



Establishing Native Forests

TĀNE'S TREE TRUST FACTSHEET SERIES

Selecting the right nursery-raised native seedlings for planting

FACTSHEET 18, 2024 – by David Bergin & Mike Bergin

Refer to the [other factsheets in this series](#) for more about successfully establishing native forests.

Online version of this document with clickable links: <https://docs.tanestrees.org.nz/1590/>



Bare-rooted stock in an open-ground nursery bed (left) and containerised planting stock (right).

Introduction

The use of strong, healthy planting stock is critical to the success of any planting programme. And good planning is vital – seed must be collected from the best sources and nursery stock raised for planting programmes well ahead of the planting season. Part of planning is to be aware of the wide variety of plant grades and container types that are available for nursery-raised native seedlings, as described below. Also essential is to be informed as to what grade and size plants best suits the site to be planted along with the commitment, objectives and resources of those undertaking planting at whatever operational scale. The information presented here is based on a mixture of operational field experience and comparative experimental trials.

Factors that should be considered before planting include relative suitability of bare-rooted and container-grown stock, appropriate plant size and quality, and the type and size of containers.

Seed collection, germination and growing-on lines

Many native forest restoration programmes involve planting thousands of seedlings where the vast majority of plants are raised from seed. The essential requirements for propagating native plants including seed collecting, handling and storage for the more commonly planted native shrubs and trees used in restoration programmes is provided in [Factsheet 15](#). This also gives a summary of the seeding and germination characteristics of the commonly planted natives to assist those involved in collecting and preparing seed for nursery propagation.

Nursery propagation is a highly skilled and risky venture and requires significant resources, expertise and commitment to producing native plants of high quality, irrespective of scale. Therefore, the various methods used by nurseries for propagating natives is not covered in this factsheet series.



Small totara seedlings recently transferred from seed germination trays to cell trays that are the first step in raising seedlings in containers. Rather than investing in propagation facilities and expertise, some nurseries buy in these young seedlings from specialised nurseries, as growing-on lines, and subsequently focus on raising these seedlings to the target planting height.

Many nurseries collect their own seed or have contractors collect seed so have invested in propagation units for sowing and germinating seed, as well as transferring small, newly germinated seedlings from seed trays or similar to small cells or plugs (often know as pricking out) as the first stage in raising seedlings in containers. However, some nurseries specialise in providing growing-on lines of natives to supply to other nurseries that focus on the later stages of growing already germinated seedlings of all (or a selection of) their native species to the size required for planting out.

What are open-ground or bare-root seedlings?

- Although nearly all nurseries raise native trees and shrubs in containers, techniques for the production of bare-rooted (or open-ground) plants have been developed for most native species (Jaap van Dorsser, former manager, Forest Research Institute Nursery, Rotorua, pers. comm.).
- The technology of open-ground propagation of tree seedlings was developed for radiata pine and currently, millions of seedlings are raised each year for the exotic production forestry industry.
- For native species, seedlings germinated in seed trays or raised as small propagation cells are transferred directly in tractor-prepared nursery beds in rows at 12 to 15 cm plant spacing.
- Depending on the species and growth rates, in 1 to 2 years seedlings are up to 50 cm high and are prepared for planting out by mechanical undercutting and wrenching at frequent intervals for at least 3 months prior to lifting.
- For open-ground production, a well-developed seedling should have a dense, fibrous root system close to the base of the stem.



Native tree species are often propagated in polythene planter bags, such as these PB2 containers.

Container-grown planting stock

The most common method for raising native plants in New Zealand has been via the use of containers, including planter bags, impervious pots, peat pots, root trainers, and more recently, paper or biodegradable pots. Choice of containers will depend on the species grown and the age and size of plants required.

Types of containers

Light-weight containers filled with moist, nutrient-rich potting mix provide the ideal rooting environment for developing seedlings. Choice of containers for plants will depend on the scale of the project, species grown, and the age and size of plants required. Native trees raised for large-scale revegetation programmes are grown in containers of five broad types:

Planter bags are made of flexible black polythene. The different grades commonly used for large scale revegetation are PB ¾, PB2, or PB3, which correspond to the increasing size of the bag. Bag diameter ranges from approximately 10 to 15 cm and bag height is around 14 cm. The cost of seedlings raised in planter bags varies depending on the grade of the bag and the size of the order. Much larger grades of planter bags are used for supplying a full range of larger plants catering for the landscape and garden centre market.

