NEW ZEALAND PLANT CONSERVATION NETWORK

Native plant nursery management and plant cultivation

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Plant Conservation Training Module 3

by Iain Reid, John Sawyer and Jeremy Rolfe
Reviewed and revised by Matt Ward 2021

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Cover photograph: Young plants set outdoors to harden off.

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1 Introduction

THE PURPOSE OF THE TRAINING MODULES

The New Zealand Plant Conservation Network received funding in 2005 from the New Zealand Government's Biodiversity Condition and Advice Fund to develop a plant conservation training course for iwi.

This module is the third in a series developed by the Network and is intended to provide an introduction for iwi to the management of a native plant nursery and the cultivation of native plants. Other modules are available or being developed for:

- An introduction to New Zealand's plant life (Module 1)—a module that introduces the New Zealand flora
- Covenant management (Module 2)—a module covering techniques for managing and restoring Nga Whenua Rahui covenants or bush, dunes or wetlands on your own property
- Streamside and wetland management (Module 4)—a module that describes how to manage streamside and wetland vegetation

WHAT IS THE NEW ZEALAND PLANT CONSERVATION NETWORK?

The New Zealand Plant Conservation Network was established in April 2003 and now has over 950 members worldwide.

The Network has a vision that "*The rich, diverse and unique native plant life of New Zealand is recognised, cherished and restored.*"

To achieve that vision the Network is working with many people and organisations throughout New Zealand.

Our unique strength is in linking people interested in plant conservation with comprehensive, accessible and accurate information to support their efforts in promoting and conserving native plants. By fostering plant identification and conservation skills, providing an online one-stop shop for conservation best practice, and emphasising the importance of working together, our vision can be achieved. Our role is to facilitate and advocate for plant conservation as well as providing information and support to plant conservation practitioners, landowners and managers.

Our biennial conferences are highly regarded as the best place to meet people who are passionate about plant conservation and to network and collaborate on shared issues and challenges. Our website and newsletter Trilepidea are leading sources of up-to-date information about native plants and their conservation in New Zealand.

The importance of plant conservation in New Zealand

Plant diversity is a key component of nature's life-support systems. The quality of our life, the quality of the water we drink, the quality of the air we breathe and the quality of the soil are all dependent on maintaining natural plant communities. Most of New Zealand's indigenous plants and fungi, the communities they are part of and the animal communities they support are endemic. That means they do not occur naturally in the wild anywhere else in the world. Our responsibility is to protect these natural resources, not only because of the ecosystem services that they deliver or because of the many uses to which they can be put, but because of their intrinsic right to exist. New Zealand is world renowned for its flora, fauna and fungi and is regarded internationally as a global biodiversity "hot spot". The continued survival of New Zealand's native plant life is threatened.

In 2017, the New Zealand Threatened Plant Committee listed 403 indigenous vascular plant species at risk of extinction in the wild (Nationally Critical, Endangered or Vulnerable). In addition, a further 158 species were listed as At Risk - Declining and another 693 listed as At Risk - Recovering, Relict or Naturally Uncommon. Many native plant communities in New Zealand are also threatened, such as wetlands, coastal dunes and lowland forest. In addition, more than 65 species of fungi and non-vascular plant species are also known to be at risk of extinction in the wild.

Among the most significant threats are land development (such as subdivision, wetland drainage and forest clearance), invasion of exotic plant, animal and fungal species and human-induced global environmental changes (such as a changing climate). Plant conservation, in response to those threats, will halt and reverse the current decline of native plant life in New Zealand.

WHAT THE NETWORK DOES

The Network is involved in a variety of programmes to implement the New Zealand Biodiversity Strategy and Global Strategy for Plant Conservation. Those programmes include: education and advocacy, developing plant conservation strategies, prioritising conservation effort and gaining resources, providing technical expertise and disseminating information about native plants.

A key area of work is education, which means raising awareness of the plight of New Zealand's indigenous plant species and fungi and educating people about the native plant life of New Zealand (through publications, its web site, meetings and training courses and biennial conferences). This module is one component of the Network's national training programme for plant conservation.

MORE INFORMATION ABOUT THE NETWORK

More information about New Zealand's native plant life (including all native plants mentioned in this module) and the New Zealand Plant Conservation Network may be obtained from the Network website at www.nzpcn.org.nz. This website includes information about how to become a Network member to gain full access to the website and to receive the monthly Network newsletter. The contact address for the Network is:

New Zealand Plant Conservation Network
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INVOLVEMENT OF THE NORTHTEC

This book was written for the New Zealand Plant Conservation Network by Iain Reid formally of NorthTec and John Sawyer and Jeremy Rolfe of the Network. NorthTec has been involved in plant training programmes for many years, running a range of modules including innovative Horticulture and Sustainable Rural Development programmes. These modules are delivered at many marae and remote rural areas throughout Northland, providing communities with the knowledge and skills to create their own small business enterprises, by taking advantage of Northland's diverse and unique local microclimates and natural resources.

For more information about the courses run by NorthTec:

Website: https://www.northtec.ac.nz
Pathway Manager, James A. Smith: jalsmith@northtec.ac.nz

ACKNOWLEDGEMENTS

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2 Native plant nursery management

ESTABLISHING A NURSERY

Propagating New Zealand native plants from seed, spores (from ferns) or cuttings is a satisfying activity and most native plants are not difficult to propagate. An area for propagating and growing plants is termed a nursery.

ECONOMICS OF RUNNING A NURSERY

Establishing and running a plant nursery properly can be very costly, so think carefully about whether it is the right course of action before planning to build one. Quality, disease-free plants can only be produced in a proper set up that can be costly to build. For example, Mark Dean of Naturally Native Nursery Tauranga assisted in the planning and set up of a small marae nursery at Makaurau Marae in Mangere. It was built in 2004 and cost approximately $85,000 to set up. In this case the nursery was built to grow about 15,000 plants per year. Funding for this project came through a commitment from Water Care.

You can build a nursery more cheaply, but the quality of your plants may not be as good. In the above case, the cost to produce each plant worked out in excess of $4.50, compared with $2.50 – $3 to buy them from an existing nursery. It may be even cheaper for a large commercial operation if plants are grown under contract and in bulk. It is very difficult to produce plants more economically than buying from a commercial nursery. However, there may be other motives for establishing a small nursery (such as providing a central focal project for your restoration group or for bringing people together, or even just to learn about growing native plants) that would justify the costs.

Makaurau Marae nursery. Note the potting shed, standing out area, shade house and storage shed and sturdy fencing. Photo: Mark Dean.

Southland Community Nursery

The Southland Community Nursey provides facilities and materials to help people grow their own native plants. The nursery is an important networking place for those who enjoy meeting like-minded people who want to learn about the environment and growing plants.

To find out more about the Southland Community Nursery, visit their website: www.southlandcommunitynursery.org.nz

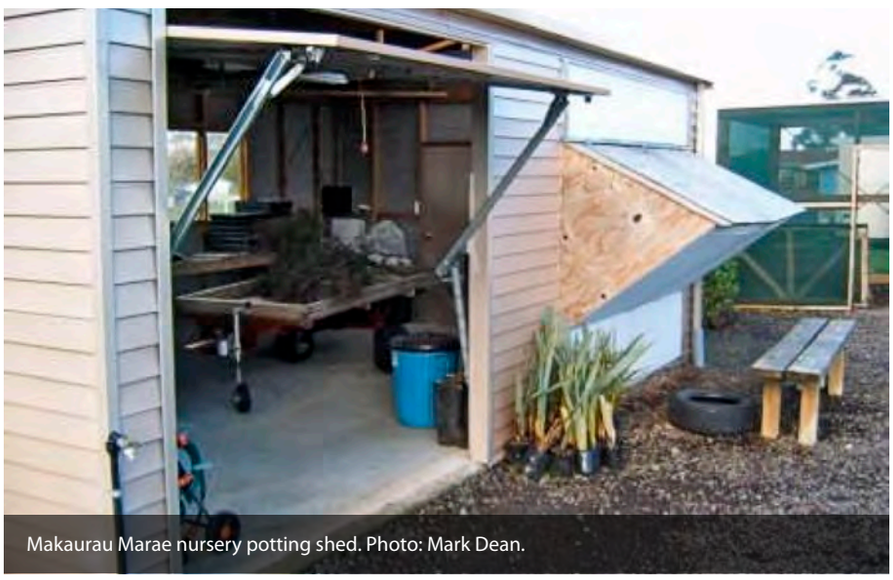
Ecological consultant Greg Jenks has had years of experience working with community groups and iwi to restore coastal dunes. He advocates that care groups concentrate on seed collection and ask commercial nurseries to produce the plants to a high standard, at a good price. Restoration groups can then focus their energies on restoration planting and after care.

The following sections provide guidance on establishing a small nursery.

REQUIREMENTS FOR A SMALL NURSERY

There are some minimum requirements when establishing a small nursery:

- Convenient location close to normal daily activities—home or work—with easy vehicle access for delivery and pick up of plants and materials.
- Dry storage for seed raising or cutting mix and potting mix/soil—preferably handy to the seed sowing, pricking out, and potting on area.
- Dry storage for containers, seed, fertilisers, other agrichemicals and equipment. Note that laws cover the safe storage of hazardous substances. This means you will need a lockable storage area, a system for catching spillage, appropriate signage, a spill kit and Material Safety Data (MSD) sheets for each chemical.
- Cold storage (refrigerator) for cool moist stratifying of seed (pre-treating seeds to simulate natural winter conditions before germination), temporary storage of cutting material.
- A place to comfortably undertake tasks such as cleaning, preparing and sowing seed, pricking out and potting on seedlings or rooted cuttings, e.g., a well-lit workbench area/table.



Makaurau Marae nursery potting shed. Photo: Mark Dean.

- Shelter from wind, e.g., hedges or artificial windbreaks.
- Access to a reliable water supply.

- A cool moist shady place to germinate seeds and establish cuttings, such as a cold frame, shade house (shade usually provided by woven plastic cloth, trellis or opaque plastic sheet) or shady side of a building or under trees (although falling leaves can cause problems). Cuttings may also be grown in a special propagation unit with a media bed with bottom heat and a misting unit (timer or sensor controlled).
- Some sort of shade house suitable for large numbers of plants.

