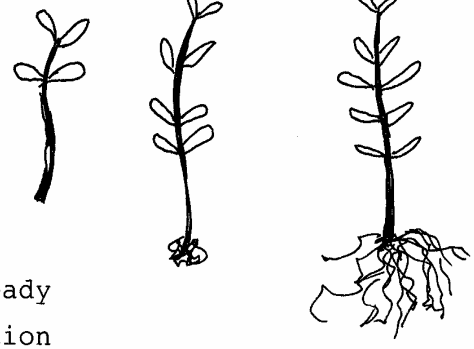


section taken from plant

prepared, ready for insertion

PRIVET HARDWOOD CUTTINGS
(taken in winter)

Stages of Stem Cutting Development



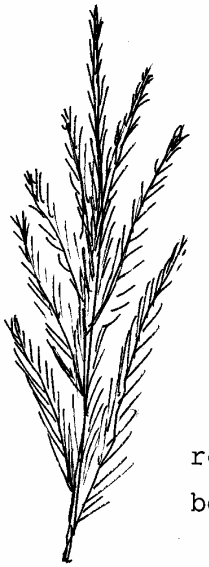
cutting ready for insertion

cutting after several weeks or months with callus developed

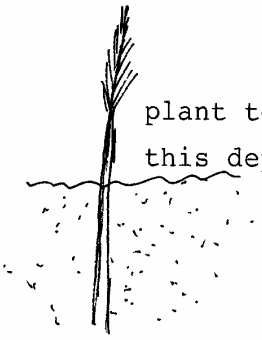
cutting with well developed root system

Stem Cutting

pull off side shoot



remove most of bottom leaves



plant to this depth

NURSERY HYGIENE

While nurseries aim to provide the ideal conditions for propagating and growing on plants, the same conditions can be ideal for the spread of pests and disease problems. In particular diseases such as 'damping off': (ie. *Pithium, Rhizoctonia, Phytophthora, Fusarium), Sclerotinia rot*, Mildews (eg. Powdery Mildew), and Grey Mould (*Botrytis)* can quickly infect and destroy large numbers of germinating seeds, young seedlings, and even more established plants.

"Many diseases, once established in a nursery are a source on many on- going problems, as they are often difficult to eradicate because they reside in soil, on nursery surfaces, equipment, in water or on alternate hosts from which they can spread and re-infect new nursery plants" (Nursery Paper No. 10 - 97 produced by the Nursery Industry Assoc. of Australia).

Insect pests (eg. aphis, white flies, mites) can also breed prolifically, in such ideal conditions (warmth and moisture), and severely damage plants in all stages of growth. They can also help spread diseases, acting as a carrier of some (eg. viruses) from plant to plant, or by making it easier for the disease to infect the plant through damaged tissue (eg. chewed areas), and because an insect damaged plant is usually less vigorous, and therefore less likely to be able to resist infection, and subsequent damage by diseases.

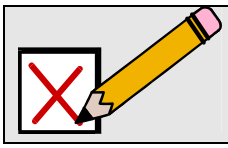
Pests and diseases can spread many different ways including:

- By dipping healthy cuttings in hormone or water in which diseased material has been dipped.
- Through irrigation (eg. from contaminated water sources) or rain water (dripping off structures or diseased plants or by splashing up soil).
- Soil-borne diseases on the hose - if it is dropped on the ground.
- Soil on the bottom of pots/trays.
- On tools, clothes, shoes and workers hands.
- Contaminated soil mixes or pots.
- Infected plant material etc.

Some recommended nursery hygiene practices include:

- Treating all soil with either steam or chemical fumigation or solarisation.
- Disinfect recycled water.
- Changing the spacing of plants can increase ventilation, reducing the likelihood of diseases occurring and spreading.
- Segregate clean and treated pots. Never store clean pots on the ground. Clean all used containers before reuse with 2000ppm quaternary ammonium compounds (quats) to remove media and plant debris. Dip all plastic containers and trays in a 1% sodium hypochlorite solution for 20 minutes, or steam treat at 60 degrees C for 30 minutes.
- Don't use/transplant diseased seedlings or cuttings (destroy by burning).
- Use good quality plant material for cutting propagation (vigorous growth, free of obvious pest and disease problems).
- Disinfect cutting material before using (a 2% sodium hypochlorite for one minute then rinsed in clean disinfected water to remove excess chemical).
- Take cuttings from top of plants - this is the cleanest part.
- Clean tools before using, and ideally between working on different plants. Scrub them clean first using plastic 'scratchies'' and 2000ppm quaternary ammonium compounds (quats). For larger tools and machinery pressure clean with a 2000ppm quat solution.
- Place clean plant material on cleaned/sterilised benches (cleaned with quat solutions).
- Segregate propagation activities from sales/growing on areas.
- Avoid handling treated soil unnecessarily. It should ideally be sterilised just prior to being used, or stored in such a manner (eg. sealed containers) that minimise the likelihood of the mix being infested with pest, weed and disease problems.
- Don't handle soil or plants unless hands have been washed with hot water and soap, or a suitable disinfectant such as Savlon or Dettol, or use disposable gloves.
- Footwear should be scrubbed clean with a brush and 2000ppm quat solution, or changed to other footwear designated for use only in the propagation or other designated areas.
- Avoid splashing water near sterilized soil, pots, benches, etc.
- Pots should always be placed on well drained surfaces (preferably concrete, screenings or raised benches.
- Hang hoses on a hook - don't lay them on the ground, particularly nozzles.

- Place any plants which you suspect to be diseased in an isolated area.
- Apply control methods to pests and diseases as soon as they are detected to prevent their spread.
- Wooden stakes and other similar materials should be steam sterilised at 60 degrees C for 30 minutes.



SELF ASSESSMENT
Perform the self assessment test titled ‘test 2.3.’
If you answer incorrectly, review the notes and try the test again.

SET TASK

1. Find a native plant which needs pruning (this could be a fully grown shrub or tree). Demonstrate pruning of this plant both in sketches and in before and after photographs. Indicate the species you are describing.

2. Plant a pot of native seed, or cuttings (whatever you prefer - don't worry too much about the time of the year for the purpose of this exercise).

ASSIGNMENT
Download and do the assignment called ‘Lesson 2 assignment’.