Solid plastic pots are 10 – 15 cm in diameter and 12 cm high, e.g. RX-90. The average cost of seedlings raised in solid pots is similar to planter bags. Seedlings left for too long can end up with distorted root systems. The containers need to be collected from the planting site and can be reused for raising plants in subsequent years.



Solid plastic pots such as an RX-90 grade have been commonly used by nurseries as the final container for native shrubs and trees.



Rootrainers come in two main sizes – Tinus and the smaller Hillson grades. While the plastic containers can be re-used for propagation, they are rather flimsy and care is required to extract seedlings especially when root systems are occasionally intertwined between compartments. Increasing cost of rootrainers and difficulties of transport and retrieving plastic and wire baskets are increasingly deterring their wide-scale use.

Tinus rootrainers are approximately 20 cm high, each unit having four 5 x 5 cm square compartments in a hinged plastic unit or “booklet”. The sides of each compartment are ribbed to encourage downward growth of roots. Rootrainers fit into a wire basket that keeps them upright and elevated off the ground, and so any roots that become exposed through a gap in the base are ‘air-pruned’. They are easy to transport to the planting site using the baskets. The booklets open for easy removal of seedlings although the bases of root systems can become intertwined between compartments and will need to be pulled apart.

Hillson rootrainers are a smaller version of the Tinus. At 15 cm high with compartments 4 x 4 cm square, they are most suited for growing small seedlings. While plastic booklets can be reused, they can be torn during extraction of seedlings, ideally require cleaning before reuse, and like all plastic containers need to be retrieved from the planting site.



Root-pruning in small plug trays with open slots. These small plugs, often referred to as forestry grade seedlings, are increasingly used for large scale planting of manuka and kanuka (left), other shrub hardwoods like karamu and tarata, and more recently for selected native trees such as kahikatea (right).

Plugs, sometimes referred to as forestry grade seedlings, are increasingly used for large-scale propagation of pioneer species, such as manuka. They are produced in a variety of tray sizes ranging from 40-60 plugs per tray. They are often tapering for easy removal with side slots and base holes to allow air pruning of roots. While the focus has been on raising shrub hardwoods at scale using plugs, recent work by Balanced Forestry has included raising totara and kahikatea in these small forestry grade plugs.



Left: Small paper-based biodegradable plugs used to raise native tree and shrub species, sometimes referred to as 'forestry grade' seedlings. An advantage of biodegradable plugs is not having to retrieve plastic containers from the planting site. Right: Native seedlings raised in biodegradable cardboard pots (similar to coffee cups) tested by Riverside Nurseries in Rangiora. The intention is to plant the seedling without removing the pot; slits in the pot assist in root extension into the soil after planting.

Revegetation trays are a semi-rigid tray of cells with various numbers of cells per tray and various cell sizes. For instance, T-28s are commonly used for raising robust seedlings where each cell is 150 mm high and 75 mm square at the top tapering to the base. Each cell is ribbed to reduce root spiralling. They are increasingly used for raising large numbers of native shrub and tree species for revegetation programmes. Some nurseries have automated machinery to carry out various tasks filling trays with potting mix to pricking out of seedlings into each cell. Seedlings can be removed from the cells and packed into planter boxes for transport to the planting site and laying out for planters avoiding the need to retrieve plastic from the planting site. Trays can be reused multiple times.

Biodegradable containers are increasingly being tested in nurseries and planters in the field. They come in a variety of forms from coffee cup shaped pots with vertical slits to paper-based cells with open bases to limit spiralling of roots and allow for air pruning. The smaller plugs are sometimes referred to as 'forestry grade' seedlings where 50 or more can be packed into planter boxes for large scale planting operations. The key requirement is for the containers to retain their integrity while seedlings are raised in the nursery for 1-2 years depending on the species and height requirements. The aim is to plant without removal of the paper or cardboard, which will break down to allow root extension into surrounding soil. Cost of seedlings raised in biodegradable plots is similar to similar size plastic containers but have the advantage of not having to retrieve plastic or adding waste to the environment.