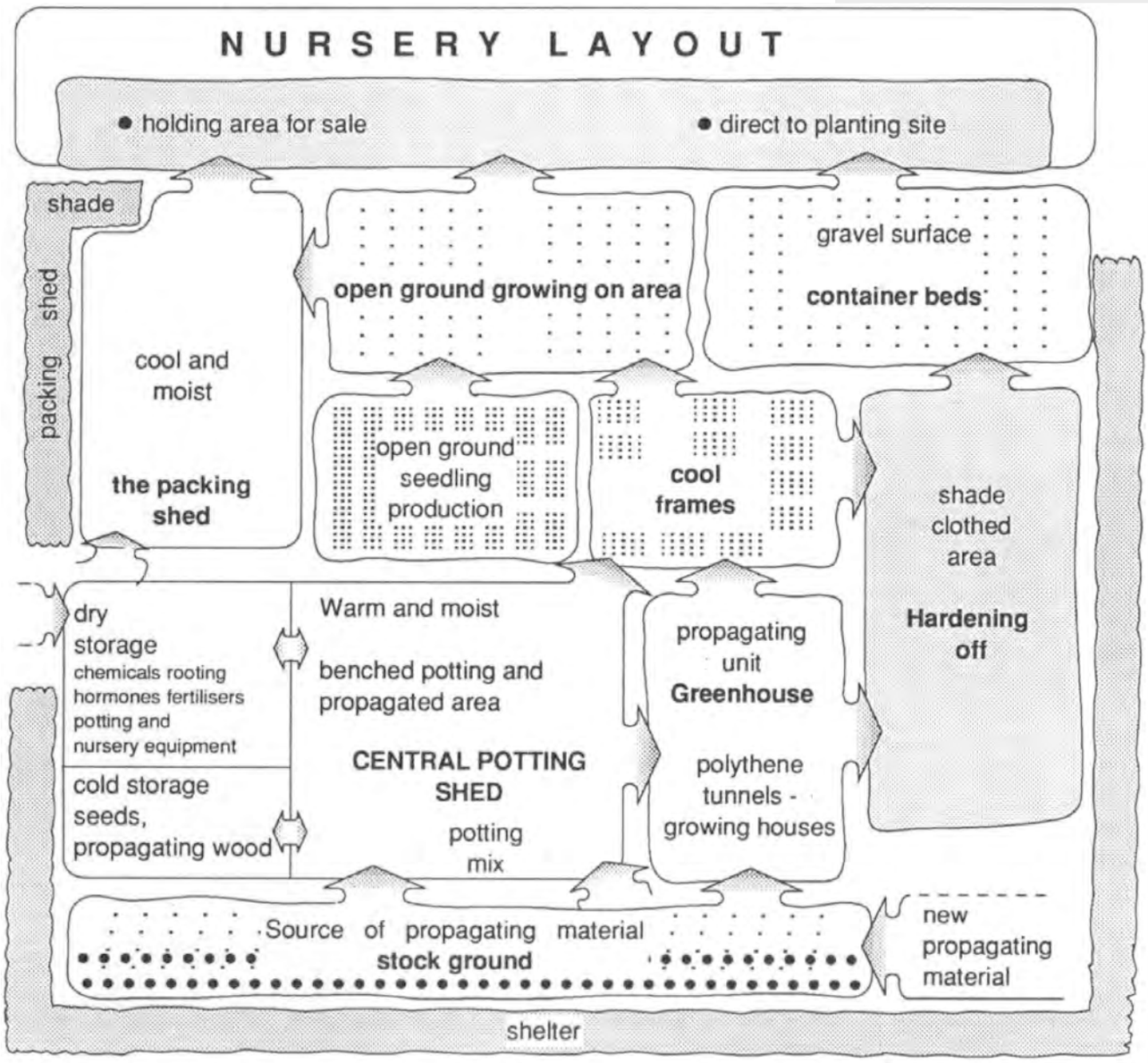
Makaurau Marae nursery shade house. Photo: Mark Dean.

- An open, but sheltered area where plants can be 'hardened off' (adapted to open conditions—full sun, wind, outdoor temperatures etc). A suitable area is flat and graveled (for drainage), sheltered from wind for plants in pots; polythene may be laid under the gravel 5 cm below for weed control or a thick layer (150 mm) of untreated sawdust laid in boxed areas.
- A packing shed may be needed if preparing plants for transport elsewhere.
- Good fencing and pest control.
- Labour requirements, e.g., staff facilities such as toilets, depending on the scale and purpose of the operation.

Makaurau Marae nursery standing out area. Note the overhead sprinklers, graveled central pathway (allowing for easy vehicle access), timber edged plant beds. Photo: Mark Dean.

NURSERY LAYOUT

Essentially all nursery layouts follow a standard pattern only differing in scale. In all these areas you must ensure the safety of people working there and for **safe** equipment movement and plant maintenance operations.



Nursery layout. Illustration printed with permission. © The Open Polytechnic of New Zealand.

RECORD KEEPING

It is important to maintain good nursery records. For example, it is imperative that you keep records of:

- The date plants are obtained/processed
- The source of your propagation material (seed or cutting material)
- Germination times
- Germination rates
- Seed cleaning and seed treatment
- Storage methods
- Cutting treatment
- Strike rate (% cuttings successfully rooted)
- Pest and disease treatments and observations of lifecycles
- The date of pricking out or potting on
- Media used for propagation and potting on

It can also be useful to label your plants with information about the species, its origin, the date sown (or cutting propagated) and batch number.

Plants with labels.

PLANT NAME:_____

Trial: _____

_____

_____

Source of seed / cutting /division:_____

Time seed collected:_____

Condition of seed:_____

_____

_____

_____

Time sown:_____

Germination time:_____

When pricked out:_____

_____

_____

_____

Growing conditions:_____

_____

_____

_____

Medium used:_____

_____

Time ready for bags:_____

Depth of water bagged in:_____

Time bags are ready:_____

Condition and number of plants when ready:_____

_____

_____

_____

_____

Nursery record sheet

CARING FOR PLANTS

The maintenance of plants in the nursery is a major task. It is important that you tend to plant health and growth needs as required. This includes:

- Watering plants and ensuring humidity requirements are met (including misting of cuttings).
- Selecting correct potting mix/growing medium for your plant and growth stage (e.g., seed raising mix, cutting mix, potting mix or growing on mix).
- Managing temperature.
- Wind protection.
- Frost protection (if needed in your area).
- Knowing when to prick out seedlings or transplant rooted cuttings.
- Knowing when to pot on plants.
- Hygiene—regularly remove dead, diseased plant material.
- Pest and disease and weed control as needed—keep an eye out for problems.
- Place plants in the correct light conditions for the plant type and stage of growth—and know when to harden off. Many ferns prefer 80% shade.
- Space plants so they don't shade neighbouring plants or restrict air movement (for disease control).
- Plant nutrition—use appropriate fertiliser when required and in the correct amounts (some potting mixes already have slow release fertilisers included).
- Aim to have plants ready for the planting season—usually autumn/winter.

When propagating native plants, it is often assumed that you will know when to collect seed or cutting material and what to do with it once you have collected it. Your local botanic garden or Department of Conservation office may be able to assist here. Otherwise members of organisations such as the New Zealand Plant Conservation Network, the Royal Forest and Bird Protection Society, your local Botanical Society, or staff at your local native plant nurseries may be able to help. Record keeping is important as you can check which treatment works best for particular plant species by reviewing your records.

Laurie Metcalf's book "The Propagation of New Zealand Native Plants" is also an extremely valuable reference book.

3 Cultivation of New Zealand indigenous plants

New Zealand is home to approximately 2,500 indigenous plant species (not counting mosses, liverworts, lichens and hornworts of which there are thousands of species). Many of these plants can be successfully cultivated. Here we are using the term cultivation in the sense of raising plants in a nursery or ex-situ situation—plant propagation in other words.

Firstly, what is an indigenous plant? An indigenous plant is any plant found growing naturally in New Zealand that has not been introduced from another land by humans. The term native means roughly the same thing. A plant that grows naturally only in New Zealand or in part of New Zealand is termed endemic. For example, kauri (*Agathis australis*) is endemic to northern New Zealand. Some New Zealand indigenous plants are also found naturally in other countries. An example is akeake (*Dodonaea viscosa*) which is quite widespread throughout the tropics and subtropics.

In general, growing indigenous plants from your local district and climate (same latitude and altitude) is best as they are more likely to be naturally acclimatised and adapted to local conditions. Plants widespread in distribution such as kohuhu (*Pittosporum tenuifolium*) may have local forms that differ from each other in such characteristics as frost tolerance. In revegetation work, using plants from locally sourced material is a first principle and is known as 'eco-sourcing'.

To cultivate New Zealand plants successfully, a little knowledge of the habitat, ecology or environment where the plant naturally grows is helpful. Growing plants in similar conditions to that in which they naturally grow is the key to success. In many books this is called growing "the right plant in the right place".

WHERE PLANTS GROW

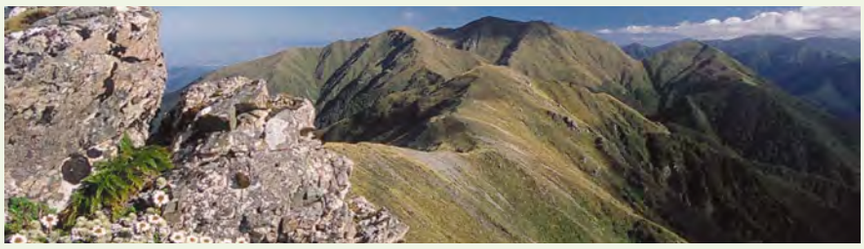
Plants grow in all regions of New Zealand, at all altitudinal zones and in all types of habitat (see opposite). For example, coastal dunes support native species such as pīngao (*Ficinia spiralis*) and spinifex (*Spinifex sericeus*) whereas in subalpine regions there is an entirely different array of plants, such as leatherwood (*Olearia colensoi*). Before attempting to cultivate native plants it is, therefore, vital that you know something about their native habitats.

Coastal: On or near the sea coast, e.g., pīngao, karo.

Lowland: Altitude of less than 500 m, e.g., maire, kohuhu, black beech.

Montane: Between approx 500 m and the tree line, e.g., mountain beech.

Subalpine: Above the tree line to the snow zone, e.g., leatherwood, tussock grasses.



Alpine: The snow zone, e.g., lichens, algae and herbaceous plants; no tussock grasses.

Photo: Les Molloy.

Altitudinal distribution of vegetation

The particular adaptations of a plant species bestow on it a range of tolerances to environmental factors such as salt, wind, cold, drought, shade or animal browse. This in turn influences the plant's distribution. Knowing the environmental and biological tolerance of a plant is vital to understanding how to grow it and also to conserve it in the wild. Environmental adaptation of plants can be described in terms of adaptation to water and seasonality (usually temperature).

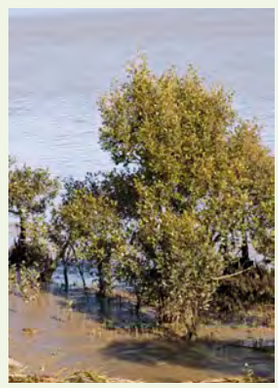
Xerophyte (arid): adapted to extremely dry conditions or physiological drought (e.g., ice or salt).

e.g., *Myosotis alboserícea*.
Photo: John Barkla.

Mesophyte: adapted to moderate conditions of dry or moisture; most plants.

e.g., cabbage tree (*Cordyline australis*)

Hydrophyte (aquatic): wholly or partly submerged in water.



e.g., mangrove (*Avicennia marina* subsp. *australasica*).

Plants and their environmental adaptations.

Having said all that, some native plants are remarkably adaptable. For example, some wetland plants, such as purei *Carex secta* and oioi *Apodasmia similis*, will grow quite well in average garden soil. Many alpine plants can be successfully cultivated in lowland situations. North from Auckland you will struggle with some alpine species.

PROPAGATION

Most native plants may be propagated by seed (or spores in the case of ferns) or seedlings (transplants) and many can be propagated by asexual or vegetative means such as cutting, division, grafting, layering, budding and tissue culture.

We now assume you have already selected your method and approach to cultivating native plants and decided on the purpose and scale of your operation (in answer to questions such as how many plants are required and what species?) and obtained the facilities and resources needed (refer to the Nursery Management section).

The next phase is collection and preparation of propagation material. Seeds, spores and cuttings are called propagules—the units of propagation (see opposite). The type of propagules used will have a bearing on your approach to propagation.

There are pros and cons of using asexual (cuttings) or sexual (seed) propagation for revegetation or restoration projects. Sexual propagation is preferred for restoration projects because this helps maintain a diverse gene pool in the restored plant populations. However, if some species are locally rare or threatened, cuttings may be the only option for boosting numbers initially.

Types of propagule

There are at least six types of propagule to choose from. The choice of propagule will depend on things such as the easiest method available, and the one which will least harm the existing individuals or the population as a whole. How to use these propagule types is covered later in the module.

Seed
Best when viable seed can be collected and is reasonably abundant. Difficult for some plants high in the canopy, or with fine seed with low viability.

Seedlings
Involves lifting and transplanting existing seedlings from the wild. Should only be undertaken when there is a surplus of seedlings that are likely to die off naturally and their removal will not affect the population and approval has been obtained from the landowner..

Cuttings
Softwood, hardwood, semi-hardwood, or nodal cuttings can be used. Usually treated with growth hormones. Best when seed and seedlings are unavailable and taking cuttings won't damage the plant. Good for getting quick maturing adults identical to parent.

