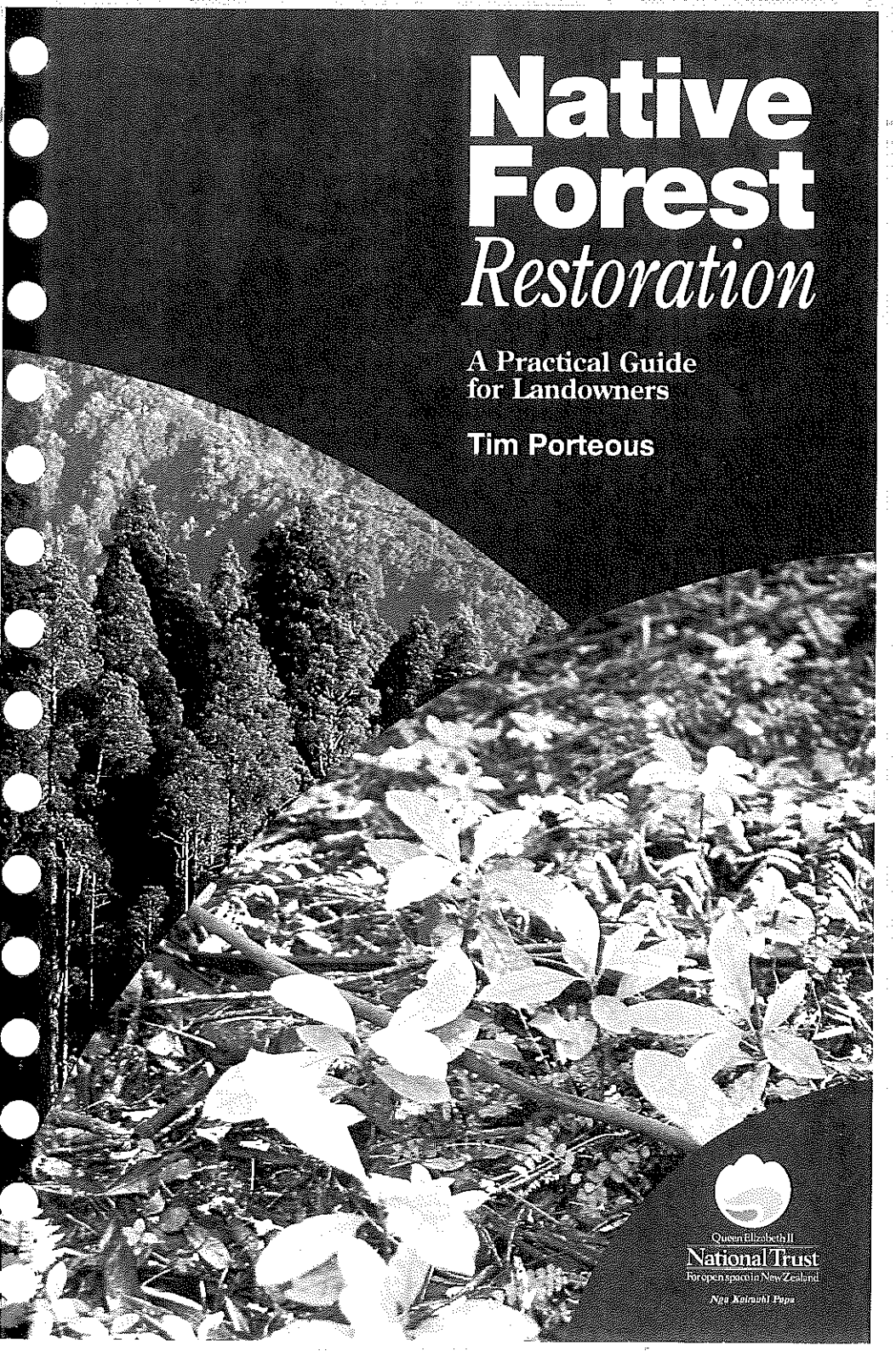
Native Forest *Restoration*

A Practical Guide for Landowners

Tim Porteous



Queen Elizabeth II
National Trust
For open spaces in New Zealand
Ngā Kaitiaki Papa

Disclaimer:

This publication is no longer in print. As it was published in 1993 some of the information provided in it may be out-of-date. Section 4.8 has been removed for review. In its place we recommend you refer to the Weedbusters website www.weedbusters.co.nz for information on invasive weeds and their control.

"From the extraordinary manner in which European productions have recently spread over New Zealand, and have seized on places which must have been previously occupied, we may believe, if all the animals and plants of Great Britain were set free in New Zealand, that in the course of time a multitude of British forms would become thoroughly naturalised there and would exterminate many of the natives."

Darwin, The Origin of Species, 1859.

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Foreword

This valuable forest remnant near Cambridge is protected in perpetuity by open space covenant. (Queen Elizabeth II National Trust)

The Queen Elizabeth the Second National Trust works with private landholders, particularly farmers, and with local authorities throughout New Zealand. The Trust's open space covenant scheme is a means by which landholders can obtain legal protection, in perpetuity, for areas of open space of particular value, such as forest remnants, wetlands, lakes and streams and rural landscapes.

The majority of National Trust covenants protect forest remnants, the scattered remains of the once vast tracts of forest which almost entirely covered New Zealand prior to the arrival of human settlers. It is precisely because our remaining forests are scattered throughout our working landscapes that some degree of management is often required to ensure their survival and restore them to a healthy and vigorous state.

This handbook draws together the principles, methods and techniques of forest restoration and re-establishment and gives practical advice on tackling common problems.

Use of this handbook will contribute to the restoration and better management of our valuable forest remnants throughout New Zealand.

Sir Peter Elworthy
Chairperson
Queen Elizabeth II National Trust
Wellington, July 1993

Preface

In 1983, the Queen Elizabeth the Second National Trust published the *Revegetation Manual* in response to increasing public awareness of the importance of enhancing the landscape by re-establishing native plant communities.

With the need to reprint the *Revegetation Manual*, the National Trust has taken the opportunity to expand upon the earlier publication to satisfy the increasing demand for information on managing and restoring **existing** native plant communities, particularly native forest remnants.

Working to improve native bush is enjoyable, rewarding and important. The majority of New Zealanders live, work and recreate in the lowlands in or around the major towns and cities. The scattered patches of bush we take for granted, but which contribute significantly to the character of this landscape, miraculously escaped the axe and fire earlier this century when vast tracts of forest were cleared for agriculture. Today, these relics face new threats from weeds, animal pests, exposure to wind, altered water tables, subdivision and neglect. In many cases their survival into the next century will be dependent on the speed at which we move to protect and manage these remnants.

Native Forest Restoration: A Pratical Guide for Landowners is intended to both stimulate interest in these topics and provide practical "how to" advice for individuals and organisations managing, restoring or recreating native bush in both urban and rural situations. Material used in Chapters 5.0-10.0 has been revised from the National Trust's *Revegetation Manual.*

I am indebted to the following people for their valuable comments on drafts of the manuscript:

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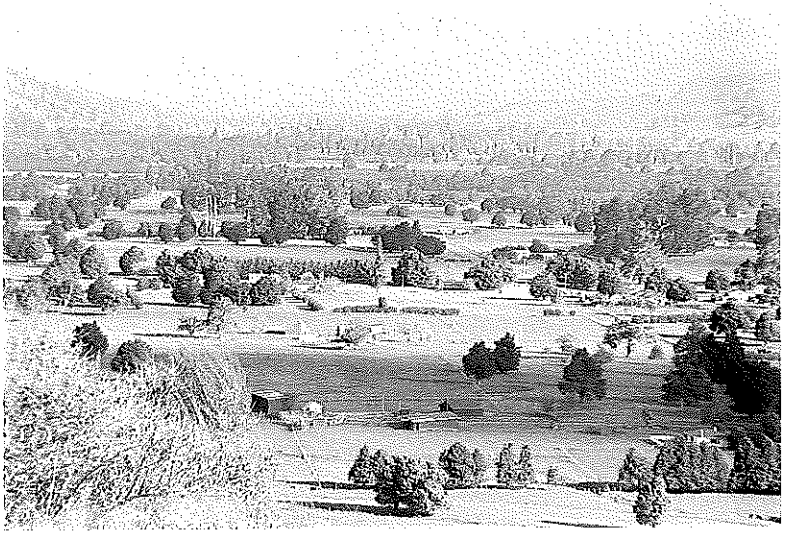
I would also like to acknowledge the assistance of the following individuals or organisations in providing illustrations:

Yates (NZ) Ltd



Native forest remnants in the Takaka valley. (Queen Elizabeth II National Trust)

Auckland Regional Council Parks Service
New Zealand Plant Protection Society Inc
New Zealand Forest Research Institute
Rowan Buxton, Landcare Research NZ Ltd
Peter Williams, Landcare Research NZ Ltd
Rod Smart, North Shore City Council
Department of Conservation
Ewen Cameron, Auckland Institute and Museum
Peter Johnson, Landcare Research NZ Ltd
Robin Gay, Department of Conservation
Martin Conway

The illustrations in Chapter 4.0 are adapted from *Bush Regenerator's Handbook* published by the National Trust of Australia. Those in Chapter 8.0 are adapted from the *New Zealand Native Plants* course material published by The Open Polytechnic of New Zealand.

My thanks also to Marilyn Wilson and Leah Perkins for typing numerous draft manuscripts.

Tim Porteous
Manager
Queen Elizabeth the Second National Trust
Wellington
July 1993

Introduction 1.0

The Value of Forest Remnants 1.1

New Zealand's forests are unique. Eighty million years of evolution in isolation from other continents produced a collection of plants and animals essentially in a state of balance, although constantly changing, adapted to our unique and very diverse conditions. Eighty per cent of our plants occur nowhere else in the world, clearly placing responsibility for their survival in our hands.

About 2000 years ago, 78 per cent of New Zealand was covered in forest. By the time the first European settlers arrived in the 1840s, 50 per cent of the land still carried a mantle of forest. However, from the 1850s until the early part of the 20th century New Zealand underwent considerable landscape change as forests were cleared on a massive scale to create our present agricultural landscape. Today, approximately 21 per cent of the land is in native forest, with much of this on steeper areas unsuited for agriculture.

Lowland forest was particularly hard hit by clearance as it covered the easiest and most favoured land for agriculture. This forest type is poorly represented in our reserve network and those remnants that remain occur as isolated islands surrounded by other land uses.

These islands, however, present us with the opportunity to protect examples of New Zealand's original plant communities in relatively unmodified states. In many parts of the world this opportunity was lost many hundreds of years ago.

In summary, forest remnants have many values that make their protection in perpetuity a high priority. These include:

- **Refuges for Native Plants and Animals**

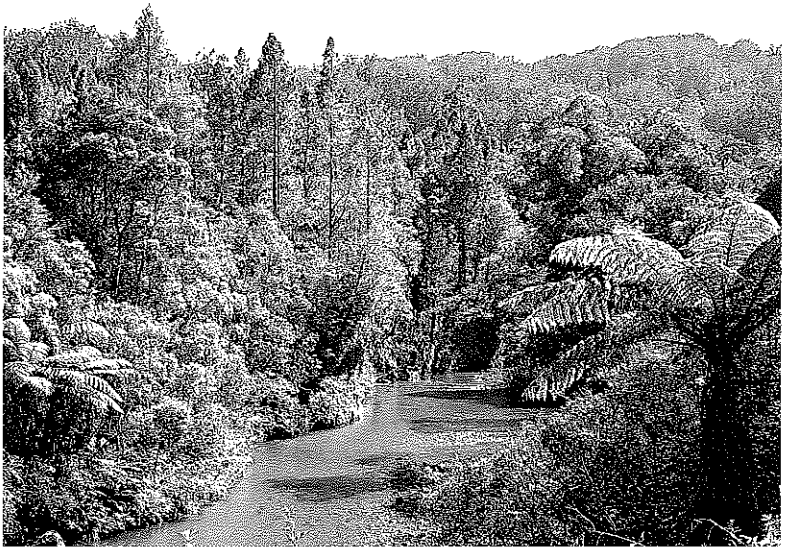
  Lowland forest remnants support the greatest diversity of plants and animals of all New Zealand forest ecosystems.