Revegetation trays of semi-rigid plastic are becoming increasingly popular for raising seedlings of various sizes and numbers of cells per tray.

Pros and cons of container grades and sizes

- Larger bags or pots allow for greater development of plant shoots and roots. Top growth can be varied by spacing out the plant containers in the nursery. However, with plants raised in roottrainers, and in trays of cells or plugs, plant growth is confined to the space available within the area of each growing compartment.
- Use of roottrainers or small containers for raising trees and shrubs, particularly broadleaved species such as karamu and five-finger, can result in tall 'leggy' plants with little foliage on the lower stems.
- Results from an establishment trial indicate that 1-year-old plants of broadleaved shrub hardwood species raised in PB3 bags survived and grew better during the first year on an open grassed site than plants raised in Tinus Roottrainers (C. Stace, Environment Bay of Plenty, unpubl. data).
- Plants from bag-grown (PB) stock had bushier tops and a larger stem diameter than the roottrainer stock. The small degree of rabbit damage in this trial was mostly confined to smaller roottrainer stock where leaders with small diameter were browsed to near ground level, often resulting in mortality. On the larger, bushier PB stock, only side branches were browsed.
- A significant advantage of smaller 'forestry grade' nursery-raised native seedlings is less bulk and cost in transporting to the planting site. Planters can use similar methods used for establishing radiata pine by packing large numbers into planter boxes or bags, as well as use standard forestry grade heavy duty spades for large scale planting programmes, similar to methods used by planters of radiata pine.



Planters can carry 50 or more native seedlings raised in plugs or in small containers in forestry planter boxes or bags, as well as use standard forestry grade heavy duty spades for large scale planting programmes, similar to methods used by planters of radiata pine.

Comparing container vs open-ground

There are advantages and disadvantages of container and open-ground seedlings for native tree and shrub species.

Container-grown plants

- Container-grown plants can be held in reserve for use over an extended period and this flexibility is a major factor in the preference for raising native species in containers.
- They can be relocated easily in the nursery and plants can be transferred to larger pots if held over, although this requires more time, resources, and space in the nursery.
- Container-grown plants with intact roots surrounded by potting mix may have greater potential for survival and rapid early growth, especially on nutrient-poor sites, but this has not been confirmed in comparative field trials.
- A major concern with container-grown seedlings is the difficulty of readily determining the quality of root systems (Jaap van Dorsser, retired nursery manager, Forest Research Institute, pers. comm.).
- There is growing concern about the environmental impact of extensive use of plastic pots and bags, which are often not reused. Increased use of paper and other types of biodegradable pots would counteract this. Research and development is underway with nurseries and research providers.

Open-ground, bare-root plants

- There are more options for managing plant growth in bare-root nursery systems, including lateral root pruning, undercutting, and wrenching operations in nursery beds (Jaap van Dorsser, pers. comm.).
- Once lifted, bare-rooted stock must be kept cool and planted within a few days.
- Seedlings are lifted by hand and carefully stored and transported to sites for planting within a day or two of leaving the nursery.
- Species such as rewarewa and kauri develop thick woody roots at an early stage and consistent production of a compact ball of fibrous roots can be difficult to achieve.
- Bare-rooted stock is easy to transport whereas plants in containers, being heavier and bulkier, require more planning for transport and care during on-site handling.
- Raising open-ground native plants is only feasible on a large-scale and requires specialised equipment and nursery expertise to produce high-quality seedlings with adequate root development for successful establishment in planting programmes.
- A significant advantage with bare-root seedlings compared to container-raised seedlings is the opportunity to easily check root systems as stock is lifted from beds. Seedlings with poorly developed or distorted roots can be rejected if defects cannot be rectified.



Left: Open-grown production of native shrub hardwoods and monocots commonly used in planting programmes. Similar to the bare-root seedling propagation methods of radiata pine, open-grown production is only viable at large scale as it requires highly skilled management and use of specialised tractor machinery. Right: Some native species readily develop fibrous root systems and can be successfully raised as bare-root seedlings, but other species require additional care to achieve a compact ball of fibrous roots for planting.