Plant division
Involves taking pieces from or dividing an entire plant, then growing on the smaller pieces.

Tissue culture
A very specialised technique involving growing or cloning a plant from bud tissue. Usually used only when a plant has been reduced to very few individuals and other methods won't work.

Root division
This involves taking pieces of root stock from which new plants can grow. Best for rhizomatous or other vegetatively reproducing plants.

4 Propagation from seeds and spores

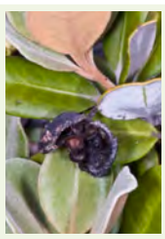
SEED COLLECTION

The critical step in seed collection is ensuring you have correctly identified your plant. Resources that can help include the website of the New Zealand Plant Conservation Network—www.nzpcn.org.nz and published field guides. The Network's Training Module 1: Introduction to Plant-life in New Zealand provides some guidance on how to identify your plant.

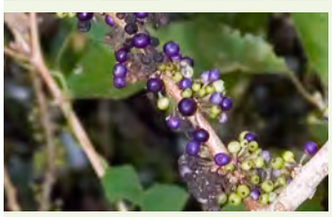
The next step is to check when is the best time to collect seed? For example:

- When is fruit ripe?
- Is the seed viable? Check a sample seed by cutting open lengthwise with a knife or secateurs and look inside for a white kernel indicating it is viable.
- How much seed do you need? A maximum of 20% seed/fruit from any individual plant is recommended.

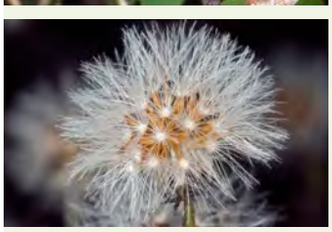
Obtain ripe capsules/fruit if you can—colour usually indicates this. For dry fruits the capsules are usually brown or grey when ripe, whilst fleshy fruit usually have a bright colour. See below for more information about when seed is ripe for collection.

1. **Capsules and pods**
   e.g., kowhai, *Pittosporum*
   - Medium to large seeds.
   - Ripe when capsules or pods begin to dry and open, but can be sown green. Germinate quicker.
   - Don't leave too long after opening.



2. **Berries**
   e.g., *Fuchsia*, māhoe
   - Many small brightly coloured berries with many pip-like seeds.
   - Ready when fruit is ripest.

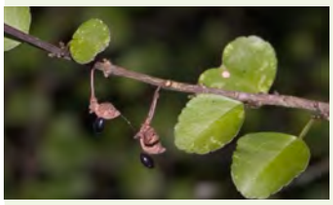


3. **Daisy-type seed heads**
   e.g., *Olearia*, *Celmisia*
   - Daisy-like, petalled flower heads. Produce small whispy seeds.
   - Ripest when released by gentle touch (like thistle)

4. **Drupes**
e.g., *Coprosma*, tawa, karaka, puriri
- Large fruit with one or few large seeds, not pip-like.
- Ripe when fruit is soft, deepest colour and starting to shrivel.

5. **Racemes**
e.g., kamahi, *Veronica* spp., pate
- Long seed heads, seeds in husks or thin shells.
- Make sure husks contain seeds.

6. **Grass-like**
e.g., *Carex* spp., tussocks, toetoe
- Spikes or panicles with many small seeds.
- Ripe when dry and brown (past green stage).
- Collect before seed is released.



7. **Small seeds**
e.g., wharangi, lacebark
- No conspicuous fruit or berry.
- Small seeds dry and harden as they mature. Sometimes in a husk.
- Strip when capsules dry and brown.

8 **Receptacle-borne seeds**
e.g., rimu, tōtara
- Seed appears on end of coloured fruit receptacle.
- Seeds ripe after receptacle at most colourful stage.

9. **Coned seed**
e.g., kauri
- Small winged seed occurring in base of each cone scale.
- Mature when cone is brown and open.
- Fallen, unshattered cones are okay.

10. **Pip fruit**
e.g., kawakawa
- Small pip-like seeds scattered over the surface of the fruit.
- Mature when fruit is highly coloured
- Collect whole fruit

11. **Fine capsule-borne seed**
e.g., rātā, kānuka
- Small capsules that produce many fine, wind-borne seeds.
- Ripe when capsules brown off and begin to crack.
- Collect whole capsules.

When is seed is ripe for collection.

Ensure that you have permission to collect propagation material from the landowner, local authority or the Department of Conservation (if on Crown land). The Department of Conservation has a standard process for issuing permits for plant collection, and in some cases this costs money, so please check well in advance before you need to collect. If you are gifted seed, cuttings or plants, it is worthwhile checking that they have been obtained in an ethical way.

Make sure you collect the seed before they are dispersed by wind or birdlife. With wind-dispersed seeds (e.g., pohutukawa and daisies) it can be helpful to place a small bag over the seed head and shake. With tall trees, use a net or ground sheet around the base of the tree and shake or knock the tree to release the seed. Another option is to climb trees (safely) or trim small branches containing ripe fruit. Long-handled loppers may be useful for this.

Store the seed in a labeled paper bag with desiccant (material that helps absorption of moisture). Place the bags in a refrigerator (not freezer) or a dark dry place. Some seeds do not store well and should be sown immediately.

SEED PREPARATION METHODS

1. **Small seed, e.g., manuka, carex**
   - Often contained in a capsule that needs to be picked just before it opens, and dried in an opaque paper bag to catch the seed
   - Seeds that look like dandelions need to be collected when they look fluffy
   - Sow in a seed tray on fine damp sphagnum moss or seed raising mix, and cover the tray with clear plastic or a glass sheet

2. **Hard seeds, e.g., kākābeak, kowhai**
   - Dry and sow at any time of the year
   - Clip the end off the seed base or soak in hot water for 90 minutes
   - Sow as per Method 1

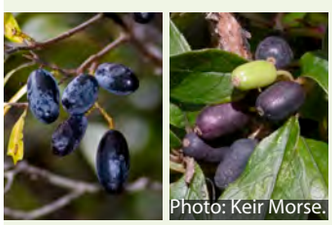


Photo: Keir Morse.

3. **Fleshy fruit, e.g., tawa, kotukutuku (tree fuchsia)**
   - Soak in cold water for 48 hours then wash off any flesh and skin in a container or in a sieve under running water
   - Sow as per Method 1

4. **Sticky seed, e.g., lemonwood, māhoe**
   - Soak and clean the seed as in Method 3
   - Mix a ratio of 1 part seed with 10 parts of fine potting mix that has been dampened until it is doughy
   - Seal in a plastic bag or other cool storage container
   - Label, squash down to about 3 cm thick with as much air squeezed out as possible, and store in a fridge or other cool storage for about six weeks
   - Sow as per Method 1

5. **Pigeonwood, kahikatea**
   - Clean as per Method 3
   - Prepare for cool storage (about 5–6°C) as per Method 4
   - Store for about 6 months
   - Sow as per Method 1

6. **Hinau, miro**
   - Clean as per Method 3
   - Prepare for cool storage as per Method 4
   - Store for more than 12 months
   - Sow as per Method 1

7. **Kauri (cone, seed shown), rewarewa**
   - Either sow immediately, or store dry
   - Sow as per Method 1
   - Best sown fresh but can be sown at any time of the year,

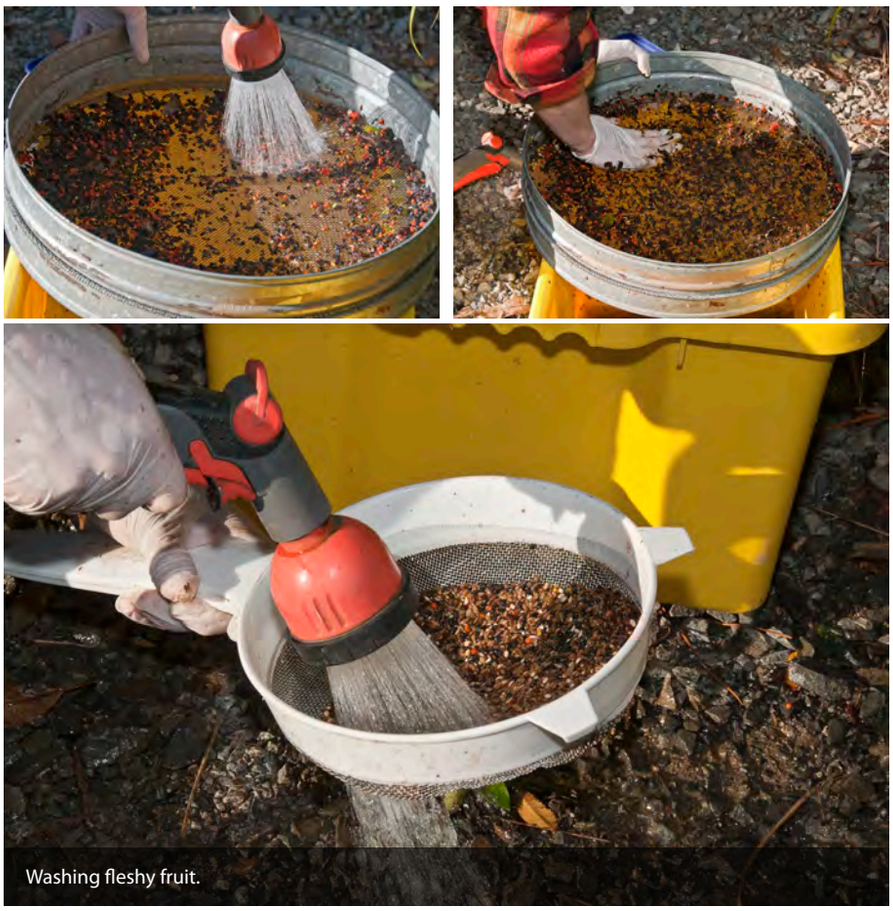
Seed preparation

CLEANING SEEDS

Cleaning seeds is done to reduce the risk of fungal attack. There are some principles to follow when cleaning seeds (adapted from Metcalf 1995):

- Do not leave fruit/seed in plastic bags—empty into open boxes, or if dry place in open jars, in a cool well ventilated place.
- Dehiscing fruits such as koromiko (*Veronica* sp.), manuka (*Leptospermum* spp.), kānuka (*Kunzea* spp.) and towai/kamahi (*Weinmannia* spp.) can be left in a cardboard box or paper bag in a warm place for a few days until the capsules split (dehisce). The fine seeds may be shaken out and require little or no cleaning.
- Rengarenga (*Arthropodium* spp.) seeds in black capsules can be removed once the capsules have split. Rubbing the capsule between the hands is sufficient to free the seed. Then in a shallow tray winnow the seeds by gently blowing across the seeds—this will blow away the lighter chaff type material. Alternatively use a series of sieves
- Mix the sticky (mucilaginous) *Pittosporum* spp. capsules with sand to free their seeds.
- Legume seeds, such as kowhai (*Sophora* spp.), broom (*Carmichaelia* spp.) and kākābeak (*Clianthus* spp.) are in pods, which may be placed in a tray and a wood float rubbed across them. Crush the pods sufficiently to allow the chaff to be sifted out.

- Fleshy fruited material—place in a bucket or similar vessel, mash or pulp them, then stir in enough warm water to make the pulp liquid. The container is then put in a warm place for 2–3 days, to allow partial fermentation to occur. Use a kitchen sieve to wash the remaining pulp from the seeds. The washed seeds may then be spread out to dry on absorbent paper and any remaining skins or other rubbish can be removed by hand



Washing fleshy fruit.

SEED DORMANCY

Dormancy is a period in an organism's life cycle when development is temporarily suspended to minimise the organism's metabolic activity and help it to conserve energy until conditions are right for it to become active again. Some plant species have little or no seed dormancy, and others have a limited dormancy that usually disappears after a short period of dry storage.