  By protecting these remnants, not only are the range of plants protected but also the biological life that they support. Forest remnants also provide refuges for representative plants and animals including those which are classified 'rare or endangered'.

- **'Snapshots of the Past'**

  Remaining forests provide living impressions of what much of New Zealand looked like prior to the arrival of humans. They are living

Opposite: A fine example of lowland forest to the west of Rotorua.
(New Zealand Forest Research Institute)



Lowland forest in Northland. (New Zealand Forest Research Institute)

museums of our natural history. They also provide a template for revegetation and restoration activities.

- **A Context for Understanding Our Plants and Animals**

  Forest remnants provide a context for viewing, studying and understanding our plants and animals and their inter-relationships (ecology). They are outdoor classrooms and laboratories.

- **Representative Soil Types**

  Forest remnants are important for conserving soil types in as close to their original state as possible by maintaining forest soil organisms and un-compacted soil.

- **Wildlife Corridors**

  Forest remnants not only support native animals, especially birds, but also can provide essential corridors linking one area of forest with another, allowing birds to move between areas for feeding and breeding.

- **Genetic Diversity**

  Forest remnants increase the chances of protecting a more complete range of local genetic variation (ie variation of inherited characteristics) within species of plants and animals. Throughout the world there is concern about the loss of potentially valuable genetic variations in plants through the clearance of forests.

Kahikatea forest in Westland. This forest type, once widespread, is now relatively rare as a result of clearance for agriculture. (New Zealand Forest Research Institute)

- **Importance to Maori**

  Forest remnants have important roles in Maori culture, past and present, including spiritual values and sources of traditional foods, materials and medicines.

- **New Zealand's Landscape Character**

  Forest remnants contribute to an aesthetically and spiritually satisfying landscape, especially in contrast to open agricultural landscapes. They contribute to an area's character and identity.

The rate of loss of forest cover in the past, the uniqueness of our biota, and the many natural and human values contained within forest remnants, mean that those who come after us will regard us as short-sighted opportunists if we fail to protect the remnants of our once extensive lowland forest systems.

2.0 Managing forest remnants

2.1 Why it is Necessary to Manage

Management is often necessary because our remaining native forests are subject to threats for which 80 million years of isolated evolution did not prepare them.

The degree of management required varies with the type and degree of threat. The ultimate aim of any restoration and management programme is to create conditions in which the forest community becomes relatively stable, vigorous and self sustaining and thus the need for active management is reduced.

2.2 Threats Facing Native Forests

2.2.1 Direct Threats

Clearance is the most obvious direct threat to forest remnants. Clearance of forest may be to generate income from the sale of timber products or to convert the area to an alternative land use (exotic forestry, agriculture, subdivision, etc.). A landowner's ability to clear forest remnants may be controlled by Regional or District Plans or by statutes.

If a landowner wishes to ensure protection against the actions of future landowners, there are a number of statutory mechanisms that can ensure protection of forest areas in perpetuity or for a set period of time. These include protective covenants with the Queen Elizabeth II National Trust or under the Reserves Act. These are discussed in Section 2.5.

Accidental fire poses a considerable threat to forest remnants, especially in areas of low rainfall. Fires can be caused by human use of an area, or surrounding land use (e.g. burning stubble).
(See Section 2.4.5)

2.2.2 Indirect Threats

While clearance has always been the most significant and obvious threat to forest remnants, other less obvious factors have been at work since the arrival of humans in New Zealand.

As forests were cleared the remaining remnants were left fragmented, exposed to wind, and subject to water table modifications. Frequently remnants were open to stock trampling and browsing.

In addition plants and animals from many parts of the world were

A severely grazed forest interior east of Otorohanga prior to fencing to exclude stock. (Queen Elizabeth II National Trust)

introduced. Finding niches and opportunities because of the degraded state of many remnants, the "alien invaders" flourished – frequently to the detriment of their native counterparts.

Today weeds, animals, and exposure to desiccating winds pose significant threats to our forest remnants. Active management is required to ensure their sustainability and to maintain their character.

In summary, the main requirements for good management of native forest remnants are:

- adequate animal control (both domestic and feral)
- sufficient shelter to reduce the effect of wind and sunlight at the forest edge
- control of weeds that threaten ecological processes within the forest

Starting a Management Programme 2.3

Restoring and managing a forest remnant is enjoyable and rewarding. Native forest responds well to management inputs and remarkable results can be easily achieved and often in a very short time.

Points to consider:

- Firstly establish your overall management goal for the remnant. Is it to attempt to restore the area as closely as possible to its original state by removing all exotic plants and reinstating the full range of vegetation associations from ground cover plants to canopy trees? Or is it just to accept the present modified character of the remnant and to minimise further degradation?

- Secondly, it is important to identify those issues that are important to the overall goal of improving the health, stability and long-term sustainability of an area, as distinct from dramatic but temporary phenomena. For instance, immediately after fencing off a forest area that has been subject to grazing, there is often a profusion of seedlings, of both native plants and exotic weeds. While the area may look weed infested and unsightly, if native trees and shrub seedlings are present it is likely they will eventually overtop the weeds that are in the meantime providing sheltered growing conditions.

Deer and cattle have depleted this forest remnant. (Department of Conservation)

2.3.1 Level of Knowledge Required

Many landowners may be hesitant about embarking upon a restoration and management programme, fearing that an in-depth knowledge of botany and ecology is required. While people with this knowledge will have a head start, it is not a pre-requisite for good management. Local knowledge, a keen eye for detail, talking to others involved in managing similar areas, and commitment, are the most important requirements. There are many excellent illustrated reference books now available to enable the landowner to identify the major trees and shrubs in their forest area. Some of these are listed at the end of this chapter.

The *New Zealand Native Plants* course offered by The Open Polytechnic of New Zealand provides an excellent grounding in native plants and native forest ecology.

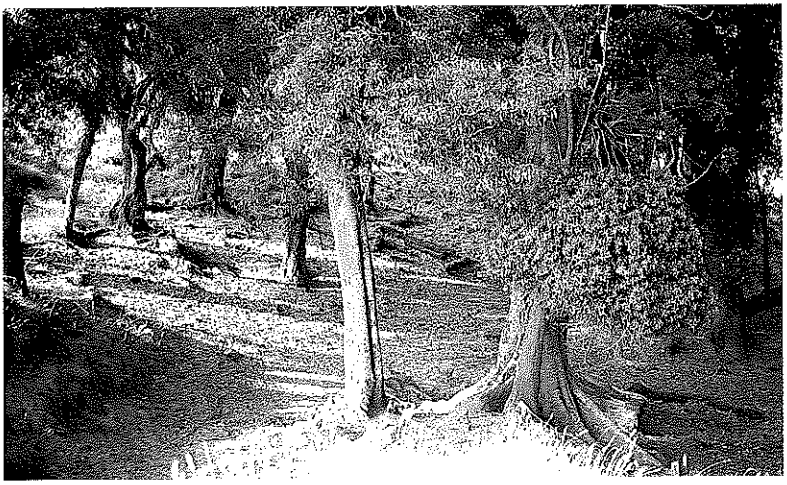
2.3.2 Sources of Information and What to Look For

Take time to get to know your forest remnant by identifying the major native species, and any weed species. Take samples to a local nursery or

Department of Conservation office for identification, or identify them from books.

- Check to see if there is good regeneration, especially at the edge of the forest.
- Invite someone knowledgable in native plants and animals to visit and give you an assessment of the health of the forest, its special values and any likely problems to be encountered in restoration. While a comprehensive list of all plants present is extremely useful both now and as a reference point in the future, it is not essential. Get the expert to identify the main canopy species, the main sub-canopy species and the main colonising species (normally growing at the edge of the forest or in "light wells" within the forest). This expert might be a local Department of Conservation officer, a member of the Royal Forest and Bird Protection Society, the local QEII National Trust representative, a botany teacher or any person with specific skills in this area.
- Talk to other landowners who have actively managed their forest remnants. For instance, a local landowner is likely to have dealt with similar weeds and pests.

Above all, it is important not to rush in and make hasty decisions that may turn out to be, at best, a waste of time and resources and even a hindrance to the restoration process. For example, it is pointless to clear an area of gorse adjacent to a forest area if the gorse is acting as a nurse crop for native tree and shrub seedlings which will eventually smother the gorse. The answer often lies in working with nature, not against it. There is a need to understand nature's processes and make them work for you.



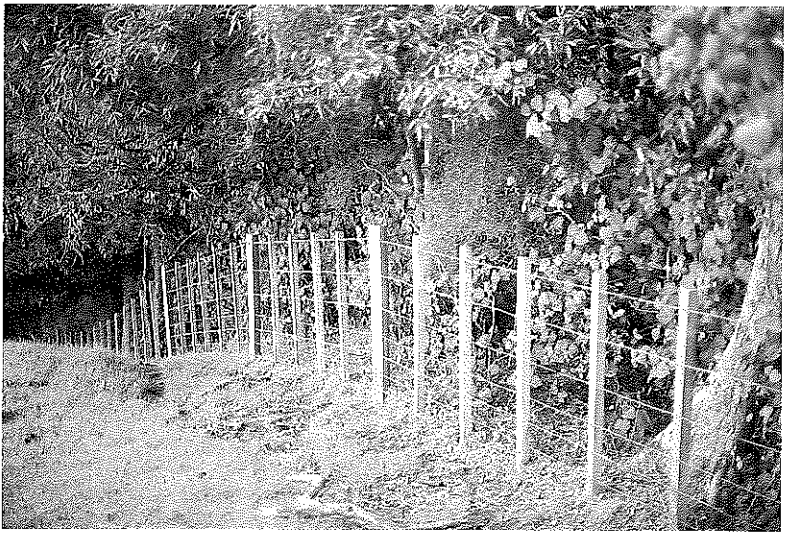
The understorey layer of this Waikato remnant has been eaten out by stock.
(Queen Elizabeth II National Trust)

2.4 Background Factors to Consider

As well as familiarising yourself with your forest and its local context, there are a number of background factors to consider when planning a restoration and management programme.

2.4.1 Fencing to Exclude Stock

The exclusion of stock is the top priority in any management programme. *(See Chapter 3: Animal Control)* If a forest remnant is being fenced off for



When stock is excluded a good understorey often quickly develops. This forest remnant near Gisborne has been fenced for five years.
(Queen Elizabeth II National Trust)

the first time it may be that fencing right up to the bushline on all sides is the best option. However it may also be an opportunity to consider other options such as:

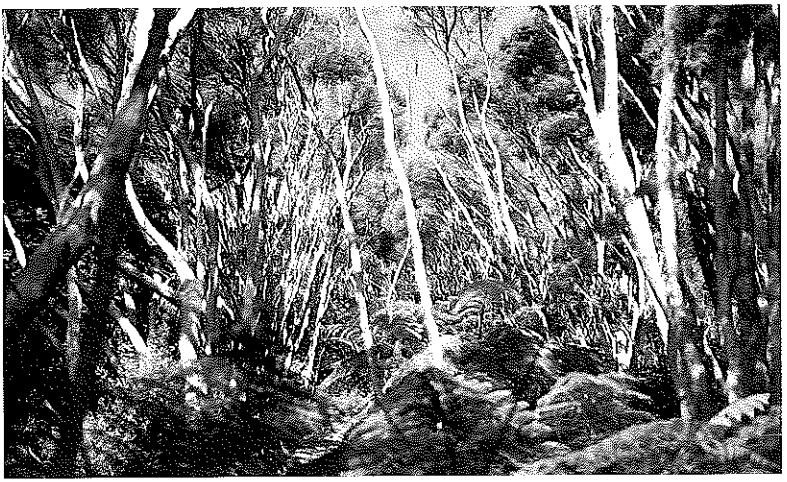
- Incorporating other areas of native or exotic trees into the fenced off area.
- Linking to areas of little farming value (for instance a steep gully, awkward corners or wet places). These areas may either naturally regenerate into native vegetation over time or be actively revegetated with native plants. Alternatively, the area can be planted up in some type of tree crop to provide additional income.
- Fencing off riparian strips to provide a buffer zone of vegetation along waterways.

- Fencing off an area on the windward side and planting a forestry/tree crop. This will provide shelter for the forest remnant, can be used as a nurse crop to extend the remnant and may eventually provide an income. Care must be taken that the species used do not have the potential to become a weed in the forest remnant.
- Linking the forest remnant to shelter plantings and via them to other areas of vegetation or homestead plantings. This provides opportunities for wildlife corridors and can often produce aesthetically pleasing results.