Size of seedlings

- The choice of seedling size is dependent on the species being planted, the characteristics of the site including degree of exposure, the weed species and the animal pests present, the density and pattern of planting, and the resources and commitment to after-planting care.
- Large, well-conditioned plants at least 50 cm tall are likely to give the best results in large-scale programmes designed to produce low- to medium-density stands of trees.

- Smaller plants (approximately 30 cm high) will require more intensive weed control and site maintenance.
- Where rapid regrowth of fern and shrub hardwoods can be expected, tall seedlings (up to 80 cm) are less likely to be overtopped and suppressed between maintenance operations.
- On open sites, vigorous grass species such as kikuyu (*Pennisetum clandestinum*) can smother small plants within a short space of time.
- Larger plants have greater potential for recovery from browsing damage caused by rabbits, hares, possums, goats, deer, and grazing stock.
- Smaller stock may be feasible for establishing large numbers of some of the faster-growing shrub hardwood species as a nurse crop, but taller, older seedlings may be more desirable for establishing the slower-growing native conifer species.
- Although larger plants are more expensive, their higher survival rate is likely to mean that smaller numbers are required.
- Comprehensive trials are required to determine relative performance and cost of large and small stock on a range of sites.

Topping – does it work?

What is it?

- Topping is a method to reduce the height of nursery-raised seedlings by cutting back upper foliage of seedling crowns preferably some time before planting. It will temporarily curb plant growth and may allow bulking up of lower foliage if pot size allows sufficient growing space.
- It is often used to hold over plants if there are planting delays and it enables easier handling of stock during the final stages of nursery production including storage and transport to the planting site.
- Topping also increases the proportion of root mass to the above-ground foliage mass and may assist in reducing transplanting stress with less transpiration loss from foliage after planting.
- Topping of planting stock is carried out by skilled nursery personnel preferably well in advanced of delivery to the planting site.

Bushy crown species

- Topping is less of a problem for naturally bushy shrub and tree species often used as nurse covers to provide early shelter and create a rapid canopy, such as manuka and kanuka, and it can stimulate bulking out of the foliage.
- Species often used for hedging such as broadleaf or corokia can be topped in the nursery if required.
- Topping of manuka and kanuka grown in bulk is often done by motorised hedge trimmers.

Tree species with single leaders

- Topping however, may create problems for tree species with strong apical dominance, as it can result in multiple leaders and poor form in the developing tree long after planting. For example, topping of kauri, kahikatea and tanekaha is not recommended.
- Some judicious reduction in height of tree seedlings can be carried out by cutting the tallest leader close at a fork using a secateurs for such species such as totara that often have straggly crowns and multiple upper branches.

Caution with topping

- In addition to confining the method to bushy foliage shrubs and trees, topping is best used where there are only short delays in planting, e.g., delay from autumn to spring planting.
- All planting stock can become root bound even if it is topped (Jaap van Dorsser, pers. comm.), so long delays in planting or holding stock over to the following planting season should be avoided as roots are likely to become severely bound.
- If stock is held over for planting the following year, plants must be repotted into larger containers for dispatch as larger grade seedlings.



Topping is often used to reduce the height of selected native species to give a more balanced shoot to root ratio especially when seedlings are raised in confined small containers that produce leggy plants. It is best used for shrub hardwoods like manuka (left) with bushy crowns rather than tree species with a single leader (right). Topping alone is not sufficient to hold stock to the following planting season as root systems will also become root bound, so seedlings will still require potting-on to larger containers.