Dormancy factors are probably involved when native plant seed, placed in what appear to be ideal conditions, fail to germinate. This is nature's way of ensuring that germination does not occur at the wrong time of year, when survival is unlikely. Light sensitive seeds, such as grasses (and some daisies), may not germinate if covered.

You may also come across rudimentary or undeveloped embryos that require a period of 'after-ripening' to mature and become capable of germinating.

Dormancy factors can be put into two categories, physical (or mechanical) and physiological dormancy:

Physical (or mechanical) dormancy

This is often the case with plant species that have hard seed coats and woody seeds (stony endocarps).

For example, native legumes such as broom (*Carmichaelia* spp.), kowhai (*Sophora* spp.) and kakabeak (*Clianthus* spp.) have a hard seed coat. This prevents water absorption and needs to be softened or punctured to allow water uptake to occur. In nature, this would occur through weathering and or microbial action. Several methods have been devised to overcome this type of dormancy:

Hot water treatment

This involves placing seeds in a heat-resistant container, pouring boiling water over them, and covering to prevent the water from cooling quickly. The temperature of the water should be 77–99°C. For slightly softer seed coats, such as kākābeaks (*Clianthus puniceus* and *C. maximus*), the temperature should be 50–77°C. Leave the seeds to soak for 12–24 hours or longer if older seed. Drain the seed, combine with seed-raising mix and leave for a further 24 hours before sowing.

Warm-moist stratification

To soften woody endosperm type dormancy, clean fleshy coverings from seeds. Soak seeds for 24 hours. Drain off the water, mix the seeds with 3–4 times their own volume in moist medium (sand or sawdust), place in a plastic bag and seal it. Place in a warm 21–24°C place (e.g., hot-water cylinder cupboard) for 1–12 weeks, depending on the species. Check that the medium remains moist. The seed may be sown immediately after the storage period

Scarification

This method involves cracking, puncturing or reducing the thickness of the seed coat, and is more time-consuming and tedious than the hot water treatment. Scarification methods include:

- Abrading (wearing down) the seed coat with a triangular file or piece of sandpaper fixed to a piece of wood.
- Abrading the seed coat by shaking in a screw top jar lined with sandpaper.
- Chipping or nicking the seed coat with a small hand tool (although this is very hard and has to be done carefully to avoid cutting yourself).

Harvesting immature fruits

Some seeds are capable of germinating even though the enclosing fruit/seed coat is not quite mature. Sow these seeds immediately, before the seed coats have not had time to harden. This can be done with kowhai (*Sophora* spp.)

Physiological dormancy

This type of dormancy is principally due to internal mechanisms, such as biochemicals (hormones) either within the seed or seed coat or both. Depending on the species you can subject them to:

Warm-moist stratification

This method is outlined above.

Alternating warm-moist stratification with cold-moist stratification

Cold–moist stratification

- Prepare seeds as for warm-moist stratification.
- Clean fleshy coverings from seeds.
- Soak seeds 24 hours.
- Drain off the water and mix the seeds with 3–4 times their own volume in moist sand, peat or sawdust.
- Place in a polythene bag and seal it. Leave it at room temperature for 3–4 days to enable the seeds to absorb as much moisture as possible, otherwise the chilling period is less effective.
- Place the bag in a refrigerator set at about 3°C.
- Gently shake the bag once a week to keep the seeds well aerated and moisten the mix as required.
- Most species require only 4–12 weeks refrigeration, after which they are sown immediately

Outdoor chilling

The chilling requirements of some seeds may be met by placing the sown seed outdoors over winter in cooler and colder parts of the country.

- In autumn, sow the seed in a container and cover with a layer of coarse sand to help prevent the growth of liverworts and algae.
- Put the container in a cold shady place, such as the south side of a building or fence, for the winter.
- Protect emerging seedlings from slugs and snails. In spring the container can be moved to a cold frame or greenhouse to encourage germination.

Dry storage

For other species, a period of dry storage may be all that is required to overcome dormancy.

SEED STORAGE

There are some rules relating to the storage of seed. They include:

- Cleaned seeds not sown immediately must be stored in conditions that will retain their viability for the longest time. Check for pests and diseases before storing, treat if necessary (pesticide) e.g., derris dust.
- Some seeds do not store well so are best sown immediately examples include: kauri (*Agathis australis*), karaka (*Corynocarpus laevigatus*) and Marlborough rock daisy (*Pachystegia insignis*) .
- Ideal conditions for seed storage include:
  - Low storage temperature -1° to 5°C
  - Low moisture content (8–10%) in the seed—difficult to assess without specialised equipment, but air drying for a few days will usually suffice.
  - Low humidity
- Seeds that can be stored for a period in paper envelopes/bags without temperature or moisture control (open conditions inside) in autumn, then may be s own in spring include *Acaena*, *Arthropodium*, *Carmichaelia*, *Clianthus*, *Entelea*, *Geranium*, *Leptospermum*, *Myosotis*, *Phormium*, *Viola*.
- Dry storage may be required. This may be done using an air-tight container, such as screw top jars containing a desiccant (e.g., silica gel) or paper bags in a cool, dry environment with low humidity. If storing in paper bags, ensure that the seed is protected from mice and insects.
- Seeds that will not tolerate dry storage must be kept in cool-moist storage (stratification method)**:** Clean fleshy coverings from seeds. Soak seeds 24 hours. Drain off the water mix the seeds with 3–4 times their own volume in moist sand, peat or sawdust. Place in a polythene bag and seal it. Leave it at room temperature for 3–4 days to enable the seeds to absorb as much moisture as possible, otherwise the chilling period is less effective. Place the bag in a refrigerator set at about 3°C (range 0–10°C). Gently shake the bag once a week to keep the seeds well aerated and moisten the mix as required. Most species require only 4–12 weeks refrigeration, after which they are sown immediately.

GROWING MEDIA

There are various types of growing media for plants. The appropriate material to use differs for sowing seeds, for cuttings and for potting plants. This section provides details of the options available.

Potting mix

The growing medium used for growing plants in containers is potting mix. There is a range of potting mixes for different end uses. Commercial mixes commonly contain peat or shredded bark, tree fern fibres and slow release fertilisers. Pumice, sand, perlite or vermiculite may be added to achieve desirable properties, such as drainage.

The ideal growing medium holds in its larger pore spaces 20–30% air (% of total volume), in its smaller pore spaces 20–30% easily available water (water freely available to plant roots) and has a water buffering capacity of 4–10% (water available to plant only by expenditure of energy i.e., it is more tightly held to the media particles). Other properties of a good medium are:

- It must not expand or shrink excessively.
- It should be uniform.
- It should be free of weed seeds and harmful pests and diseases.
- The pH should be optimum for seedling growth or root initiation (5.5–6.5).
- It should be able to support cuttings firmly in place.
- It should provide suitable conditions for the germination of seeds and the growing of seedlings.

	**Bark**: Shredded to a fine or medium particle/granular size and composted.
	**Gravel**: Sometimes added to the bottom of pot to improve drainage**.** Also for scree technique—see below.
	**Perlite**: A lightweight volcanic glass material that is used like pumice in plant propagation. This is a porous silicous material artificially produced by rapidly heating natural volcanic glass to 1200°C. Sterile but supplies no nutrients.
	**Pumice**: Lightweight, free draining, well aerated, sterile volcanic material. Commonly used in plant propagation.
	**River sand:** Not beach sand. River sand is used in propagation mixes because it is angular and provides more air spaces than beach sand which tends to have rounded grains that fit more compactly together. Cuttings may be struck in pure sand.
	**Sphagnum moss, peat or coir fibre:** Added to growing medium to increase the moisture holding capacity of the medium. Sphagnum is sometimes used alone to grow seeds.

Other media that may be used include:

Acid/Basic: For example scoria, lime, and limestone chips.

Ponga fibre: From the tree fern trunk; used for orchids.

Soil-Loam: Soil containing a mixture of particle sizes: sand/silt and loam. Not much used nowadays as variable and may harbour disease. Mixed with organic material (compost) to make a growing medium.

Vermiculite: Flakey micaceous mineral from South Africa—crushed, graded and artificially heated. Supplies magnesium and potassium.

Seed-sowing mixes

Equal parts of peat, sand and sawdust or finely granulated bark make a suitable mix. Alternatively, equal parts peat, perlite and bark can be used or 2 parts peat and 1 part pumice.

To supply nutrients such as phosphate and calcium to the seed you can add super phosphate (116 g) and dolomite lime (58 g) per 100 litres of mix. A box 60 cm × 60 cm × 28 cm holds 100 litres and can be used for measuring ingredients.

Potting mix

As above but add 6 month slow–release fertiliser such as Osmocote or Nutricote (35 g) and Dolomite Lime (30 g).

Rooting (cutting) mixes

Good aeration and firmness required. Various combinations of sand, peat, sawdust or bark, perlite and pumice may be tried.

SOWING SEED IN CONTAINERS

When sowing seed in containers there are some recommended minimum requirements: clean containers, seed-sowing mix, seeds, fine dry river sand, small screed boards, 5–6 mm sieve, watering can, atomising spray, floats, labels, pencil or marker pen and a sheet of glass or polythene film.

The procedure for sowing seed in containers is as follows:

1. Use only clean containers. If the container is dirty, wash it clean and then soak for about 15 minutes in a solution of 1 part of household bleach to 20 parts of water.
2. Ensure mix is evenly moist but not too wet. Loosely fill the container with the mix and remove the surplus.
   - Lightly firm the mixture using a float to ensure the surface is level and about 5–10 mm below the rim of the container. Don't over-firm as this will reduce the aeration and drainage properties of the medium, and hinder seedling growth.
   - Alternatively use sphagnum moss as a medium.
   - Remove large lumps from the surface.
   - For fine seeds, sift a little mix over the surface.
3. Sow the seeds. Avoid sowing them too thickly—overcrowded seedlings become drawn and spindly and are more prone to disease. Sow from side to side across the container and sow as evenly as possible.

An old seed mix recipe

Different seeds require different soil mixtures but on average the most successful results are obtained with the addition of:

- **One-third sand (the finer the better)**
- **One-third bush mould or leaf mould (not taken from under coniferous trees)**
- **One-third old top soil (loam) well rotted**

or

- **2 parts fine soil**
- **1 part leaf mould (rotted leaf litter) or peat**
- **1 part river sand**

1 Heap good quality seed mix into a tray or pot. Firm gently then smooth off level with the rim.

2 Firm mix to within 5–10 mm of the rim using a presser board or the clean flat bottom of a another tray or pot.

3 Sow large seeds individually a regular distance apart. Scatter smaller seed evenly and thinly.

4 Firm the seeds gently into the mix with a presser board or the clean flat bottom of another tray or pot.

5 Cover the seeds with a layer of grit, vermiculite, or sieve a layer of mix about the thickness of the seed over them.

6 Smooth off the top of the grit so that it is level with the rim. If seed mix was used, gently firm it down with the presser.

7 Label with the name of the plant and the date. Water with a fine-rose watering can and place on a well-drained surface.

8 Apply fungicide to the seedlings at regular intervals to prevent them damping off. Do not over-soak the mix.

4. Very small seeds are best mixed with fine dry sand, about 3–4 times the quantity of seed. Medium seeds may be sown more thinly and gently firmed into the mix with a float. Large seeds can be either scattered or placed singly at regular distances. Generally they are simply pressed into the mix to a depth of about half their diameter, but they can be firmed into the surface with a float and covered to a depth equalling their own diameter. Alternatively individual seeds may be sown into containers such as cell trays, eliminating the necessity for pricking out and resulting in quicker growth of the seedlings.

5. Sieve a little mix over the seeds to cover them. Very fine seeds such as mānuka (*Leptospermum scoparium*) kānuka (*Kunzea* spp.) pohutukawa / rātā (*Metrosideros* spp.) germinate quite well uncovered, and grasses (which, as we said before, are light sensitive) such as *Chionochloa* and *Poa* are best left uncovered.