When considering the possibilities it is important to bear in mind the level of available resources. For example, large areas of rank grass awaiting planting can become fire hazards as well as making plant establishment much more difficult.

2.4.2 Natural Succession

Under natural conditions vegetation develops on a bare site through a series of stages. This can be seen in areas that have been burnt or subject to landslides. The textbook model of succession is as follows: the first plants to grow on or colonise the area are lichens, then mosses and small herbs. With time soil fertility builds up and hardy shrubs and trees become established. They create a sheltered, shaded environment, attract birds carrying other seeds and eventually taller tree species become established. These taller trees overtop and shade out the smaller trees and shrubs and, in time, replace them. Eventually taller, slower growing canopy trees become established. Each group of plants in the succession makes



In time this tall kanuka will be over-topped by taller trees such as rimu, tawa, rewarewa, etc. This area on the Coromandel Peninsula is protected by a QEII National Trust open space covenant. (Queen Elizabeth II National Trust)

Young rimu coming up through kauri in Northland. (New Zealand Forest Research Institute)

the site suitable for the next group of plants and unsuitable for themselves, so they are eventually replaced. Eventually there is a period of relative stability where the vegetation does not change much over a long time.

In forest remnants any bare soil will be quickly covered by a mix of grass, exotic weeds, bracken, ferns and native shrubs and trees. By controlling the exotic plants and favouring the native plants it is possible to imitate the process that would take place in an entirely natural situation. *(See Appendix I: Native Colonising and Nurse Plants)*

2.4.3 The Importance of Birds for Plant Colonisation

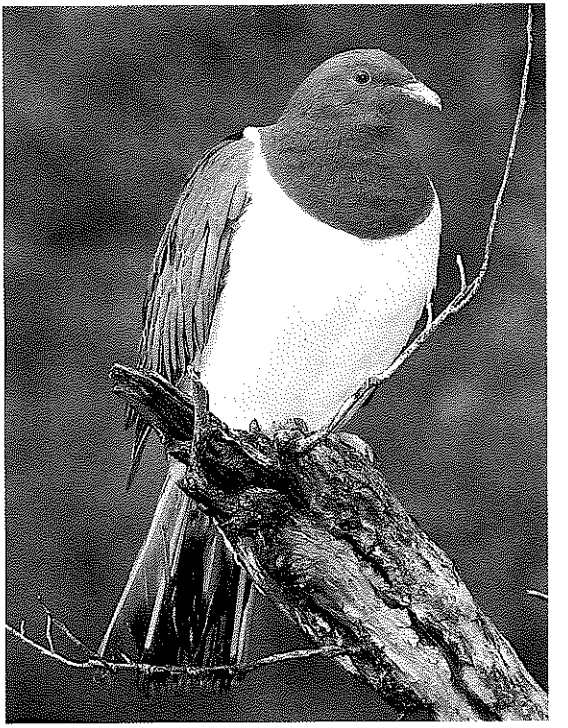
Birds play a major role in the spread of many New Zealand lowland forest plants by eating the fleshy fruits and dropping the seed elsewhere. All the podocarp seeds are bird distributed, and a return to forest can be hastened by planting species that will attract birds.

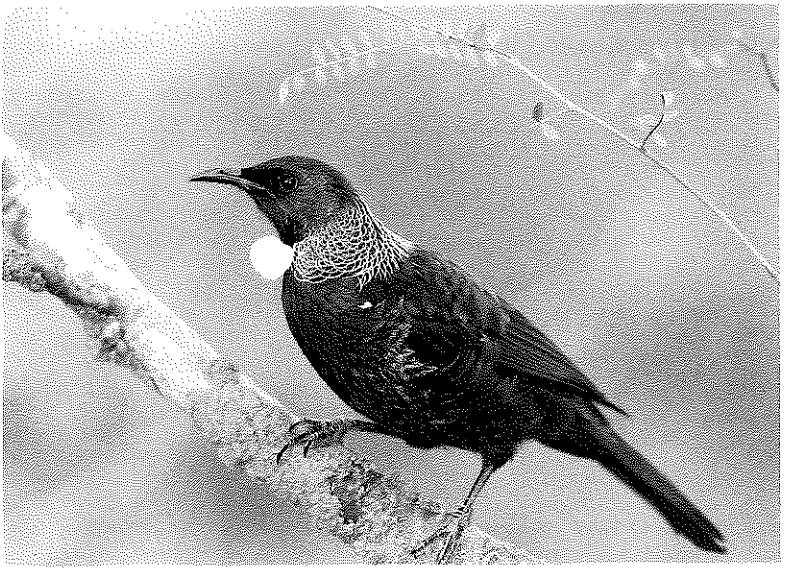
The New Zealand pigeon, which eats a wide variety of fruits of native plants, and the leaves, buds and flowers of many species, has a very large appetite and is among the most important bird for spreading seed, particularly seeds contained in large fruits such as tawa, miro, karaka, matai, taraire and puriri.

The pigeons move from place to place following the supply of fruit and congregating where there is an abundance. In autumn and winter, the main food is the miro fruit. The pigeon is the major disperser of this species and is the only common forest bird able to disperse the large seeds of tawa, taraire, and karaka.

Other native birds such as the bellbird, silvereye, and tui, and several introduced species, are also important seed dispersers.
(See Appendix II: Bird Distributed Plants)

The native pigeon (kereru) eats and distributes large quantities of seed of native trees and shrubs.
(Department of Conservation)





Tui. (Paul Gay)

2.4.4 Genetic Purity (Provenance) of Native Plants

One of the major reasons that effort is put into protecting and managing forest remnants is to preserve their ecological history – the unique collection of plants that has developed over hundreds of years on that particular site and in response to local conditions.

It is important if shelter or revegetation plantings are to be established that the following guidelines be observed.

Avoid:

- Planting species outside their natural geographic range. For example, kauri naturally occurs only in the northern half of the North Island above a line from Kawhia to Te Puke.
- Using non-local plant populations as source material when planting species within their natural geographical and ecological range.
- Planting species in unnatural habitats within their natural geographic range. For example, if a plant only grows on cliffs or in very dry, steep areas, it should not be used for revegetation in wet areas.

There are a number of reasons for adhering to the above guidelines. Firstly, local plants are better adapted to local conditions and will grow better than plants from other areas. Secondly, plants of the same species, but from different locations, may show great variation in the way they grow (form). This variation may be partly due to the effect of local environmental factors and partly due to genetic differences. This variation can be very marked between local populations. It is these local variations that make up local landscape character and contribute to an area's uniqueness. This

Genetic variation in manuka grown from seed from different areas in the North Island. (Herwi Scheltus)

uniqueness is worth preserving by using only local species. Thirdly, moving plants beyond their natural range to areas where they were not previously present confuses the picture for people in later years studying vegetation patterns and processes. This is especially so where no records exist of what was transferred and when, of where it came from and of where it was moved to.

New plantings in areas of conservation value – near a national park, forest park, covenant or reserve, for example, should be of plants grown from seed gathered in that local area.

Where the landscape has already been heavily modified or the original plant communities have been replaced by exotic plants, the issue of genetic purity is less important, but it is still advisable to use local stock to improve the chances of success.

Keep records of the species used, their source, time of planting and results as part of the management programme.

2.4.5 Fire Protection

The establishment of a fire break around a forest remnant may be sensible in high risk areas, for instance in areas adjacent to roadsides or areas of rank grass. A firebreak where the bulk of the vegetation cover is removed, especially the woody vegetation, reduces the fire risk. However, well-grazed pasture or the establishment of non-inflammable plants or crops is preferable.

Some native plants are relatively fire-resistant and can be used to establish a buffer between a forest remnant and a potential source of fire. *(See Appendix IIIa: Fire Resistant Native Plants)*

Other native plants have the ability to recover well from fire and therefore can be useful in areas prone to fire.
(See Appendix IIIb: Native Plants Capable of Recovering from Fire)

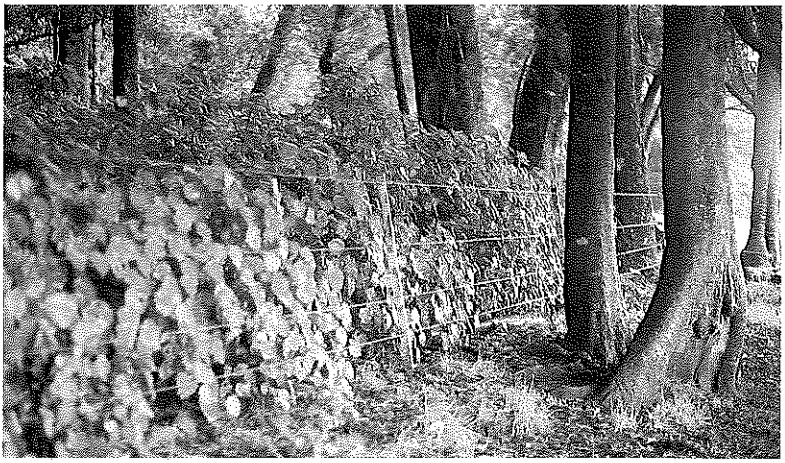
2.4.6 The Forest Edge

In entirely natural situations the transition from grassland to tall forest is gradual and may take place over a considerable distance with the height of the vegetation gradually increasing. This 'streamlined' effect lifts the wind over the forest and prevents its entry into the understorey. This contributes to the creation of a relatively moist and humid microclimate in the forest conducive to the germination and growth of native trees and shrubs.

In contrast, forest remnants often have an abrupt edge between farmland and forest. This results in winds penetrating into the forest producing dry, cool conditions. Forest remnants, by definition, have a greater proportion of edge to their size and therefore the detrimental effects of wind penetration are greater than in larger forest areas.

One of the fundamental steps in forest remnant restoration is to "seal off" the forest edge. This can be achieved by:

- Revegetating around the edge with hardy colonising native species.



A healthy forest edge is beginning to develop after fencing off this forest remnant in the Waikato. (Queen Elizabeth II National Trust)

The use of a nurse crop may be necessary if conditions are particularly severe. The side exposed to the prevailing wind should be sealed off first. Often this is the only side necessary as the resulting improvement in the microclimate within the remnant will result in improved natural regeneration and the establishment of a thick understorey. *(See Appendix I: Native Colonising and Nurse Plants)*

- Planting a tree crop on the windward side of the remnant. This can provide eventual additional income and if harvested (in the case of a timber crop) on a rotational basis can provide permanent wind protection.

The forest edge is also the common entry point for weeds of forest remnants. Regular checks should be made for the presence of weeds especially if the area has only recently been fenced off, as weeds may have been controlled by grazing.

2.5 Legal Protection of Native Forests

2.5.1 Protection While Retaining Ownership

Private landowners can ensure that their forest remnant is protected for future generations to enjoy, while continuing to own the land, through use of one of the following mechanisms:

a) Queen Elizabeth II National Trust Open Space Covenant

The National Trust is an independent organisation established by Act

of Parliament in 1977. An open space covenant is an agreement between a landowner (or lease holder) and the Queen Elizabeth II National Trust. The owner agrees to manage the defined area in a way that is detailed in the covenant. This binds not only the existing landowners but any subsequent owners as well, since the covenant is registered against the title. Open space covenants have proved to be a very successful mechanism. Over 1200 landowners have entered into a covenant with the National Trust.

b) Department of Conservation Conservation Covenant, or Covenant with a Local Authority

These are similar in principle to a National Trust open space covenant but the agreement is between the landholder and the Crown.

This small but ecologically valuable Taranaki forest is protected in perpetuity by a National Trust open space covenant. (Queen Elizabeth II National Trust)

c) Protected Private Land Agreement, Department of Conservation

A landowner, through the Department of Conservation, can have an area of natural value set aside as "protected private land" under the Reserves Act 1977. A protected private land agreement provides a similar degree of protection to a covenant. The agreement is notified in the New Zealand Gazette and the notice is registered on the land title and it is normally binding on subsequent owners.