Alternatives to raising natives from seed

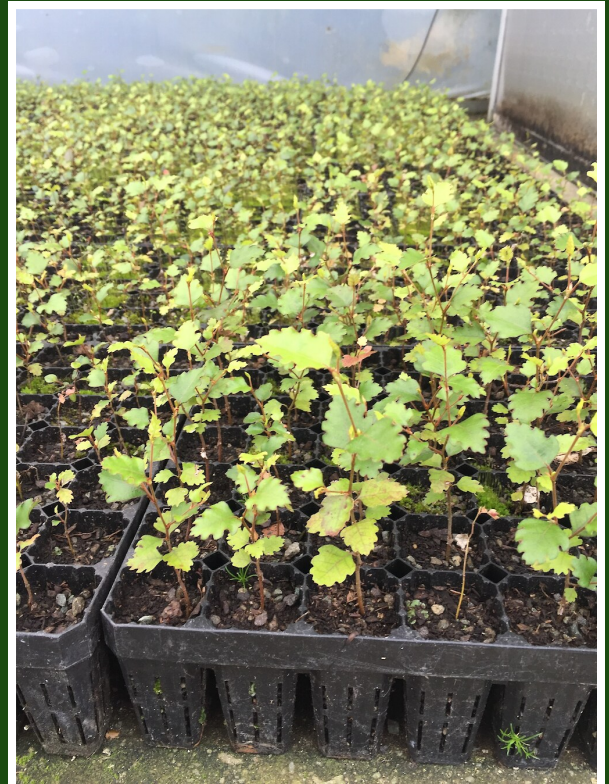
Propagation via seed should always be the preferred option. In an era of climate change and increasing risks of biotic agents such as myrtle rust, it is particularly important to maximise genetic diversity. This increases resilience in forest species, i.e., if there is a greater pool of genotypes, then there is a greater chance that at least some genotypes will be adapted to future environmental and biotic stressors than if there are only a narrow range of genotypes to start with.

Cuttings

- Use of cuttings carries the risks of lower genetic diversity and inbreeding depression in the planted population when practiced on a large scale and source material is restricted to a limited number of individuals.
- For species where collection of seed is difficult, as with infrequent seeding species or those producing small quantities of seed, rooted cuttings can be used to bulk up stock, but this must be done judiciously.
- If necessary, cuttings should be collected from a minimum of 10 parent plants preferably from naturally established plants to ensure a wide genetic base.
- And care must be taken to avoid establishing plants of the same clone at the same location.

Wildings

- Lifting small, naturally regenerated seedlings (often referred to as wildings) from within native forest where it is appropriate, is another option to bulk up nursery supply of those species where it can be difficult to collect adequate seed or where germination is slow and erratic.
- Propagating natives from wildings is labour intensive and costly as mortality can be high. Collecting small seedlings 10 cm high or less is likely to provide improved survival rates.



These red beech seedlings being raised in plug trays were transplanted as small wildings. They were carefully lifted from the forest floor of an Otago beech stand on private property, with permission from the landowner - to make up for the difficulty of collecting seed.



While there are large native plant nurseries supplying millions of natives to restoration and planting programmes nationwide, there are many small to medium-size nurseries also providing good quality stock of various grades and container types.

Seedling quality

- Plant tops are easily checked for vigour, height, spread, colour, and absence of fungus and insect damage.
- The development and health of root systems should be assessed for both container-grown and bare-root stock.

- Root distortion can occur at the base of the stem when seedlings are transferred to the propagation cells. This can be difficult to identify later and can lead to root strangulation or tree toppling (Jaap van Dorsser, pers. comm.).
- With container-grown stock, ideally, plants will have been transferred to a larger bag or pot as soon as the roots have spread into the available potting mix in the first container. Any root distortion found during repotting must be rectified to avoid subsequent root strangulation and toppling.
- Before planting, a random selection of seedlings, whether they are container-grown or bare-root, should be inspected carefully. If plants are root bound, taproots are distorted, or fibrous feeding roots are poorly developed, then the whole batch should be rejected.
- Bare-root systems should be trimmed to a compact root ball.
- Cool, moist storage is essential between lifting and planting for bare-rooted plants. Where possible, place seedlings in a cool store for short-term storage.
- At planting, root systems of container-grown seedlings should be sufficiently developed to bind all the potting mix into a cohesive mass that does not disintegrate when removed from the pot and placed into the planting hole. If the root systems have not had sufficient time to develop after repotting into larger containers, the potting mix will fall away and root exposure may increase transplanting stress.
- Root-bound plants should ideally be rejected. If they have to be used, the root ball should be loosened, any fibrous roots teased out or cut to encourage growth into the surrounding soil after planting. Seedlings with grossly distorted or underdeveloped root systems should be discarded.