6. Otherwise the rule of thumb for sowing depth/covering seed is the cover should be 1–3 times the diameter of the seed. Small seeds should be sown to the depth of their own diameter, larger seeds sown at a greater depth. The growth of liverworts and algae can be troublesome so with species that take several months to germinate, cover them with grit or

coarse sand rather than seed sowing mix. Liverworts and mosses are sometimes an indication that the container is getting too much moisture.

7. Label the container (species, date sown, source) and water lightly with a fine-rose watering can (or an atomising spray for fine seeds). During bright weather, shade the container with a sheet of newspaper.

   – One option is to cover seed containers with clear glass to maintain humidity around fine seeds. Glass should be turned at least once a day to allow condensation forming on its undersurface to evaporate otherwise there is the risk of damping off or some other fungal disease.

   – A combination of paper and glass can also be used that keeps the seed container dark and warm. This has the advantage that without newspaper the container can get too hot very quickly.

SOWING SEEDS IN OUTDOOR BEDS

Sowing seeds in open ground (or nursery beds) involves preparing the ground beforehand to create a weed-free soil with a fine tilth. The best approach is to proceed as for a vegetable garden bed. The soil should be dug over or rotary-hoed and worked to a fine tilth, then rolled or trampled firm. Organic matter, sand or grit may be added to improve the soil structure and make it more friable. Cultivate the surface frequently to eliminate any weeds present and to encourage dormant weed seeds to germinate. This technique is rarely used for native species.

1. Just prior to sowing, cultivate the top 10 cm of soil to bring the surface to a fine tilth and rake it level.

2. Either broadcast the seeds or sow them in drills. Firm the seeds into the surface and cover to a depth of 2–3 times their own diameter. Take out drills of the correct depth with a hoe, back of a rake or a pointed stick, sow the seeds and fill in the drill. After sowing moisten the beds and place 50% shade cloth over the seedbeds to help retain moisture, increase humidity and exclude rodents, birds and cats.

3. Once the seedlings have germinated they can be pricked out into containers or lined out in the open ground. Often this is left until autumn.

AFTERCARE

- Ensure that the seed-raising mix or soil does not dry out during germination, but avoid over-watering. Check regularly—lifting the tray to gauge dryness by its weight is often done but this requires experience. A general watering (e.g. scheduled overhead watering of entire shade-house/nursery setup) could make the mix too wet, so an atomising spray can be used to avoid over-watering but check that the mix is not drying out deeper down.

- Maintain good ventilation to prevent disease.

- Maintain optimum temperature range—not too high that it inhibits germination or too low.
- Shade from direct sunlight—until germination has occurred or even after this for shade-loving species. Small quantities grown in plastic bag or small propagation case should be kept in a well-lit situation but not in direct sunlight.
- Disease—check for diseases, ensure good ventilation and hygiene, avoiding over-watering. Application of a preventative fungicide is sometimes used but should not be necessary if cared for correctly.
- Pests—check for slugs, snails etc.

Germination can be very erratic and some species, e.g., *Leptecophylla*, may take up to 3 years to germinate. Patience is a virtue.

CONTAINER SYSTEM

It is important to decide early which method to use for storing your plants. This can have a big impact on space utilisation in the nursery.

- When considering these issues you need to think ahead and imagine what will make it easier for you to get the right size and depth of container for the plants' needs for the planned growing period.

Suitable containers may include planter bags, pots, root trainers, trays or recycled containers such as milk cartons and ice cream containers.

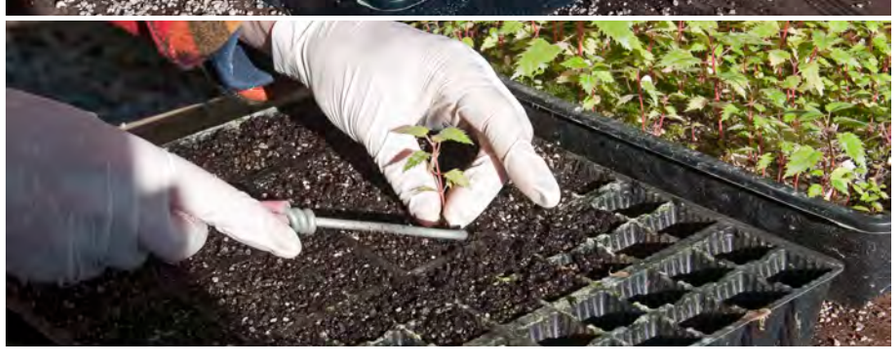
PRICKING OUT

Pricking out is the transplanting of small seedlings into pots or trays where there is more space for them to grow. This is generally done after the cotyledons (seed leaves) have emerged and, for some slow growing species, after 2–3 true leaves have been produced.

This is a delicate operation.

- Gently tease the seedling out of the seed raising mix—a knife or pencil will suffice for this (some people use plastic plant labels but these flick the seedlings if they catch on something). Hold the seedling by one of the cotyledons to avoid damaging the stem.
- Meanwhile, make a hole in the growing-on medium of sufficient depth and width to accommodate the root system of the seedling—a pencil or dibber can be used for this depending on the size of the seedling.
- Tranfer the seedling and hold it in place with the root system centered in the hole.
- Sprinkle a quantity of growing mix over the roots and press it down and around the root system until the seedling is gently firmed in place. Firming is done to ensure that the roots are in contact with the medium and to avoid air pockets in the media, which would result in the roots drying out.
- Water with fine droplets to prevent the seedling drying out.

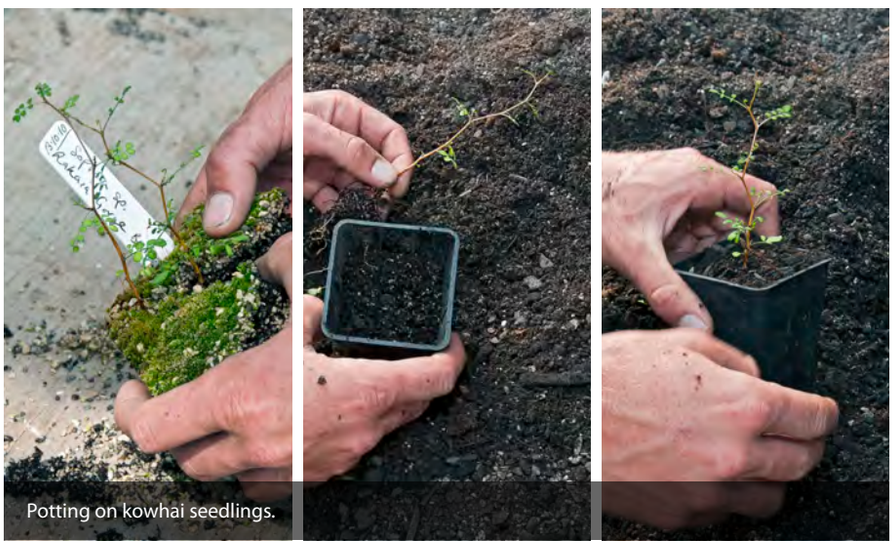
Pricking out may be done in stages as seedlings do not like being swamped by cold wet potting mix. After pricking out, the seedlings are placed in a greenhouse, cold frame or other protective structure for at least a few days to recover from transplanting shock. Growing in plant cells avoids this process. The resultant seedlings are merely potted on.



PLANTING AND POTTING ON/UP

Place any seedling or rooted cutting in a suitable–sized container at the right time. Transplanted seedlings may also be potted up for growing on. Steps to take:

- Get the right size and depth of container for the plants needs for the planned growing period.
- One-third fill the container with moist potting mix. Press/shake down the mix firmly.
- Place the plant carefully in the centre. Hold it suspended with the roots straight down. Fill potting mix around it gently.
- Leave a 25 mm 'lip' free of potting mix. Shake the mix to make it settle, then press to firm it.
- Water in well (do not over-water). Don't bury the stem too deeply as the stem may rot at the base.



Potting on kowhai seedlings.

RE-POTTING

Plants will usually exhaust their soil nutrients within 6–12 months and, if growth is rapid, will soon outgrow their container. Be careful not to put tiny plants in very large containers. Repotting of plants will be necessary when you spot these signs:

- Roots start emerging from the bottom drain holes.
- Growth slows down.
- Plants lose leaves or leaves begin to turn yellow.

5 Special sowing techniques

Parts of this chapter, including scree technique, bog technique and orchids are adapted from Metcalf (1991 & 1993).

Not all of our native plants can be sown in the conventional ways outlined above. Some plants require special techniques to be grown including;

- Some alpine genera: *Donatia*, *Gaultheria* and *Dracophyllum*
- Some bog plants
- Daisy-type plants
- Ferns and lycophytes which are sexually propagated from spores not seeds
- Orchids
- Parasites (e.g., mistletoes)

SCREE TECHNIQUE

Some plants germinate on clay banks, shingle screes and other well drained sunny sites free from competition. The scree technique imitates those conditions. Species such as *Celmisia*, *Myosotis*, *Gentianella*, and *Raoulia* are some of the genera that benefit from this technique. Also some of the tree daisies (e.g., *Olearia* and *Brachyglottis*) may be grown in this way.

The requirements for this technique are: seed, suitable containers, sowing mix, 10 mm stone chip or coarse grit, labels, pencil or marker pen, and watering can.

The technique involves having a layer of 10 mm stone chip or coarse grit over the surface of seed raising mix. The seed is scattered over the surface of the gritty surface layer. The fluffy seeds of the daisy family do not always fall easily between the stone chips so it is preferable to sow these seeds before applying the stone chips or grit.

Label the container and lightly water with a fine-rose watering can. Place in a well lit site, but out of direct sunlight.

BOG TECHNIQUE

No, this does not mean growing plants in the toilet! This technique mimics pakihi (low-fertility swampland) conditions and the conditions provided by moss cushions, the low hummocky plants that grow in many bogs. Usually these cushions are saturated and yet provide aeration essential for germination.

The requirements for this technique are: seed sowing mix, sphagnum moss, clean containers, small screed board, floats, sieve, labels, pencil or marker pen, watering can, atomising spray bottle, and a sheet of clear glass or polythene film.

Two methods may be used:

Method 1

1. Fill the seed container with seed-sowing mix and water it.
2. Rub some sphagnum moss through a sieve with a mesh size of about 1 cm and spread a layer 5–8 mm thick over the surface of the mix. Before sieving, moisten the sphagnum to prevent it breaking up to finely. If the moss is too fine, algae will soon grow on it and may inhibit germination. Sow the seeds on the moss and moisten with an atomising sprayer.
3. The container should be kept under close conditions in a propagation case or covered with a piece of glass or polythene if placed in a greenhouse. Only water with an atomising sprayer; the mix should not be allowed to dry out. Once the seedlings are well up they should be gradually hardened off before being pricked out.

Method 2

A shallow container less than 5 cm deep is used. A small punnet is ideal. If deeper only fill to 4 cm deep.

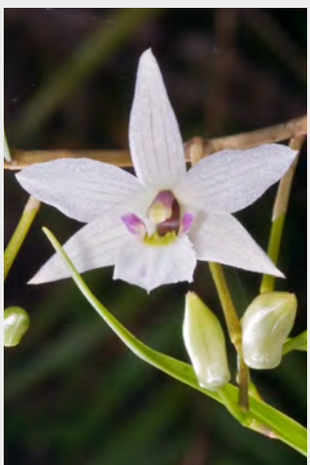
1. Fill the container with seed-sowing mix and sow the seeds. The seeds will not need to be covered. The mix should be very free draining.
2. Place the container in a tray or dish that is as deep as itself. Fill the tray or dish with water to half the depth of the seed sowing mix and maintain it at this level. This method does not require overhead watering.
3. Once the seedlings have produced their first true leaves, progressively reduce the water level over 3–4 days before removing the container from the water. Harden off the seedlings before pricking out.