2.5.2 Gifts, Bequests, Purchase

Owners who want to ensure that an area will be protected but do not wish to retain the land in their title, have several options:

a) **Gifts and Bequests**
Land can be gifted or bequeathed to the Queen Elizabeth II National Trust, the Department of Conservation or an organisation like the Royal Forest and Bird Protection Society. It is also possible to gift land to a local authority as a reserve. Where possible, it is wise to provide an endowment to assist the organisation to maintain the area in the long term.

b) **Purchase**
Land can be purchased for protection by the Queen Elizabeth II National Trust or Department of Conservation, sometimes in co-operation with regional and local authorities and interest groups such as the Royal Forest and Bird Protection Society. However, the more cost-effective forms of protection such as an open space covenant are preferable in most cases.

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3.0 Animal control

3.1 Introduction

Introduced animals can cause significant damage to native forests and degrade an area's ecological values.

New Zealand plants and animals evolved over millions of years in the absence of the wide range of animals that were introduced by Polynesian and, more particularly, European settlers. The impact of these introductions was, and continues to be, detrimental to our native flora and fauna.

These impacts include:

- Eating or damaging plants. In some cases distinctive vegetation compositions can be significantly and permanently altered as the most palatable species are eaten out.
- The annual seed crop of some plants may be eaten, preventing natural regeneration.
- Seedlings and understorey plants may be eaten or trampled, preventing natural regeneration and also opening the forest up to the effects of wind. This alters the microclimate within the forest.
- Nesting sites and food sources for native wildlife may be destroyed.
- Native animals are killed.

Damage by introduced animals will often threaten an area's sustainability

Sturdy fencing to keep out stock. This forest remnant near Wanganui is both legally and physically protected. (Queen Elizabeth II National Trust)

Goats are capable of causing considerable damage to native forests.
(Department of Conservation)

and lead to its eventual demise.

Animal control is an essential part of the management of forest remnants and is normally the first step in any restoration or revegetation programme.

Domestic Stock 3.2

This includes sheep, cattle, goats, horses and deer. Boundary fencing to exclude domestic stock is normally the first step in protecting an area of native forest.

The type of fence will depend on the type of stock being farmed. In general, a conventional 7 wire post and batten fence is preferred to electric fencing as the maintenance requirements are lower. However, in some cases, electric or a combination of conventional and electric may be the best option.

3.2.1 Sheep

DAMAGE CAUSED:

Sheep have the least impact of all domestic stock on forest areas due to their size and preference for grass species. However, over time, sheep will slow or stop natural regeneration by eating palatable seedings and trampling groundcover plants. Weed seeds can be introduced via hooves and droppings.

Sheep can also cause erosion of the humus layer and trees and shrubs then fail to receive necessary nutrients through surface feeding roots.

CONTROL:
Exclude from forest by boundary fencing with conventional 7 wire post and batten fence.

3.2.2 Cattle, Horses

DAMAGE CAUSED:
Cattle and horses selectively browse foliage and seedlings. They are large, heavy animals and therefore can cause damage by breaking branches, ring-barking trees, trampling undergrowth, and compacting soil. Weed seeds are introduced by the hooves and droppings. Droppings can raise the soil fertility locally which favours weed species.

CONTROL:
Exclude from forest by ring fencing with conventional seven wire post and batten fence. Cattle and horses can damage fences by rubbing and leaning. The addition of an electrified outrigger or top 'hot wire' can help prevent this problem.

3.2.3 Goats (Domestic)

DAMAGE CAUSED:
Goats eat any palatable leaves they can, from ground level to 2m high and will also strip bark. They will damage stems and branches by eating bark and twigs. They are also agile enough to extend this reach by walking up the sloping trunks of favoured trees.

CONTROL:
Goats are difficult to contain due to their desire to roam and browse. They will go to great lengths to overcome a fence barrier by jumping or climbing over or under. It is recommended that electric fencing with mains-operated energisers be used.

If possible, it is preferable to run goats in paddocks that are not adjacent to forest areas. In this way goats that escape can be noticed before damage occurs.

- **Modifying Conventional Fencing**
  Where a five or seven wire post and batten fence exists it may be sufficient simply to add an electrified wire on an outrigger bracket. This must remain live at all times and may prevent goats challenging the fences. Netting can be added to increase the effectiveness of the fence.
- **Mains Electric Fencing**
  Where goats have not learnt to respect fences, the minimum requirement is a five wire electric mains powered fence. In conditions where the ground surface of the land is uneven, it helps to have a non-electrified, lightly strained wire about 5cm above ground level. This will re-

duce the possibility of goats crawling under the fence. When using 'Insultimber' the optimum spacing of posts is 20m metres with three battens between.

- **Control of Bucks**
  Bucks are the most difficult goats to contain, and it may be necessary to modify an existing five wire electric fence. This can be done by attaching an 'Insultimber' dropper vertically to the top of each post to which a further three electrified wires can be added. Three 'Insultimber' droppers should be used between the posts.

  In addition, an outrigger bracket should be used to prevent animals jumping over the fence.

3.2.4 Deer (Domestic)

DAMAGE CAUSED:
Deer can considerably damage native forest areas through browsing and trampling.

CONTROL:
A 2m high mesh fence is ideal for protecting forest areas.

An alternative where deer are well trained to fencing is a five wire electric fence, 1.5m high with an electric outrigger to prevent jumping. If fawning is to take place adjacent to a forest area (and this should be avoided if possible), non-electrified netting (530mm wide) should be run along the bottom to contain young fawns and prevent them becoming separated from their mothers.

Feral (Wild) Animals 3.3

Included in this group are goats, deer, chamois, tahr, pigs, possums, wallabies, hares, rabbits, stoats, ferrets, weasels, rats and cats.

Some of these animals can be controlled in smaller forest areas by exclusion. For example, a wild goat population can be culled or driven out of the area and with suitable fencing (as for domestic goats) excluded from the area.

However, for many species the only realistic option is to reduce the animal population to a level which minimises the detrimental effect.

There are three basic options for the control of animal pests: trapping, shooting or poisoning. Each technique requires care and safety on the part of the hunter to protect not only the user but also non-target species.

In the case of trapping or hunting, the operator must be skilled in the use of the equipment and must be aware of any legal constraints on the activity. Dogs in hunting parties must be well trained. With poisoning the operator must be fully acquainted with the characteristics and restrictions

associated with the particular poison used. Some poisons can remain active for long periods and may contaminate soil and water through the process of leaching.

If you are unsure about control techniques, contact the Pest Destruction Officer through your Regional Council.

3.3.1 Goats

DAMAGE CAUSED:

See Section 3.1.3: Domestic Goats

CONTROL:

(a) Poisoning

Compound 1080 poison in a gel or grease is smeared onto the underside of preferred food plants such as broadleaf, mahoe and fuchsia. Trials have produced kill rates up to 90% of local populations with this method.

Keep dogs out of poisoned areas until carcases have completely decomposed.

NOTE: 1080 poison use is restricted. Contact your Regional Council or the Department of Conservation for further information.

(b) Shooting

This is a common technique. Adequate fencing should be installed to prevent reinfestation.

3.3.2 Deer, Tahr, Chamois and Wallabies

DAMAGE CAUSED:

Deer, tahr and chamois rely heavily on the foliage of trees under the forest canopy for food and can radically change the overall composition of a forest area.

Wallabies cause considerable damage to newly planted trees and are voracious forest floor feeders.

CONTROL:

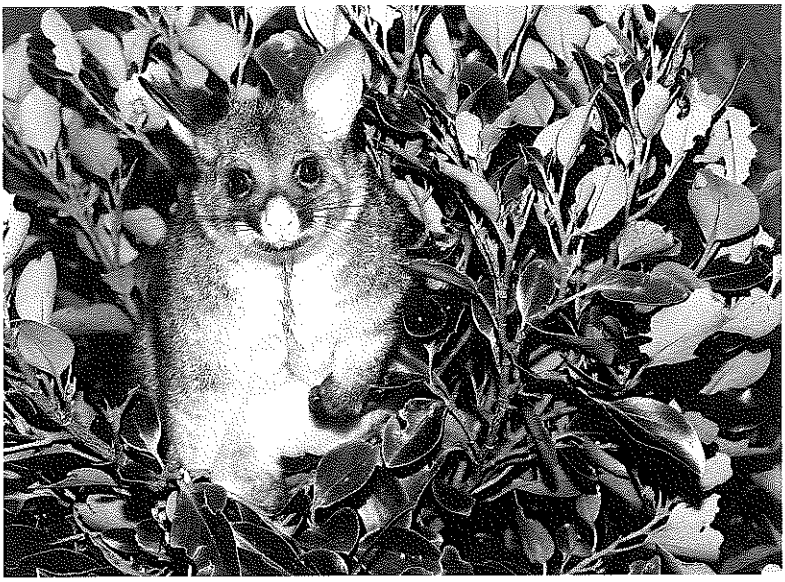
Shooting is the most common technique for deer, tahr and chamois. Hunting success has been shown to be highest in April, the time of the rut, with a secondary peak in late spring, when deer family groups break up before fawning.

Wallabies can also be successfully controlled by shooting, although poison pindone pellets can be used.

3.3.3 Possums

DAMAGE CAUSED:

Possums are a significant threat to native forest areas. Possums are browsing animals and, although they seem to prefer the forest canopy, can cause considerable damage to trees, shrubs and seedlings in regenerating forest.



Possum populations can be reduced locally through planned control programmes. (Paul Gay)

Possums frequently alter the composition of forest by heavily browsing certain species. Many of the tree species favoured by possums are important food sources for native birds. They also eat flowers and fruit of many species thus reducing food available for birds. Possums are nocturnal animals feeding at night and sleeping in nests or dens during the day. They come out of their dens around dusk and return just before dawn. They are tree dwellers but move across open country and often follow the same track regularly.

Possums are also a threat to New Zealand agriculture as they can carry bovine tuberculosis.

While it is arguably impossible to totally exterminate possums in New Zealand, planned control can reduce local populations to less damaging levels.

CONTROL:

(a) Habitat Manipulation

The removal of nesting sites in association with a control programme is worthwhile.

Methods of removing nesting sites:

- cut down and burn any standing stumps or dead trees suitable for nesting sites outside the forest
- block hollows or crevices in branches or trunks of trees

Mahoe severely damaged by possum browsing. (Department of Conservation)

- regularly check through the forest for obvious nest sites and block them up
- encourage natural regeneration in the forest by controlling other browsers such as domestic stock, goats and deer. Possums are deterred by dense, wet vegetation.

(b) Shooting

Night shooting can assist in controlling possums. Possums' eyes shine red at night when exposed to a beam of light. Use a five shot bolt action 0.22 rifle fitted with a 4 x 32 telescopic sight, sub-sonic ammunition and a silencer. A motorcycle battery in a backpack to power a light attached to the rifle is useful.

The hunter should move into the wind, working along the edges of the forest first, putting the possums between the shooter and the cover.

The hunter should move quietly, making even sweeps of the light. When a possum is seen, it is held at the edge of the light beam so not to frighten it. When ready to shoot, the possum is placed in the middle of the light beam. A gun licence is required to use a rifle.

(c) Poisoning

Poisoning is by far the most effective method of controlling possums. It is believed that the most effective control strategy is to undertake an initial 'blitz', followed up by annual control measures rather than by constant pressure. This helps to overcome the problem of bait shyness. It is worth considering using professional hunters for the initial treatment to maximise the reduction of possum numbers.

Licensed operators are also able to use 1080 poison whereas private individuals must use alternatives listed below.

Possums are creatures of habit frequently following the same tracks night after night, forming flattened pathways called possum pads. They often have favourite trees that are visited regularly. These trees can often be identified by leaves that have been eaten and claw and horizontal teeth marks up the trunk or along branches. These easily identified signs make the possums relatively simple to poison. There are four poisons commercially available for possum control:

- cyanide paste
- phosphorus paste
- pindone pellets
- talon 20P pellets

CYANIDE AND PHOSPHORUS PASTES

To use these poisons a licence to become an approved operator under the Pesticides Act must be obtained from the Ministry of Agriculture and Fisheries. Having obtained the licence, a landowner may purchase poison for his/her own use provided warning notices are posted at all main access points to the forest area.