Check size, quality and grade of your planting stock

Cost of nursery-raised native plant seedlings are a significant investment, often ranging from \$3 to over \$6, even for bulk purchases, so it pays to check that the size, quality and grade of seedlings meet your expectations and are suited to your site and resources. This checking should be done at the nursery irrespective of whether the seedlings were pre-ordered or if buying without forward planning.

The root systems of container-grown stock can be easily checked by selecting a sample and removing the container to inspect the root system. Look for any evidence of root systems being root bound, which is usually a result of not being repotted early enough into a larger pot. Also check whether the roots adequately occupy the container sufficiently to hold the potting mix in place when the container is removed.

Reject seedlings if sampling indicates seedlings are root bound, distorted, poorly formed or clearly have a low root to shoot ratio. Similarly reject leggy plants that have been left to grow too tall in the nursery often associated with cramped growing conditions. Tall floppy seedlings will not likely stand upright after planting or can be easily blown flat by wind and subsequently swamped with any competing weed growth.



Producing tall seedlings in small containers can result in leggy plants with little or no foliage on lower stems. Tall spindly seedlings planted on exposed or weed-prone sites are vulnerable to falling over or succumbing to dense regrowth of grass and weeds where seedlings are easily swamped and difficult to find during releasing operations.



While native tree species can be raised in smaller containers, care is required to ensure roots do not become distorted while confined to limited space (left). Use of containers with vertical grooves encourages downward growth of roots and openings at the base of containers encourage air pruning of roots (right).

Where size matters!

Planting nursery-raised seedlings as small grades with low height or limited bulk of foliage has been successful for selected species and planting programmes. While small seedlings raised in plugs or small containers are likely to be cheap, they will require considerably more work to keep them alive after planting.

Planting trials by Tane's Tree Trust for a range of native shrub hardwood species, comparing plant size at planting, consistently confirm the vulnerability of planting small stock. Essential requirements when planting small stock include:

- Intensive site preparation including weed and pest animal control.
- Following planting, ongoing and timely weed and pest animal control.
- Small seedlings with a single small stem are easily lost in rank grass and rabbits or hares will easily reduce the seedling to a stub.

There are examples of successful use of the smaller 'forestry grade' seedlings raised in plugs or cells in large-scale planting programmes using selected native species, where attention to good site preparation followed by timely and intensive post-planting weed and pest animal control has been carried out. For difficult sites and where operations and resources do not factor in adequate post-planting care for small seedlings, landholders and planters should consider using larger seedling grades.

Warning – small seedlings require extra care!

While all natives require best-practice planting methods, if you are not prepared to provide extra care by keeping on top of early growth of rank grass, regrowth of aggressive weeds and control of pest animals, then do not expect to get good performance from planting cheap, small native seedlings – the majority will fail!



While smaller nursery-raised native seedlings will be cheaper than larger grades, small seedlings will require likely greater expense and effort on intensive site preparation including pre- and post-weed and pest animal control. Trials and operational plantings with small, planted natives consistently show that lack of best-practice and timely management results in higher failure rates.

Native forest factsheets series

These factsheets on establishing native forest have been compiled by Tāne's Tree Trust with funding from Te Uru Rākau's One Billion Tree Partnership Fund with support from The Tindall Foundation and Trees That Count. Others providing information and undertaking peer review include Scion, Auckland University of Technology, Northland Totara Working Group, iwi, landowners and selected local authorities and government departments.

Information and recommendations are provided by Tāne's Tree Trust in good faith based on interpretation of information collated and reviewed which must be assessed by users on a case-by-case basis and/or specific technical advice for their sites. Accordingly, Tāne's Tree Trust is not liable on any ground for any loss, claim, liability or expense arising from or due to any errors, omissions or advice provided within these factsheets.

Cite this factsheet as: Bergin D, Bergin M. 2024. Selecting the right nursery-raised native seedlings for planting. Establishing Native Forests factsheet series, Factsheet No. 18. Tāne's Tree Trust. 13 pp. <https://docs.tanestrees.org.nz/1590>