Species that suit this technique include some fine-seeded species, and bog plants—*Dracophyllum*, *Epacris*, *Drosera*, *Leptospermum*, *Kunzea* and other moisture-loving species.

ORCHIDS

At last count there were about 120 described species of native orchids. Orchid seeds are very small, and are obligately reliant on mycorrhizae (root fungi) for successful establishment. They may be grown under sterile conditions in flasks containing a specially prepared medium of agar jelly and essential nutrients, similar to the tissue culture system.

To raise native terrestrial orchids from seeds in the home garden, it is first necessary to have plants growing in containers. Ripe seed is then scattered over the surface of the growing media around the base of the plant which is watered as usual. Small orchid seedlings may appear the following season. This technique ensures the seeds are inoculated with the necessary mycorrhizae from the parent plant.



Dendrobium cunninghamii.

Cultivation of epiphytic orchids (*Earina* spp., *Drymoanthus* spp., *Bulbophyllum* spp., *Dendrobium cunninghamii*) may be tried with the following method:

You will need: a new clay flower pot (12–15 cm diameter), sphagnum moss (moisten before rubbing through a 10–15 mm sieve), finely chopped tree fern fibre, peat and a piece of new toweling (25 × 25 cm or 30 × 30 cm, according to the size of the pot being used).

The procedure to follow is:

1. Sterilise the clay flower pot by boiling in water for 15 minutes.
2. At the same time prepare a mixture of equal part of sphagnum moss, fern fibre and peat and lightly moisten it.
3. Fill the pot to about ⅓ full with the mixture and firm it into place.
4. Take enough of the remaining mixture to almost fill the rest of the pot and put it on a piece of toweling. Gather the corners of the toweling tightly together so that the mixture is formed into a ball and tie with a piece of string.
5. Push the towel-encased ball firmly into the pot, ensuring that the tied corners are underneath. There should be a 2–3 cm space between the top of the toweling and the rim of the pot. Some sphagnum moss packed between the outside of the toweling ball and the wall of the pot will help to reduce evaporation.
6. Sterilise the whole by pouring boiling water over it and wait for it to cool.
7. Sprinkle the orchid seed over the surface of the toweling. Sprinkle a few tips of live orchid roots among the seeds to inoculate them with mycorrhizae.
8. Cover the pot with a sheet of glass and stand it in a deep saucer containing boiled water. Place it in a sheltered environment and keep shaded. Maintain the water at a depth of about 3 cm.
9. Germination should occur within a few weeks and is indicated by the presence of fine fungal threads around the seeds. The seedlings should be ready for pricking out after about 12 months or possibly up to 2 years.

FOREST DUFF

This involves collecting a quantity of forest duff (the top organic litter and humus layer in a forest soil) which contains the seed lying on the forest floor. It is possible to obtain 1,200 seedlings per square metre with 40 different species from good collecting sites. This technique is good for direct seeding into revegetation sites but it can be hard to transplant plants with this technique—using pots can be easier.

It is important to collect from species-rich areas and to avoid weedy sites.

The procedure is as follows:

- In autumn rake up an area of forest floor include the humus layer as well as the litter layer.
- Sieve the duff removing coarse material such as bark and twigs. Two layers of chicken netting are sufficient.
- Pack the sieved material loosely into polythene bags, moisten if needed, and loosely tie the bags and label them.
- Store in a cool, shaded place—temperature 2–4°C is ideal or place in a refrigerator. The process known as stratification, store for 8–15 weeks in this condition—the longer the better.
- Prepare a raised seedbed (10 cm deep) work to a fine tilth, incorporate slow-release fertiliser into the top 10 cm (e.g., Ozmocote). Lightly roll the seed bed and spread a 2 cm layer of prepared forest duff over the surface. Roll lightly again. Top dress with 3–4 mm of finely sieved soil and moisten.
- Keep partly shaded (you are mimicking the forest situation)—50% woven shade cloth is ideal. This can be stapled and battened to timber frames which are laid on the seed beds.
- Some form of rodent control (rats are seed predators) including use of bait stations may be needed. The shade cloth cover should keep the birds out.
- As the seedlings germinate, and in summer, raise the shade cloth frames so air can circulate. Not all seedlings will germinate in the first year so maintain for two years. Plants can be pulled when the true leaves appear.
- The following spring or autumn the seedlings can be carefully lifted and the roots trimmed to about 12 cm.
- Line out the seedlings in nursery beds for growing on. Space fast growing shrubby plants 15 cm apart in rows; tree species about 10 cm apart .
- Space rows 20 cm apart—to allow for wrenching and lateral root pruning.

Alternatively, in revegetation work the forest duff may be applied directly to the site if conditions suit. Duff beds can be overlaid with manuka brush or similar. Duff may also be spread under a nurse crop (e.g., manuka or poroporo cover). Another benefit of this method is the likelihood of introducing mycorrhizae with the duff.

FERNS FROM SPORES

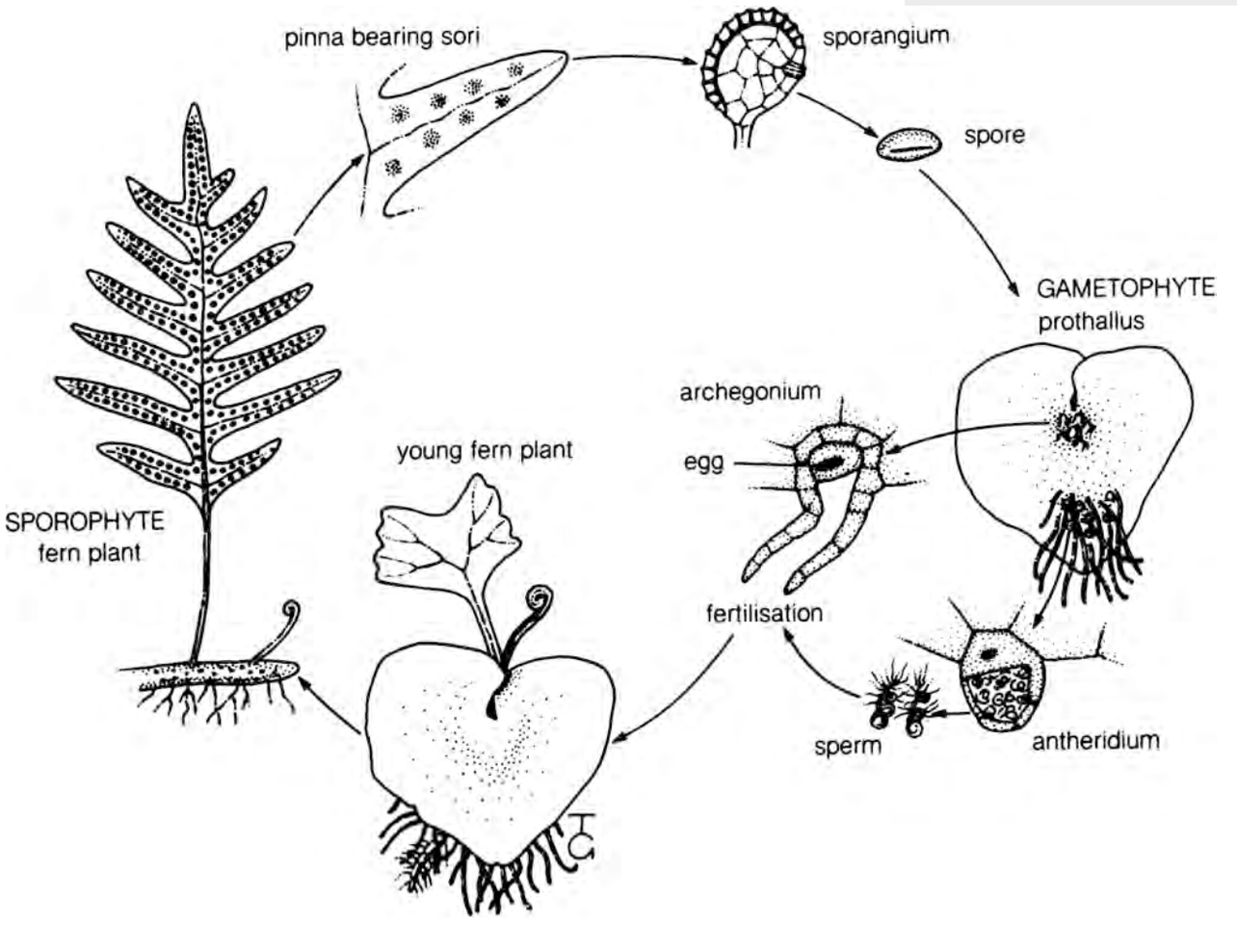
The usual method for collecting spores is to collect a frond with mature sporangium, put the frond in a paper bag or envelope, and place in a dry place for a few days. The spores will be be released into the bag, a good shake will be beneficial—the fine dust in the bottom of the bag are the spores. Note the life cycle of ferns differs from other vascular plants (see figure opposite).

There are some requirements for this technique: fern spores, small punnets or 10 cm diameter pots, seed-sowing mix, sieve, bucket, boiling water, labels, pencil or marker pen and clear polythene bags large enough to take individual containers.

The procedure is as follows:

1. Loosely fill the container with moist seed-raising mix, and use a float to lightly firm the mix so that the surface is about 15–20 mm below the rim of the container. The surface layer should be fine and without any lumps. If necessary, sift some fine material over the surface.
2. Place the container in the bucket and pour boiling water up to the rim of the container. Take care not to disturb the surface of the mix. Soak for about five minutes before removing and allow to drain and cool. This is to kill unwanted spores of liverworts, mosses and other ferns. Alternatively—place the container in an oven at 93°C for 30 minutes (not suitable for plastic containers).
3. Sow the spores and moisten with an atomising spray bottle. Spores may be sown from a broad knife blade. Pick up some spores on the tip of the blade and gently tap the blade to scatter the spores. Alternatively a piece of paper folded in half so that it becomes V-shaped, can be used.
4. Label and place the container in a polythene bag and seal with a twist tie. Place in a low-light situation, temperature 15–24°C. Bottom heat may be useful in cooler months.
5. A small wire frame is often useful to prop up the bag, otherwise it can fall onto the media.
6. Check and remoisten as needed.
7. Germination of spores is indicated by the appearance of a bright green, fine, moss-like growth (prothallus) on the surface of the mix. At this stage the temperature should be a little cooler at about 14–20°C. If too warm then development of the prothallus may be delayed. Depending on the species, the prothalli may be slow to increase in size and some can take up to a year to mature.
8. Once the prothallus has matured and fertilisation has occurred the true fern will then develop. Fast growing species can produce the first true fronds within about 8 months from sowing, others 12–18 months. At first they are pricked out into small clumps and are later separated when they are large enough. To avoid transplanting shock, place them in a polythene bag for about 10–14 days and keep shaded from direct sunlight. The bag can be opened for longer periods each day until the young plants are sufficiently hardened off.

(From top) *Asplenium hookerianum*, *Parapolystichum glabellum*, *Zealandia pustulata* subsp. *pustulata*.



Life cycle of spore-bearing plant. Illustration by Tim Galloway. (From *New Zealand Ferns and Allied Plants* by P.J. Brownsey & John Smith-Dodsworth.)

Trays of recently germinated fern spores.

A mass of fern prothalli with three young fronds visible.

SEED BALLS

The following text and photo is adapted from research undertaken by Robert Guyton as part of a Teacher Fellowship for the Royal Society of NZ. Used with permission.

The use of seed balls as a method of recreating native habitat in New Zealand is both innovative and exciting especially if you wish to accelerate the process of habitat creation.

Seed balls are used in other countries as an effective tool for re-vegetation of degraded landscapes, particularly in semi-arid areas. Trials there have shown that the process is simple and effective and can involve a whole range of people, from the very young to the elderly.