It is important that possums are primed or pre-fed with a non-toxic bait before toxic bait is laid. This attracts possums to the bait site and means that a better kill will be achieved with the toxic bait. The non-toxic bait can be made from:

3 parts flour
1 part icing sugar
some drops of cinnamon, curry or allspice

Put the bait in a clean plastic squeeze bottle. Lay this bait each day for several days before laying toxic bait. Non-toxic bait and subsequently toxic bait should be laid alongside possum pads and on the tops of branches about 40 cm from the trunk of trees that are regularly visited by possums. Once poisoning operations have been completed, all toxic bait left uneaten should be removed. This prevents possums consuming small non-lethal doses of the poison and possibly building up a resistance.

Bait should be placed in bait stations to prevent it deteriorating in the weather. These can be made out of old plastic containers. Lay bait at dusk on a fine, warm night making sure it sticks to the surface it is placed on.

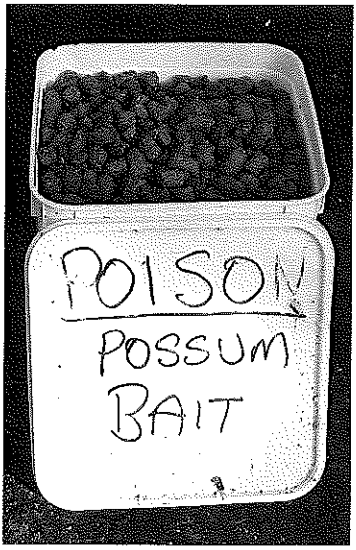
Dust around the bait with flour lure used for pre-feeding. Bait should always be placed up a tree to prevent the possibility of kiwi or weka taking the bait.

TALON 20P PELLETS AND PINDONE

These poisons are anti-coagulants which cause internal bleeding and have the advantage that no licence is required for their use and no pre-feeding is required.

Bait stations are used to dispense these poisons. Bait stations have a number of advantages:

- bait is protected from the weather
- the chance of accidental contact by humans is lessened
- they can be removed after use, cleaned, stored and reused
- they can be used continuously, rebaiting at the recommended period to gain long-term control of possum populations
- they can be used in areas where stock is present as they can be placed out of the animals' reach.



Pindone bait.
(Bruce Treeby)

A Pindone bait station.

Bait stations constructed from plastic downpipes are attached to the base of target trees, about 30cm above the ground within the forest area.

Unlike cyanide or phosphorus, possums poisoned with pindone or talon normally return to their nest to die.

(d) Trapping

Types of traps suitable for possums include:

- Live traps
- Kill traps
- Tip traps
- Jaw traps

• *Live Traps*

Live traps catch the possum live and it must then be killed by some other means; (e.g. shooting, drowning, poisoning by car exhaust, etc.). Common box traps are made of steel mesh and have a trap door that is activated when the animal takes the bait. Suitable bait includes apple, kiwifruit, citrus fruits, bread and jam or dates. Do not use a bait that is common in the vicinity as the possums will have little interest in it. For example, if

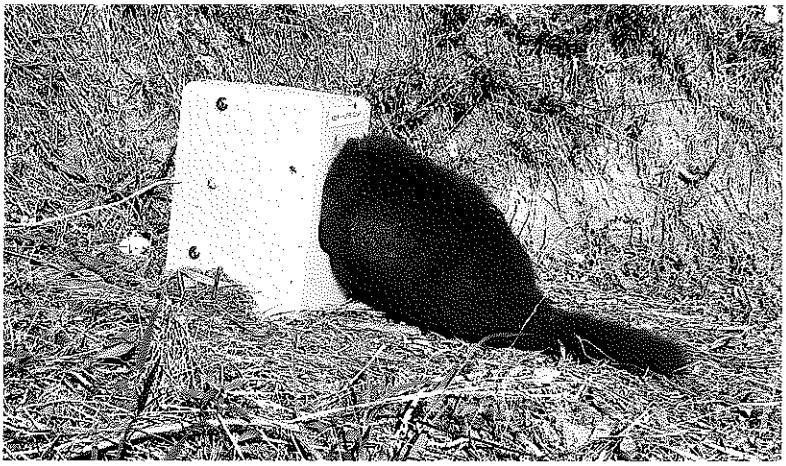
A commonly used box trap. This catches the possum live. (Bruce Treeby)

apple trees are nearby do not use apple as bait. Live traps have the advantage that non-target animals such as pets or ground birds accidentally caught can be released unharmed.

It is important to site these traps beside the seedlings or trees being damaged or beside a possum pad, with the door facing the direction from which the possum approaches. If you site the trap so close to a tree that a possum can climb down on top of it, it may trigger the door and deactivate the trap. Possums are wary of traps set at new sites. Secure the door open for the first four days and sprinkle bait in the trap. Set the trap after this bait has been taken.

(ii) Kill Traps

A kill trap catches and kills a possum by quickly breaking its neck or cutting off blood supply to the brain. The Timms trap is most effective. It is a small box made of heavy duty yellow plastic. It is easy to set and if baited with fruit with a few drops of cinnamon there is little risk to domestic animals. Bait should be fresh and firm and changed every two days.

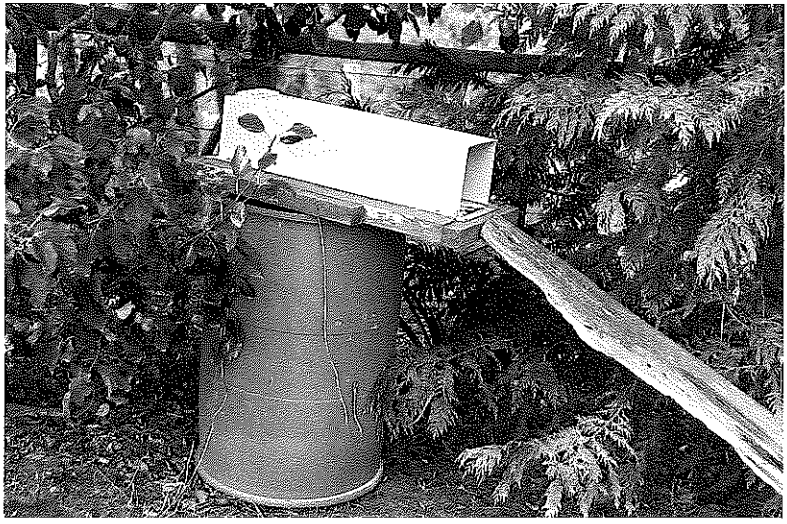


Possum caught in a Timms trap. (Bruce Treeby)

Kill traps can be set on level ground or on a limb of a tree just beyond the fork. Domestic cats appear to be deterred from putting their heads inside by the narrow opening of the Timms trap.

(iii) Tip Traps

A tip trap is essentially a tunnel open at one end with bait at the other. The floor of the tunnel is fixed at the open end and is designed to tip open when the possum has entered to reach the bait. When placed on a drum



Tip trap set on a 200l drum. (Bruce Treeby)

Tip trap detail. (Bruce Treeby)

of water the possum falls into the water and drowns. The trap floor then returns to its original position and the trap is again set.

A piece of wood inclined from the ground to the open end of the trap acts as a walkway for the possums.

(iv) Jaw or Gin Traps

The use of jaw traps is not recommended as there is a risk of trapping domestic animals or ground dwelling birds, for instance kiwi. Other methods provide better alternatives to jaw traps.

3.3.4 Cats and Mustelids

DAMAGE CAUSED:

Cats were introduced to New Zealand as domestic pets and to control other introduced animal pests. Mustelids (stoats, weasels and ferrets) were introduced to control rabbits and hares. However, they have a devastating effect on native birds by preying on both adult and young birds. Of the mustelids, stoats are by far the most numerous and widespread and are found in both farmland and forest. Cats, too, are widespread with heaviest concentrations close to urban areas.

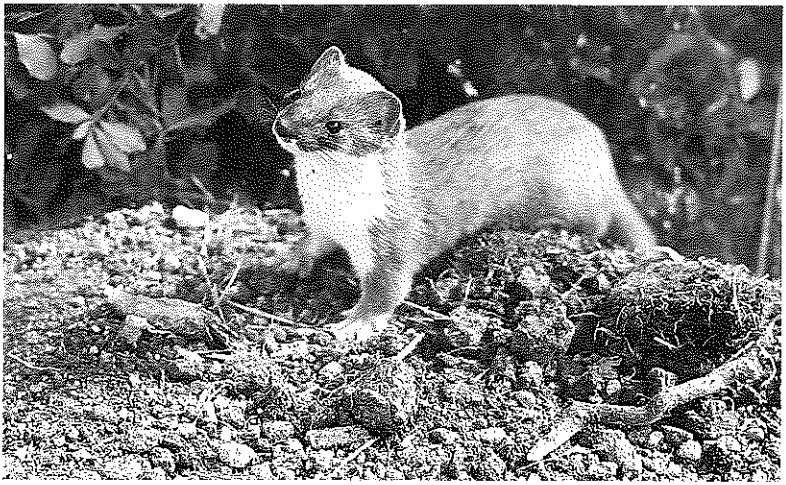
CONTROL:

a) Cats

Cats can be controlled by shooting, poisoning or trapping in box traps. Bite-sized pieces of fish injected with 1080 poison can be used in areas where there is no danger of domestic animals accidentally taking the bait. Cats caught in box traps are disposed of in the same way as possums.

b) Mustelids

Mustelids are normally controlled by trapping. The most effective trap is

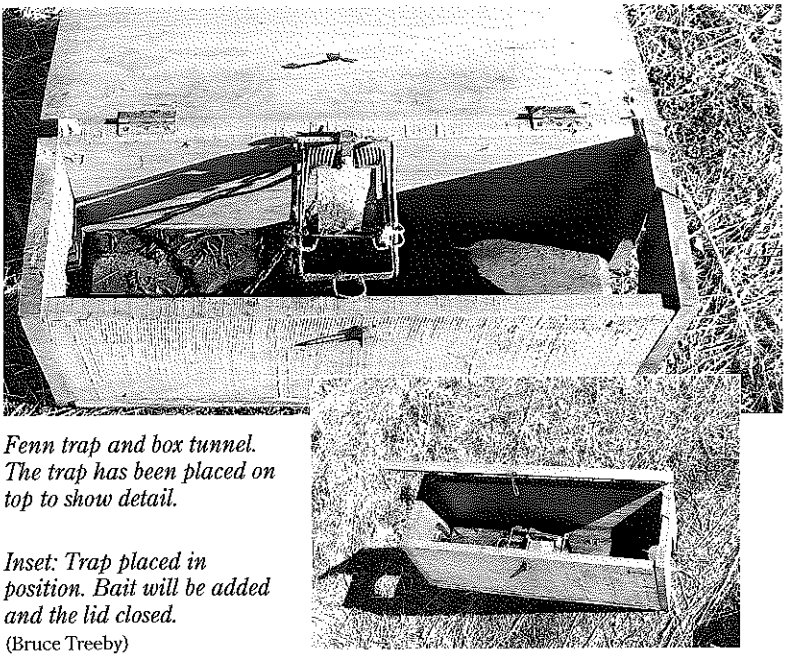


A stoat on the edge of a forest remnant. (Department of Conservation)

the Fenn trap set in a box tunnel a little larger all round than the trap. The tunnel has 3 important functions: to orient the mustelid relative to the trap so that the jaws close across its back; to disguise the trap and protect it against the weather and human interference; and to keep out large birds and non-target animals.

The trap site should be arranged along a natural runway blocked off so that approaching animals must either pass over the trap or turn back. Permanent tunnels can be constructed from materials such as planks, bricks, tiles, logs, drainpipes, even bales of straw to make a narrow covered runway with internal dimensions of about 15 x 15 x 60cm. Portable

A stoat trap. (Department of Conservation)



Fenn trap and box tunnel. The trap has been placed on top to show detail.

Inset: Trap placed in position. Bait will be added and the lid closed.
(Bruce Treeby)

tunnels can be made from 3 rough off-cuts of timber or from a shaped piece of galvanised iron. These should be pegged or weighted down to reduce accidental capture of possums and other animals. Tunnels are placed along fences, hedges, walls or the banks of streams, in bush among tree roots, beside fallen logs or in dry culverts. The entrance must be cleared of leaves and weeds, the trap placed in the centre of the tunnel, and then restricted with sticks driven into the ground at each end to exclude ground feeding birds.

Tunnels may be either blind or open. Blind tunnels are baited at the back, just behind the trap. Open tunnels with the trap in the centre should be baited on either side of the trap; or a longer tunnel could contain 2 traps with the bait in the centre. A strong smelling fish-based cat food makes a good bait.

3.3.5 Rabbits and Hares

DAMAGE CAUSED:

Rabbits and hares are animals of open grasslands and therefore do little damage to native forest areas. They can, however, have a considerable impact on revegetation plantings. Both rabbits and hares can damage areas by browsing on newly planted seedlings, often killing them, and by burrowing and digging out newly planted seedlings. Hares can be particularly damaging with their habit of biting through shoots of new trees at a

45° angle. Often the bitten-off piece is left on the ground uneaten. Bark of young trees is also often damaged by hares and rabbits.

It is very important that populations of hares and rabbits be well controlled **before** commencing any revegetation project.

CONTROL:

a) Habitat Manipulation

Potential nesting sites such as heaps of logs, blackberry and rank grass areas should be removed to reduce possible breeding sites.

b) Repellents

The commercial repellent 'Thiropel' applied to the trunks and leaves of trees or seedlings can deter hares and rabbits. However, heavy rain will reduce its effectiveness and new growth, of course, will not be protected.

c) Shooting

Hares are generally nocturnal animals and can be effectively controlled by night shooting. However, at certain times of the year, especially May to early June, they can be seen during the day and can be stalked just after daybreak or just before darkness.

A good knowledge of the local terrain is essential for safe night shooting and extreme care needs to be taken around houses and stock. A five shot bolt action .22 rifle with subsonic ammunition and silencer can be used.

d) Poisoning

Rabbits, due to their prolific breeding, are better controlled by poisoning. Pindone rabbit pellets are recommended. The first step is to locate all signs of rabbits. This is critical, as the placement of bait is vital to the success of the programme. The most obvious signs are their droppings which are oval, about 1cm in diameter and often in small heaps.

The bait can be applied in one of three different ways:

- in small heaps of 10 to 15 pellets on earth splits cut with a shovel, spade or grubber
- lightly spread on any visible signs (ie droppings, scratchings, or where plants or seedlings have been eaten)
- spread through all rabbit feeding areas with an application rate of 2 to 3 kilograms per hectare per feed.

If it is undesirable for the bait to be left around during the daytime for any reason, the bait can be put out in the afternoon and picked up the next morning. Repeat this for three days, then cease applying it for several days. Then repeat laying the poison for another three days. It is important to lay enough bait for two days' feeding by all the rabbits in the area. After 10 to 14 days, check for rabbit signs. If necessary, repeat the application.

3.3.6 Rats

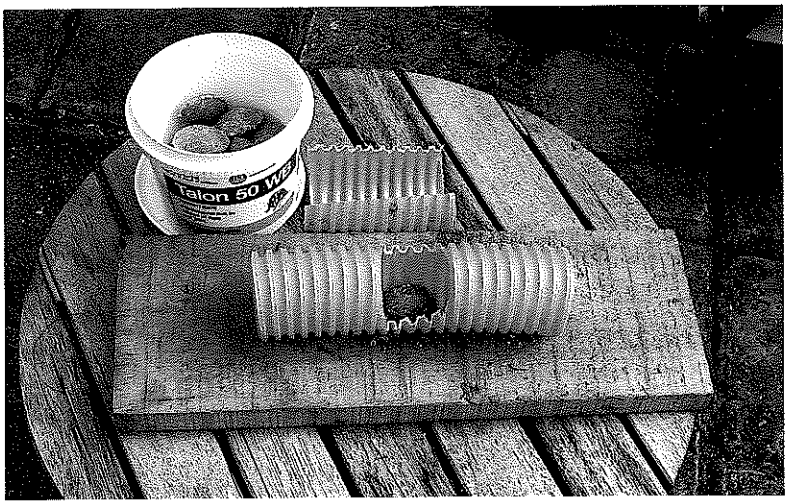
DAMAGE CAUSED:

There are three types of rats in New Zealand: Polynesian rat, Norway rat and Ship rat.

The ship rat (*Rattus rattus*) is the most common and is a good climber. It eats small animals, eggs and young birds and a wide range of native fruits and other plant material. Rats, especially the Polynesian rat, originally introduced by the Maori, also consume large amounts of forest tree seed.

CONTROL:

Rats are controlled by poisoning with anti-coagulant poison baits; e.g. Talon 50 WB. Bait stations can be made out of flexible drain pipes 60 cm in length. A section of the top of the pipe is cut out to give access to the central portion. A shorter ½ section of pipe is used to fit over this cavity once baits have been placed in the tube. Tubes can be mounted on boards or fastened down with wire hoops. Bait stations are set up at the edges of tracks, beside heavy vegetation and along the centre of clear access ways.



Rodent bait station. (Bruce Treeby)

Further Sources of Information:

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King, Carolyn M.	*Immigrant killers: introduced predators and the conservation of birds in New Zealand,* Auckland University Press, Auckland, 1984
Nelson, P.C.	Hares Control, Fencing, Repellents, Protection Devices *Horticulture Produce and Practice,* No. 286
	Possum Control, Horticultural Crops and Orchards. Poisons, Repellents and Protective Measures *HPP*, No. 273
	Possum Control, Horticultural Crops and Orchards. Traps, Snares and Shooting *HPP*, No. 274
	Instructions on how to control your possums using Pindone Possum Pellets Pest Management Services Ltd, Wellington
	Instructions on how to control your rabbits using Pindone Rabbit Pellets Pest Management Services Ltd, Wellington
TOPNZ	*New Zealand Native Plants* course The Open Polytechnic of New Zealand

Weed control 4.0

Introduction 4.1

For the purposes of this handbook, the term 'weed' is applied to any plant that detrimentally affects the ecology or sustainability of a native forest community.

Most weeds of native forests are exotic species and thrive here in the absence of natural predators. Many weed species are better able to establish themselves on disturbed sites than some native plants. Therefore, where weed species are present or likely to become established, some form of management is necessary if the objective is to retain forest remnants in something like their natural state.

Ways Weeds Affect Native Forests 4.2

Different weeds have different modes of growth and therefore varying effects on forests.

Weeds can be divided into the following five groups related to their effects.

4.2.1 Smothering

Some creepers prevent light from reaching the leaves of the host trees or shrubs. Old man's beard (*Clematis vitalba*) is an example. The host plant is often smothered and eventually dies from lack of light.

4.2.2 Competing With and/or Replacing Canopy Trees

Some weed trees pose a threat by over-topping the native canopy trees and competing for light.

These trees often establish quickly, taking advantage of the increased light levels when an opportunity such as a fallen tree occurs. Having established they then create a seed source and potential for further spread.

Sycamore (*Acer pseudoplatanus*), tree privet (*Ligustrum lucidum*) and ash (*Fraxinus excelsior*) are examples. These and other weed tree species have the ability to form pure monocultural canopies thereby excluding the majority of native species.

4.2.3 Suppressing Natural Regeneration

Natural regeneration of a forest is dependent on the ability of native trees and shrubs to reproduce themselves by the production of seeds which

Old man's beard smothering native vegetation near Mangaweka, south of Taihape. (Queen Elizabeth II National Trust)

germinate on the forest floor.

Weeds that form a dense mat on the ground prevent germination and establishment of native seedlings so that trees and shrubs at the end of their lives are not replaced and eventually the composition of the forest changes.

The majority of weed species that suppress natural regeneration are light demanding and occur mostly in clearings or at the forest edge. They can be suppressed by spraying with herbicide and/or planting out the areas. Grasses are an example of light-demanding ground cover.

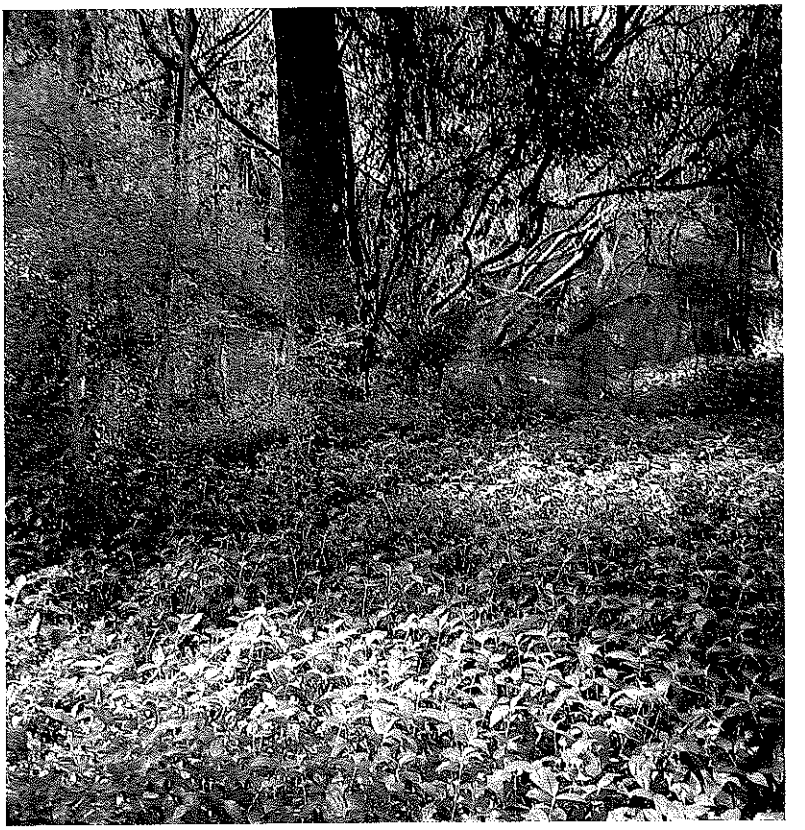
More serious ground covers (in terms of their effect on forest ecology) are those which tolerate low light levels and penetrate into the forest. Wandering Jew (*Tradescantia fluminensis*), Wild ginger (*Hedychium* spp.) and Climbing asparagus (*Asparagus scandens*) are examples.

4.2.4 Strangling

The twining nature of some creepers constricts the growth of the trunk of the host plant. Honeysuckle (*Lonicera japonica*) is an example.

4.2.5 Nurse Plants

Some exotic plants that in other situations would be regarded as weeds can actually be beneficial by encouraging natural regeneration of native



Wandering jew forms a dense carpet preventing natural regeneration of native plants. (Queen Elizabeth II National Trust)

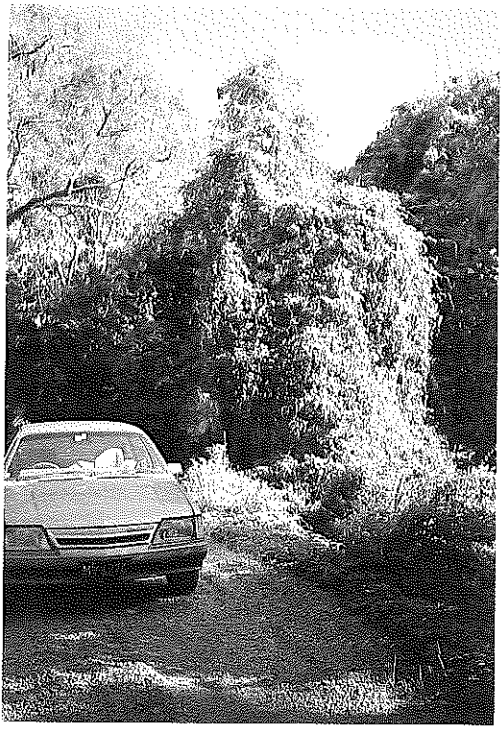
plants. As broom, gorse and lupin mature they may provide ideal shelter, semi-shade and litter for the germination of many native trees and shrubs. Alternatively, they provide an excellent environment for planting native trees and shrubs. They are also nitrogen-fixers, adding nitrogen to the soil.

Preventing Weed Establishment in Forest Remnants 4.3

Weed control can be expensive and labour intensive. Any management programme should ensure all practicable steps are taken to prevent weeds becoming established in a forest remnant.

Two fundamental steps are:

(a) Eliminate potential seed sources such as infestations of weeds in nearby shelterbelts, or individual seed trees in adjacent gardens or paddocks. While birds and wind often play a major role in seed distribution and are beyond the control of the landholder, removal of nearby seed sources can significantly reduce the problem. Co-operating with owners of neighbouring properties to eliminate weed sources over a wide area is extremely important.