A seed ball on the ground, just prior to sprouting.

Making a seed ball

The process is similar to making chocolate truffles! You will need seeds, compost, clay and water.

Seeds

Collect seeds from as close as possible to the proposed restoration site. Clean and store each type of seed according to its needs. Seed preparation is described in detail in Chapter 4.

Once you have a good supply of seed, you can mix them together in combinations such as you would find naturally.

Compost

Compost collected from beneath the sorts of trees you plan to grow serves two purposes. The sprouting seeds will use nutrients from the compost to grow, once they have exhausted their own reserves. At the same time, mycorrhizae that occur as spores or fragments in the compost, will 'partner

up' with the growing seed and begin their beneficial association with the plant. These fungi appear to be essential to the successful establishment of native plants. The compost needs to be sieved to remove stalks and leaves, then dried in a shaded place.

Clay

The most suitable clay to use is red terracotta clay, collected from a site free of weed seed. Often, digging deep will ensure that no unwanted seeds become part of the mix. The clay needs to be dried and ground finely to ensure a lump-free mixture. Two bricks can serve as an effective grinder. Other clays, the blues and whites, are not suitable for this process, as they contain minerals which interfere with the growth of the seedlings.

Mixing

Take one part seeds, add three parts compost and mix until the seeds are coated. Put in five parts of powdered clay and mix the whole lot together. Add a little water, until the mixture is like dough. Be careful not to use too much water. Pinch off a small amount of the mix, compress it between your fingers then roll it between the palms of your hands. The seed ball should be the size of a small marble and should feel 'sound'. As you roll more and more seed balls, set them out to dry in a shaded place. They will be dry in a few days and can be dispersed from that time on.

Scattering seed balls

Seed balls don't need to be hand planted. They are simply scattered about the site you wish to re-vegetate. They can be thrown, rolled, fired from a slingshot or dropped from a helicopter! The ease of application means children love to do this work and elderly people find it very rewarding to be able to take part in a project that doesn't require backbreaking digging!

The most suitable sites for 'seed balling' are those free from thick grasses, such as exposed soil beneath exotic trees, broom and gorse and in pine forests. This may also be amongst native nurse plants, such as manuka, on beach foreshores and amongst harakeke/flax (*Phormium tenax*).

There is no need to water the seed balls. They will absorb moisture from the ground, the dew and the rain and will sprout when conditions are right. Many seeds will grow from a single seed ball and the plant most suited to the micro-conditions of that site will prevail. Note that seed balls are the size of marbles, they are easy to make, light to transport and simple to apply.

Seed balls ensure a very high strike rate, protect seeds from birds and insects and can be spread in very difficult areas. They provide an opportunity for an enjoyable community activity and they don't cost anything!

6 Propagation from cuttings

Cuttings are clones so they do not provide the genetic diversity that seeds do unless they are taken from a wide range of specimens. Because many New Zealand plants are dioecious, there is also a risk that only one sex is propagated from cuttings if the the sex of the source plants is not known. Nevertheless, cuttings are excellent when seeds or seedlings are unavailable.

TAKING CUTTINGS

There are a number of requirements when taking cuttings:

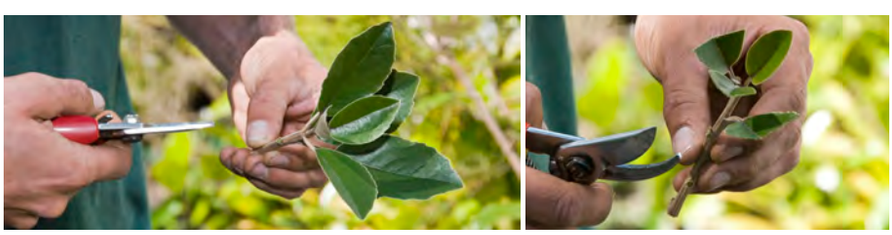
- Cutting material should be young, healthy (pest and disease free) from stock plants that are well nourished, well lit, and vigorous with good growth form. Take cuttings of healthy stock from harsh sites for planting into harsh sites.
- Be non-flowering/fruiting—if not possible, remove flower /fruit.
- Short side and lateral shoots are best except with long hardwood cuttings.
- Conifers (e.g., kawaka—*Libocedrus plumosa* and kauri—*Agathis australis*) are best grown by selecting vertical branches with 'apical dominance' to produce a plant with a vertical leader shoot. Otherwise you will have a droopy plant.
- The cutting must be capable of producing adventitious roots, or in the case of a root cutting, form new stems.
- Cuttings are best taken in morning or evening, but can be taken at any time of the day if the material is handled and treated correctly.
- Cutting material must be kept cool and turgid from the time of collection until the cuttings have been inserted in the rooting mix.

The optimum time to propagate your species depends partly on your method.

- Long hardwood cuttings, e.g., tree daisies (*Brachyglottis*, *Olearia*) and *Veronica* species: —outdoors, early winter
- Short hardwood cuttings—indoors, February to March.

Leaf reduction

Leaf reduction is done to reduce transpiration loss and to prevent wilting. It also means cuttings can be spaced closer together which is more economical. It is done by removing some leaves entirely and between ⅓ and ½ of others.



Removal of terminal growth buds and flower buds.

Remove flower buds to divert the energies and resources of the plant into root production (primarily) and shoot production (secondarily). Removal of soft growing tips helps to inhibit vegetative growth in favour of root growth. This may suit the Epacrids such as *Acrothamnus*, *Epacris* and *Dracophyllum*.

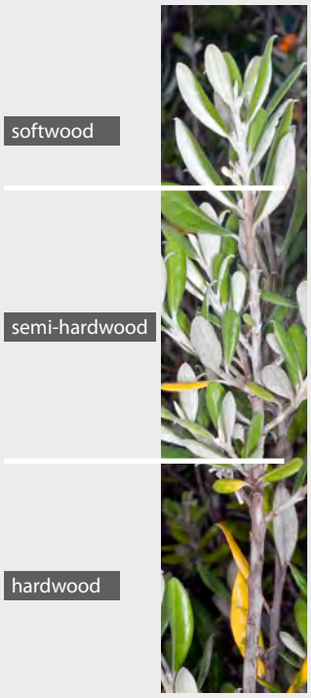
CARE OF CUTTING MATERIAL

For taking care of cuttings there are a few simple requirements which include a pair of secateurs, some polythene bags, labels, a pen or pencil and water. Optional items include newspaper, methylated spirits (or similar) for cleaning secateurs between plants (hygiene) and a cooler bin.

- Ideally, process the cuttings as soon as possible, but otherwise temporarily store in a cooler bin or a refrigerator for a few days (no more than a week).
- Moisten inside of polythene bags (short term), or wrap in moist newspaper (longer term)
- Label and bag separately each batch of cutting material

CUTTINGS SUMMARY

1 **Choose softwod, semi-hardwood or hardwood**
- Semi-hardwood is most commonly used. Take 7–15 cm (varies between species depending on internode length).
- Short side shoots are preferable.
- Best between February and May.



2 

Cut just below a node is best
- Remove any flowers or flower buds, most leaf and side shoots.
- Keep cool and moist.

3 

Can treat with growth hormones to force rooting
- Indolebutyric acid (IBA) or naphthaleneacetic acid (NAA).
- Wound base of cutting

4 

Plant into potting mix quickly
- Reduce size of large leaves.
- Keep cool at 12–15° C.
- Maintain a humid atmosphere.
- Watch for damping off, mildew or other fungi.

STEM CUTTINGS

These are the commonest forms of cutting for NZ native plant material. They are usually divided into softwood, semi-hardwood, or hardwood cuttings—depending on the maturity of the wood.

Softwood cuttings (including herbaceous or greenwood cuttings):

These are made from soft succulent shoots and are usually taken in spring and early summer, from the tips of the current season's growth (are therefore termed tip cuttings), usually the side shoots rather than the leader shoots. Late spring/early summer is the best time to take these cuttings.

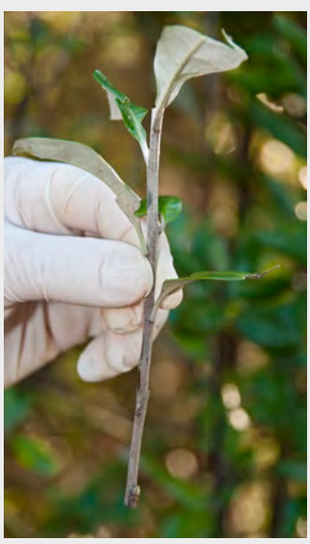
Softwood shoots are more delicate so require more care and attention, but have the advantage of rooting more readily. Lengths of 7.5–10 cm long usually suffice. Collect material that is turgid and not too soft and sappy. A good test is to bend the shoot at right angles; if it snaps, the material is suitable (in most cases).

Cut the cuttings with sharp secateurs or cut extra long and use a scalpel later.

It is most important that you keep the cutting material cool and moist to prevent wilting. The cuttings should be prepared and inserted into the propagation medium as soon as possible. Softwood rooting hormone powders may be used. A knife, scissors or secateurs are good for preparing the cutting. Bottom heat is an advantage, and also some form of misting. Spray with water during hot dry weather conditions.

Some experimentation may be involved when deciding on when cuttings should be taken. For some species the suitable period for taking cuttings may be as short as 2–3 weeks. The rooting period may be as short as 2–4 weeks for many species.

Semi-hardwood (semi-ripe) cuttings



Semi-hardwood cuttings are made from stems or sections of stems that are intermediate between the softwood and woody stages. Cuttings are taken from partially matured or ripened wood, after a flush of growth. They may be divided into:

- **Soft semi-hardwood**: the shoots are still growing, but their lower portions have taken on a degree of firmness and they are becoming woody.
- **Firm semi-hardwood**: much of the shoot is becoming woody.

Size ranges average 7.5–15 cm (up to 20 cm for *Leptospermum*) and as little as 25 mm for some *Veronica* species. Treat as for softwood. Require use of a glasshouse or cold frame to maintain high humidity. Remove side shoots and lower leaves, large leaves may be reduced in size. Cuttings can be taken anytime for most species but generally from February to April/May.

Hardwood cuttings

Hardwood cuttings are taken from more mature wood that has become quite hard, generally in late autumn or winter when growth has matured and when plants are more or less dormant. There are two kinds of hardwood cutting:

- **Indoors**: cuttings are usually 12.5–18 cm long
- **Outdoors**: are lined out and rooted in open ground and cuttings are 20–25 cm long. Cultivate the cutting bed and lightly trample. Dig a trench 10–15 cm deep, and place approximately 2 cm of clean river sand in the bottom, then plant the cuttings to about ⅔ of their length. Firm the soil around them. Weed and water during spring and summer.

Treat short hardwood cuttings the same as semi-hardwood cuttings. Long hardwood cuttings should be selected from vigorous growths. Remove lower leaves and side shoots, leaving about ⅓ to ¼ of the foliage. Remove soft sappy growth. Trim the base of the cutting below a node (3–7 mm below) with a knife or a pair of secateurs.

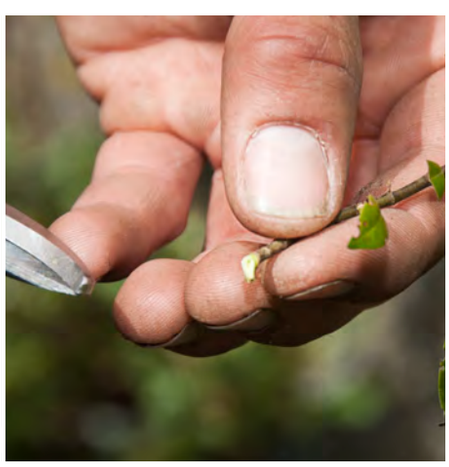
With forest cabbage tree *Cordyline banksii* and dwarf cabbage tree *C. pumilio* a piece of stem can be cut into sections 3–4 cm long. The sections can be laid horizontally and half buried or set vertically in the potting mix. Bottom heat is needed to encourage rooting.