Many weeds of native forests are common garden plants. Wisteria and banana passionfruit invading a forest remnant near Taumaranui.
(Queen Elizabeth II National Trust)

(b) Eliminate potential sites for establishment of weeds. The saying "nature abhors a vacuum" is nowhere more visibly demonstrated than in a forest where any opportunity of increased light or clear ground will be taken up by colonising species. If weed seeds are present, clearings provide an opportunity for their establishment, particularly if they are quicker at establishing than native species.

Therefore, it is sensible to plant up bare areas and corners with native species (unless they are required as open areas, e.g. as a picnic area) to ensure good ground cover and eventually canopy closure.

(See 8.2.3b: Canopy closure)

This is why revegetation will often form part of a forest restoration programme. *(See Chapter 5)* However, when the risk of weed species establishing on bare ground is obvious, the best option may be to sow the area down in grass. This will act as a temporary ground cover and weed suppressant.

Regular checks to monitor potential weed establishment sites are vital even when the forest grows out to the enclosing fence.

Preventing Weed Re-Establishment After Removal 4.4

Disturbed open sites created by weed control are ideal for weed establishment. It is therefore important to consider how an area will be treated before embarking on widespread weed clearance.
The major options are:

- Have a supply of native plants ready to plant when conditions are favourable. The aim is to shade the soil as quickly as possible to prevent weed seeds germinating or establishing. These native plants should be quick growing trees and shrubs propagated from local seed sources.
- After clearance, leave the area for some months to allow remaining weed seeds to germinate, selectively spray the area and then plant out with native plants.
- Mulch the area immediately after weed clearance with untreated sawdust or bark chips and spot spray any weed growth until native plants for revegetation work are available.

Points to note are:

- Areas that have been heavily infested with weeds will contain weed seeds in them and these seeds may remain viable for many years. A close check will need to be kept on such areas for a number of years after planting as re-infestation is likely to occur.
- In some cases, especially where the level of weed infestation is low and a healthy degree of natural regeneration of native species is occurring, the spot removal of weeds may be all that is necessary. The removal of weeds in such cases can be undertaken over a number of years to allow the upcoming natives to fill the gaps caused by removal of weeds.
- At all costs avoid overclearing: that is clearing an area greater than can be dealt within any one year. Not only will the seeds of the removed weed plants quickly germinate and grow, but quick-growing, free-seeding weed species such as convolvulus may invade the area, thus compounding the problem.

4.5 Methods of Weed Control

There is a range of methods available for the control and eradication of weeds in forest areas.

The method chosen at any one site will depend on a range of factors:

- the types of weed(s)
- the degree of infestation
- the available resources of labour, time and finance
- personal preference

In many cases a combination of methods will be required and experience will show which methods suit the particular circumstances.

4.5.1 Hand Weeding

This method is labour intensive, but is suitable for areas of low infestation of weed species which pull out easily, or specific weeds which can be targeted especially.

The weed plant is pulled, or eased with a tool, out of the ground. The soil is shaken from its roots and any available leaf litter is placed over the site from which the weed has been removed. It is important not to leave bare soil as this will encourage further germination of weed seeds. In many cases, it is better to wait until weeds reach a 'pullable' height, as many smaller ones will die out. Economy of effort is important.

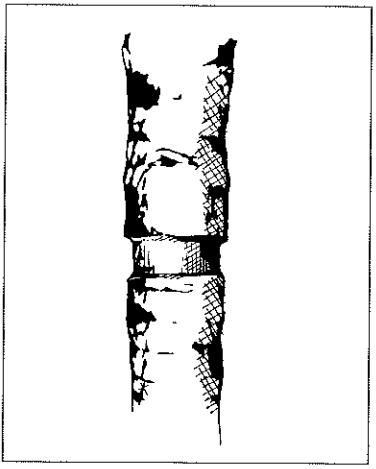
The weed can be removed from the area or alternatively hung to die on nearby plants. Difficult-to-kill weeds such as Wild ginger, Climbing asparagus and Wandering Jew must be disposed of off-site.

4.5.2 Ring-Barking

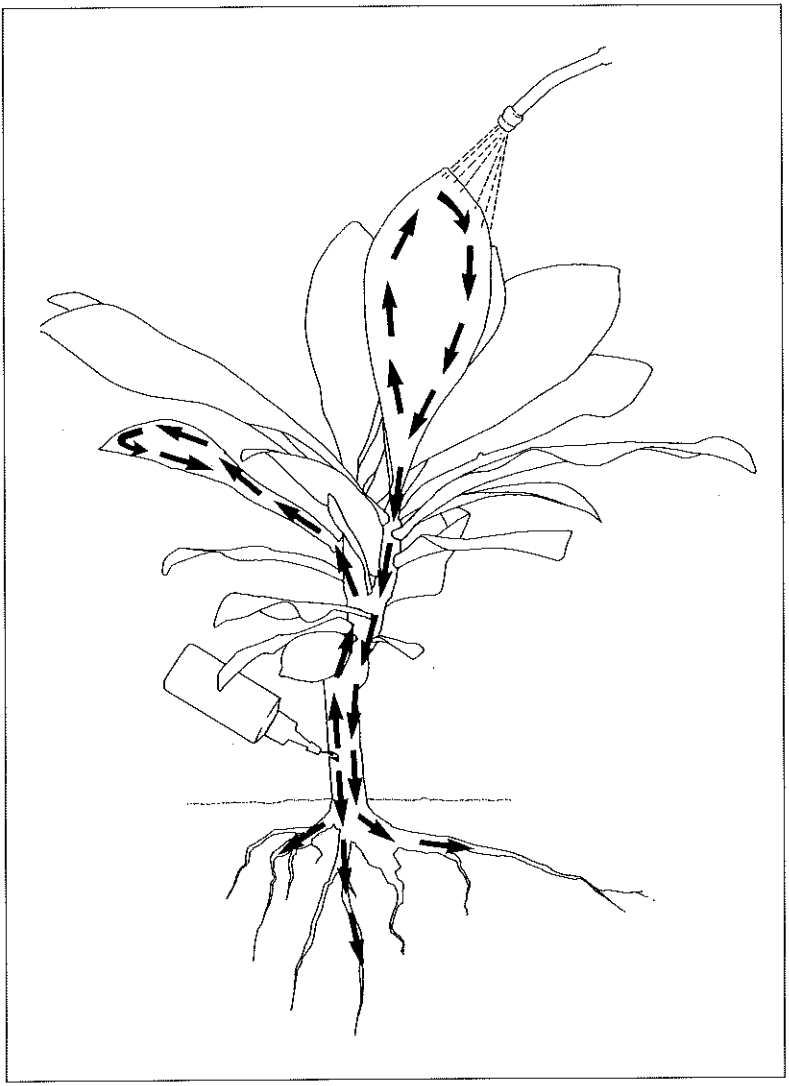
This method can be used instead of herbicides on trees and shrubs with a sufficiently large stem or trunk.

With a sharp chisel, axe or chainsaw, make two parallel and deep cuts into the sapwood right around the base of the plant. Cuts should be at least 5cm apart and all the bark should be removed from between the cuts.

NOTE: This method is not always successful as a callus may grow to heal the wound or the plant may resprout from the base. Frilling or chipping is preferable.



Ring-barking.



How herbicides are translocated around a plant.

4.5.3 Herbicides

SAFETY NOTE: Herbicides must be used with care.
(See 4.5.8: Using Herbicides Efficiently and Safely)

While much can be achieved in controlling weeds by hand and with a limited range of tools and machinery, herbicide is often necessary for larger infestations.

Herbicide can be applied in a number of different ways:

- sprayed on the leaves (foliar spray)
- applied to a cut stump
- applied after frilling the trunk
- injected into the trunk

4.5.4 Foliar Spray

Spraying either from a knapsack sprayer or with a hand gun is a quick and convenient method of weed control. It is recommended that only non-residual herbicides be used in spray applications within forest remnants.

a) Follow the manufacturer's instructions regarding mixing and application.

b) Spray only in still conditions to avoid harming non-target plants.

c) During spraying, non-target plants can be shielded with the use of cardboard, plastic board (the material from which real estate "For Sale" signs are now made) or a large plastic container with the bottom cut out.

d) The use of a surfactant (spreader) can aid effectiveness.

e) The use of marker dye can assist in preventing double spraying and wastage.

f) A foaming agent can be added to minimise spray drift.

Foliar spray is best suited to low growth or to the spray regrowth of stumps. Spraying regrowth gives good translocation down to the root system.

Climbers such as honeysuckle or old man's beard often climb up and over desirable host plants. Spraying the whole infestation is often impractical and undesirable. Cut the climber at waist height in Winter or Spring. Allow the rootstock to resprout and spray the foliage in late Summer.

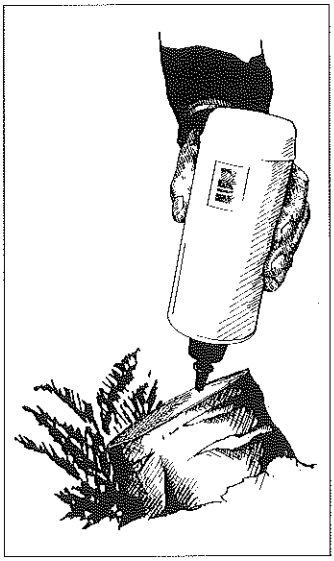
4.5.5 Cut-Stump Method

This is useful for small to medium-sized woody weeds.

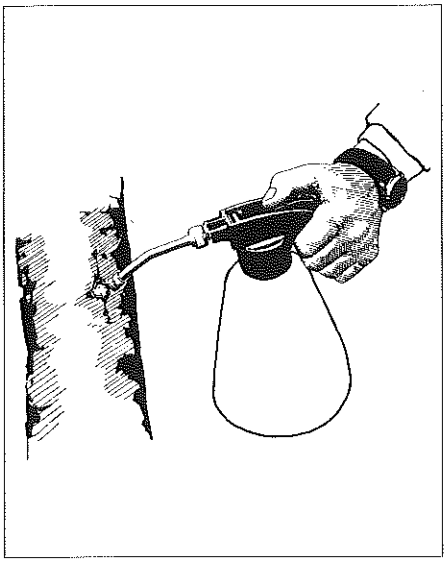
a) For larger specimens, remove the top of the plant for easy access.

b) Cut the base of the plant close to the ground with a straight flat cut. The cut must be horizontal so that the herbicide rests on the cut area while being absorbed.

c) Apply herbicide immediately as the sap ceases to flow once the tissues are severed. For convenience, use a paintbrush, eye dropper or small squeeze bottle. For larger specimens, wipe the herbicide around the outer rim of the cut only.



Cut stump method.

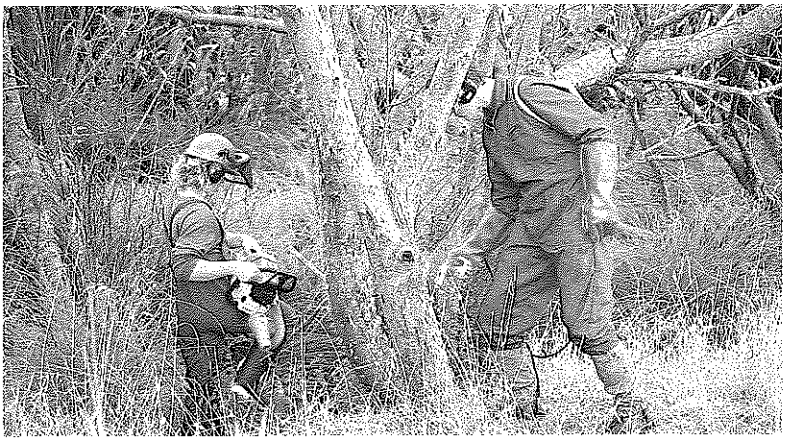


Tree injection method.

4.5.6 Tree Injection

Tree injection is useful for large shrubs and trees where their felling and removal is difficult or would cause damage to surrounding vegetation. A sheep drench pack with gun is suitable for injecting the herbicide.

a) Drill holes sloping into the sapwood at regular intervals around the tree, using a cordless drill, brace and bit or chainsaw driven auger.