Nodal and internodal cuttings

A node is a joint on the stem where a leaf is attached or a bud arises. Nodal cuttings have the basal end trimmed just below a node. Internode is the section of stem between nodes. With internodal cuttings, the basal end is trimmed between nodes. Internodal cuttings are mostly used for plants that root very easily so that it makes little difference where the cutting is taken. You can get more cutting material by the internodal method.

Heel cutting

A heel cutting is usually torn from the main stem so it retains a 'heel' of the main stem attached to its base. The heel is trimmed. Native conifers and cuttings grown in cold frames may benefit from this method.



ROOT CUTTINGS

A few native species may be propagated in this way. Pieces of root are cut into short lengths and inserted into a cutting mix. The sundew *Drosera binata*, true flax (*Linum monogynum*) and kohekohe (*Dysoxylum spectabile*) may be grown this way.

The prepared cuttings may be laid horizontally on the surface of the rooting mix and covered with mix, or inserted vertically making sure the polarity of the root is the same. Trim the top end of the root nearest the stem system squarely and the basal end diagonally to distinguish the two ends.

'Toes' of *Cordyline* species may be treated as a root cutting and inserted vertically into the potting mix.

LEAF CUTTINGS

Roots and a new shoot form adventitiously at the base of the petiole and develop into a new plant. The original leaf eventually withers away. Leaf cuttings are most commonly used for plants with thick fleshy leaves, such as parataniwha (*Elatostema rugosum*).

WOUNDING

Some plants benefit from wounding of the basal (bottom) end of the cutting. This may involve:

- A slice wound where a shallow 1–3 cm-long slice is removed. Double slicing involves removing a second slice from the opposite side (use a sharp scalpel or vegetable peeler).
- 2–4 evenly spaced vertical cuts 2–3 cm long (or less) penetrating the bark and into the wood.
- Incision wounding where the base of the stem is split to about 1 cm (using secateur or knife). Often a grain of wheat is inserted in the gap; when it germinates it produces auxin which enhances root initiation.

An alternative treatment is "heat shock treatment" which involves exposing the cuttings base to a temperature between 35°C and 45°C for 30 minutes or so. The rest of the cutting can be insulated by using a Styrofoam plate. Another method involves exposure to salinity (salt).

There are several advantages of wounding. The principal one being that it increases the rate of root production by:

- Increasing water uptake.
- Facilitating movement of new roots.
- Inducing formation of root initials, which develop into embryo roots.
- Causing accumulation of carbohydrates and hormones in the wound area.

ROOTING HORMONES (GROWTH REGULATORS)

Rooting hormones are synthetic growth regulators used to hasten root initiation on cuttings and to increase the strike rate. They increase the quality, number and uniformity of roots, and are useful for difficult to root species but may not always be necessary. The main ones are indolebutyric acid (IBA) and naphthalenacetic acid (NAA). They come in powder, liquid and gel.

The concentration varies from 0.1 to 0.8%. The lowest concentration is used for softwood cuttings and the highest for hardwood cuttings.

- **Powder**: Dip moistened end of cutting in powder. Never dip the cuttings into the original container, as moisture and bits of cutting will get in, causing the hormone powder to deteriorate. So place powder into another container. Throw away surplus.
- **Gel**: As for powder but don't need to moisten basal end of the cutting
- **Liquid**: Diluted hormone powder
  - Soaking method: cuttings are stood in 2.5 cm of solution for 24 hours
  - Quick-dip method: basal end of cutting is dipped in a stronger solution for 3–5 seconds.

Store rooting hormones in a refrigerator or cool dark place and ensure the lid is secured.

AFTERCARE OF CUTTING MATERIAL

- Grading cuttings into batches of uniform size to help prevent smaller cuttings being overshadowed by larger ones. This also helps to ensure they all receive the same amount of light and it also helps to prevent disease.
- Very soft cuttings must be dibbled into place to stop them being bruised. Most other cuttings may be gently pushed into place.
- When outdoors, prepare the cutting bed as for seed bed. Locate the bed in a place that is sheltered and shaded at mid-day. Long hardwood cuttings are set out in June. Water when necessary, mulch and keep weed free.
- In cold districts pre-callusing may be performed by allowing the cuttings to form callus in boxes of damp sawdust before lining out during late August or early September.
- Leaf cuttings are left in the cutting bed until the following late autumn or early winter when they are lifted. Those large enough can be planted in their permanent positions. The rest may be lined out for growing on.
- Rooting medium must be able to hold the cuttings firmly in place, be well aerated and provide sufficient moisture.
- The cuttings should be well watered when they are all first planted to remove airpockets and firm the medium around them. They subsequently need sufficient water, humidity, and adequate light without being exposed to excessive or direct sunlight.

WILLOW WATER

Willow water is an alternative to rooting hormone. The following is adapted from an October 1984 'Growing Today' article by Roland Clark titled '**Wonderful willow water**':

- First cut current year willow shoots into short pieces, say 2.5 cm long, after removing leaves.
- Place the short shoots in a glass at the right side up position
- Pour about 1.5 cm of water into a glass and cover glass with a plastic bag for about 24 hours
- The extract may be kept overnight in a refrigerator without much change in activity.

Application

Steep the bases of the cuttings for about 24 hours overnight so that the extract is absorbed by cuttings.

Difficult to root cuttings require a more concentrated extract which may be obtained by steeping as many willow cuttings as possible in a glass, or the cuttings may be given a longer period to absorb the extract—they may be moved to another glass of willow extract again for no more than 24 hours.

Please note: This is not intended to encourage you to grow willows but may be worth a try if they are available. Its effect may be improved with use of rooting hormones. The active ingredient (s) is not known.

ROOT PRODUCTION

The process of root production is as follows: roots are initiated in meristematic tissue (actively dividing cells) between vascular tissues in the plant stems. Root primordials are formed which develop into young roots. The rootlets then rupture surrounding tissue and link with vascular systems. During rooting, callus tissue develops on any cut surface. Contrary to common belief this callus formation is incidental to root formation and the adventitious roots simply push their way through it.

Rooting temperatures

The temperature of the rooting medium greatly influences the rooting of cuttings. Bottom heat of between 18 and 23°C with cooler air temperature is ideal for many species. Many species will root in an ambient temperature average of 12–15°C. Some species will root within 7–10 days (e.g., kākābeak and some Veronica's - formerly hebes).

The air temperature should be cool to moderately warm (spring and summer daytime air temperature of 21–27°C and winter of 12–15°C is alright) as high air temperatures can be injurious to cuttings. Warmer air temperatures will stimulate vegetative growth at the expense of root development and increases water loss from the leaves. Misting will help cool the plants and air temperature. So the motto is: roots warm, leaves cool.

Shield from direct sunlight during the early stages (pre–rooting), some form of shading may be necessary during hot weather. Once cuttings have rooted they may be hardened off to stronger light conditions.

The temperature of the rooting mix should be several degrees warmer than the air to encourage root development.

Misting/fogging and watering

Misting may be high tech automatic or as simple as applying an atomising spray during very warm weather. Keep the rooting medium moist without over-watering. Bottom heat will dry the medium out so check to see if watering is needed.

A misting unit provides a fine spray of water above cuttings to prevent them wilting. Units in large greenhouses may operate in conjunction with soil-warming cables controlled by a root thermostat, and may have a cut-off switch that is responsive to light, moisture or time.

Fertiliser/nutrients.

Supplementing the nutritional requirements of plants may be required. A range of slow release fertilisers are available (such as Osmocote and Nutricote), and they are often already incorporated into the potting mix. Some plants prefer soils to be acid or alkaline or low in nutrients. Foliar and liquid feeding are also options and some plants will benefit from mycorrhizal fungi being present.

Health and hygiene

It is important to regularly monitor the condition of your plants. Check for diseases, pest damage, weeds and nutrient deficiency. If necessary treat pests with insecticide and fungal infections with fungicide. Remove any diseased or dead material such as dead leaves or dead or infected cuttings. Remove growing medium from around infected material and replace with new medium. Remove weeds and keep the propagation facilities clean. Plants may require additional fertiliser-organic or inorganic as to your preference. Prevention is better than cure, and maintaining the correct conditions can mitigate any need for using chemicals.

7 Other propagation methods

DIVISION

Division of existing plants is also a useful propagation method, but only for herbaceous plants that form clumps such as flax (*Phormium* spp.), NZ iris (*Libertia* spp.), bush flax (*Astelia* spp.), rengarenga (*Arthropodium* spp.) and Maori onion (*Bulbinella* spp.), grasses and sedges. Division can also be used for plants that produce rhizomes or have prostrate stems that root as they spread, and mat-forming plants such as *Raoulia* spp., *Acaena* spp. and *Scleranthus* spp. The best time for dividing plants is in the spring or autumn.

Using forks to divide a clump of rengarenga.

One division method is to push two forks back to back into the clump. Then pull the handles apart gradually. Otherwise a sharp spade or knife may be used. Repeat as often as possible. Sections for planting should have three stalks or buds and good root structure.

Trimmed side leaves of flax.

Trim the leaves and long roots by about half. When dividing flax a young central leaf or 2 may be left untrimmed. Plant, pot up or heel in and water immediately.

OTHER PLANT PROPAGATION METHODS

- **Layering**: simple or mound layering—some veronicas and coprosmas, bush lawyer and *Ipomoea*
- **Air layering:** could be tried with various tree and shrub species
- **Tissue culture**: high tech—valuable for mass produced plants
- **Bulbils/plantlets:** *Asplenium bulbiferum*

Bulbils on *Asplenium bulbiferum*.

- **Auricles:** swollen stipe base of king fern—*Ptisana salicina*

Stipe bases of *Ptisana salicina*.

- **Budding and grafting**: used for cultivars—like a cutting except that the cutting called the scion, is placed on and bound to a rooted seedling/sapling or rooted cutting of the same species (usually)—which is called the rootstock or simply stock plant.

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Glossary

Antheridium: The male reproductive organ of a moss or liverwort.

Archegonium: The female reproductive organ of a moss or liverwort.

Dehiscing: Opening at definite places, discharging seeds, pollen, or other contents, as the ripe capsules or pods of some plants

Dibble: Use a pointed tool to make holes into which seeds or seedlings are planted.

Eco-sourcing: Collecting propagation material from local sources that are ecologically similar to the situation into which the material will be planted.

Ex-situ: Literally means "off-site conservation" and involves protecting threatened plant species by growing them away from their wild habitat.

Gametophyte: The gamete (sex cell) producing generation of the plant life cycle; in ferns, known as the prothallus.

Internode: The section of stem between nodes.

Node: A joint on the stem where a leaf is attached or a bud arises.

Mucilaginous: Moist and sticky.

Mycorrhizae: A symbiotic association between a fungus and a plant root.

Obligate: Restricted to particular conditions or circumstances.

Pinna: In ferns, a primary division of a frond.

Propagule: Any plant material used for the purpose of plant propagation.

Prothallus: A small, flat, delicate structure produced by a germinating spore and bearing sex organs. It is the gametophyte of ferns and some other plants.

Sori: A cluster of sporangia on the margin or underside of a fern frond.

Sporangium: In ferns, the sac or other structure containing spores.

Sporophyte: The spore-producing stage of a plant life cycle.

Stratification (stratifying): The process of pretreating seeds to simulate natural winter conditions that a seed must endure before germination. Many seed species undergo an embryonic dormancy phase, and generally will not sprout until this dormancy is broken.

Tilth: Refers to the structure of a soil. A good tilth means it has a good structure and nutrients to grow healthy crops.

Transpiration: Similar to evaporation it involves the loss of water from parts of plants, especially leaves, stems, flowers and roots.

Turgid: Swollen, inflated (rather than limp or wilted when referring to cuttings).

Wrenching: Cutting a plants roots without lifting it from its position.