Injecting willows with herbicide, Taupo Swamp, Plimmerton. The holes are being drilled with a chainsaw-driven auger. (Queen Elizabeth II National Trust)

b) Place the correct dose of herbicide into each hole immediately as it is drilled. If necessary, wait until the liquid subsides then apply the remainder. It is important to follow the manufacturer's recommendations for the correct dosage.
(See Table I: Weed Control)

NOTE: Best results are achieved with plants which are actively growing.

4.5.7 Frilling or Chipping

This is an alternative to tree injection when equipment such as drench pack and gun is not available.

a) With a sharp chisel or axe, make a deep cut into the sapwood at regular intervals around the base of the tree. Take care not to ring-bark the plant as this will reduce the uptake of herbicide and, therefore, the effectiveness of this method.

b) Immediately apply herbicide using a paintbrush or squeeze bottle.

NOTE: For multi-stemmed plants, inject or chip below the lowest branch or treat each stem individually.

4.6 Using Herbicides Efficiently and Safely

Although using herbicides is fairly simple, there are a number of rules for successful results:

- Apply herbicide when the plant is actively growing.
- Do not apply herbicide when the plant is under stress, eg extreme heat, frost, drought, disease.
- Do not re-apply herbicide too soon after initial treatment. Wait until the plant begins actively growing again.
- Do not spray in windy weather or if rain is expected in the next few hours.
- Leave plants in the ground until the roots have died off.
- Make sure herbicide does not come in contact with non-target plants.
- Closely follow the safety instructions on the label and wear correct protective clothing.

4.7 Herbicides for Forest Restoration Work

In forest restoration work, care is always needed with the use of herbicides to ensure that only the target plants are affected, and that the minimum quantity of herbicide is applied.

Frilling or chipping.

In addition, using the most suitable herbicide and technique for the weed problem is also important. For instance, the **spray** application of residual or hormonal herbicides which can affect surrounding vegetation is normally not recommended. However, applying these types of herbicide as a localised cut-stump treatment may be both efficient and acceptable. (It should be noted also that residual herbicides can be useful in preparing grassed sites for revegetation.)

The most suitable herbicide for most weed control work in forest remnants is glyphosate, most commonly marketed as Roundup®. It is a non-residual, translocated, knock-down herbicide. However, not all weeds are adequately controlled by glyphosate and the detrimental effects of some weeds warrant the use of other herbicides.

4.8 Common weeds of Forest Remnants and their Control

Table I (pages 47 to 89) lists common problem weeds of forest remnants and suggested herbicide control methods.

The following points should be noted:

- The suggested treatments contained in Table I have been drawn from manufacturer's recommendations, and anecdotal evidence (that is the experience of farmers, Department of Conservation staff, Noxious Plants Officers, etc.).
- The list does not necessarily contain all possible methods of chemical control for a particular weed.
- Whatever herbicide is used, it is important that the general recommendations on the label are adhered to.
- In many cases, repeated treatments will be necessary in subsequent years.
- With spray application, the use of a penetrant such as Pulse® or Boost® to improve the effectiveness of the herbicide is recommended.
- The percentage figures (eg 20%) indicate the % of herbicide to be used mixed with water.
- The following Tradenames are used:

Banvine® is a Registered Trademark of DowElanco (NZ) Ltd.

Boost® is a Registered Trademark of DowElanco (NZ) Ltd.

Escort™ is a Trademark of E I Du Pont de Nemours and Co. Inc., USA

Gallant® is a Registered Trademark of Dow Chemical Company, USA

Grazon® is a Registered Trademark of DowElanco (NZ) Ltd

Pulse® is a Registered Trademark of Monsanto Company, USA

Roundup® is a Registered Trademark of Monsanto Company, USA

Tordon® is a Registered Trademark of Dow Chemical Company, USA

Trounce® is a Registered Trademark of Monsanto Company, USA

Revegetation principles 5.0

Revegetation 5.1

Revegetation is the establishment of local native plants to create plant communities using one of several methods. Commonly this is undertaken to extend or provide shelter for an existing forest area. However, it is also possible to recreate forest areas through a carefully planned revegetation programme. There are many examples of stable and self-sustaining forest areas around New Zealand that 20 to 30 years ago were areas of grass or herbaceous and woody weeds.

5.1.1 Planning a Revegetation Project

A revegetation project will normally span many years, so careful planning is essential to ensure that all matters have been thought through and the project will succeed.

Many revegetation projects falter after considerable time and resources are put into them because an important aspect is overlooked or because resources are not budgeted for past years one and two. For example, if weeds are a serious problem, they should be controlled or eradicated

Revegetation projects can involve the whole community. (Herwi Scheltus)

before any planting takes place. Plants need to be ordered or propagated 18 to 24 months before planting so that they are of an appropriate size for planting out (30 to 60cms).

It is important to itemise the level of resources and the time that will be required each year for the duration of the programme. The costs and time can then be anticipated and budgeted for. It is a good idea also to plan the year ahead and highlight in a 12 month plan necessary actions. For instance, controlling rabbits and hares at a planting site needs to be undertaken well in advance of planting.

The flow diagram, right, illustrates the range of options and stages that need to be considered and planned for in a revegetation programme. These options and stages are discussed in subsequent sections of this handbook.

5.1.2 Keeping Records

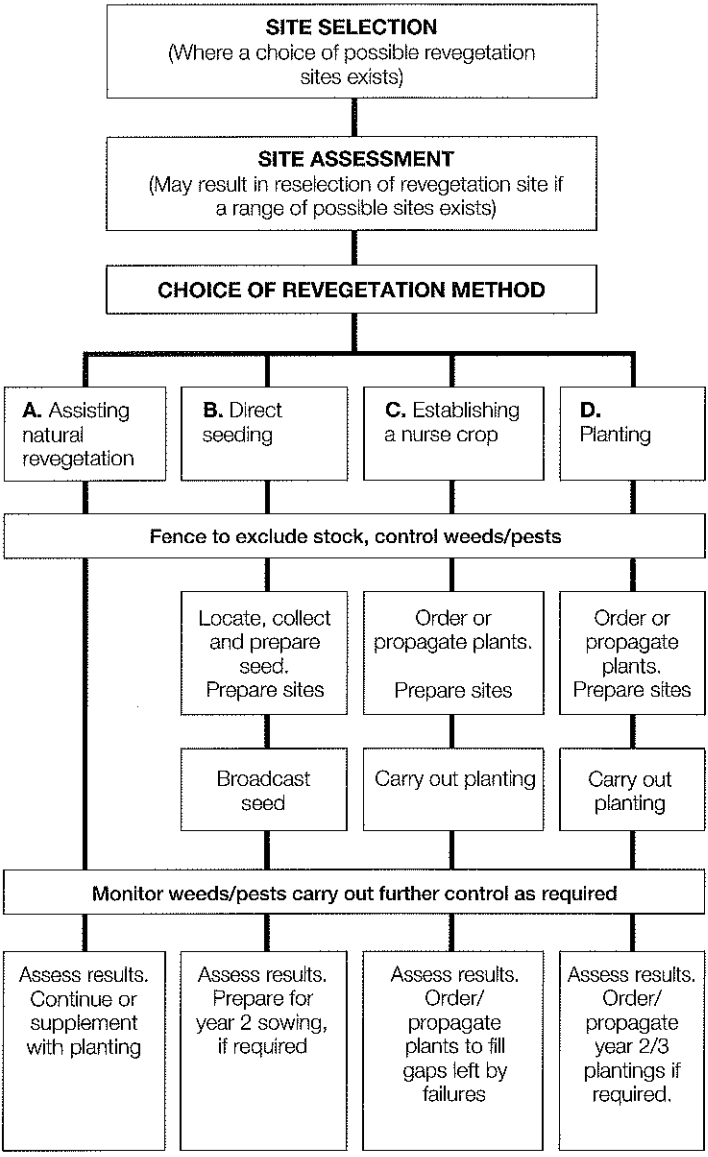
The importance of recording as much information as possible about all aspects of a revegetation programme cannot be over-emphasised. Not only will this information assist in an assessment of the present methods (what has worked and what has not) but also it will assist others who may embark upon a similar programme.

If possible, record the following:

a) **Site Description**
   Site Location
   Size
   Status of the site
   (eg. QEII National Trust covenant/Protected Private Land, etc.)
   Purpose of the revegetation
   Vegetation cover before planting
   Surrounding vegetation and seed sources
   Soil type
   Exposure to wind

b) **Plant Material**
   Plant Material (species, sources of propagating material)
   Plant size
   Condition

c) **Planting**
   Site Preparation (weeds controlled, herbicides used, fencing, etc.)
   Dates
   Weather conditions
   Layout
   Treatment (Fertiliser/staking, etc.)
   Labour
   Planting method (Spade/post-hole borer, etc.)



Planning a revegetation programme.

d) Follow-up Maintenance
Weed and pest control, etc.

e) Monitoring
Assessing the success of the project.
Survival rate after 12, 18 and 24 months.
Lessons for the future.

5.1.3 Site Selection and Assessment

(a) In many cases a revegetation project will be extending an existing forest area or restoring gaps (or "light wells") within an area. Where these areas are small, the choice of site does not need further consideration. However in larger areas there will be various sites and some parts will be more suitable for the establishment of plants than others. The more favourable microsites should be used first to establish plants. Features such as remnant patches of top soil, or moist depressions which are sheltered or frost free, contribute to rapid plant growth. Planting on favourable microsites first helps to create a more favourable environment for subsequent plantings. Take time to observe nearby sites where native plants are naturally growing. Here, nature will have done the hard work of matching the right plants to particular sites. It is then quite a simple matter to repeat those vegetation patterns on the proposed revegetation site.

(b) The other possible type of site for a revegetation project is the bare site covered only in grass or weeds. Again the site should be assessed for areas where plant establishment is likely to be optimised, and these areas used first.

When starting a revegetation programme and you have the choice, do not choose sites that are very exposed to prevailing winds, subject to water logging in winter or are 'frost-pockets' where cold air drains producing heavy persistent frosts. If in doubt, seek local advice from nearby landowners if they are more familiar with the area.

If possible, choose sites that are well sheltered, have adequate moisture and fertility and no problem weeds.

However, it is possible to revegetate the most difficult of sites with native plants. It is just a matter of matching the right plants for the site and the right revegetation method.

5.2 Selecting the Revegetation Method

There are a number of revegetation methods to choose from or to use in combination with each other.

The main methods are:

- Assisting natural regeneration

Healthy regeneration of groundcover and shrub species.
(Queen Elizabeth II National Trust)

- Direct seeding
- Establishing a nurse crop
- Planting

5.2.1 Assisting Natural Regeneration

While this method does not fall strictly within the definition of revegetation given earlier in the chapter, it is, nevertheless, an effective method of converting areas to native plants.

For success this method requires:

a) Sufficient adjacent seed sources of quick-growing colonising species.

b) An absence of grazing animals and control of animal pests. *(See Chapter 3)*

c) Control of competing grasses and weeds.

Natural regeneration in healthy forest areas can be prolific. By contrast, at the edge of a remnant or planted area a dense grass sward may prevent native trees and shrubs from germinating and establishing.

The method involves the following:

a) Remove the dense grass sward at the site by screefing (chipping off the surface vegetation to expose the soil) or spraying with knock-down herbicide. This is best done in mid-late summer in time for the annual native seed crop. Seed can be left to drop on to the prepared site from adjacent seeding native species or can be spread by hand. Alternatively small seed-laden branches can be brought in from other sites and laid on the area.

b) 12 to 18 months later a mixture of weeds, grasses and native seedlings will have germinated.

c) Select 4 to 6 of the most vigorous native seedlings in each square metre, hand weed around them and mark their position with a small stake.

d) While protecting these seedlings with a shield of some form (e.g. a 2 litre plastic drink bottle with the bottom cut out) spray out or screef away all the other germinating plants. The surplus native seedlings can be carefully dug out for potting up and growing on.

e) Once the area has been cleared, it can be useful to mulch the area with shredded bark, sawdust, etc. to prevent the growth of further competing vegetation and to conserve the moisture around the selected plants.

f) The selected plants will quickly grow together, shading the ground, making it less favourable for the growth of grass and weeds, and effectively extending the forest. Other shade-tolerant plants can be introduced under the colonising species.

Points to note:

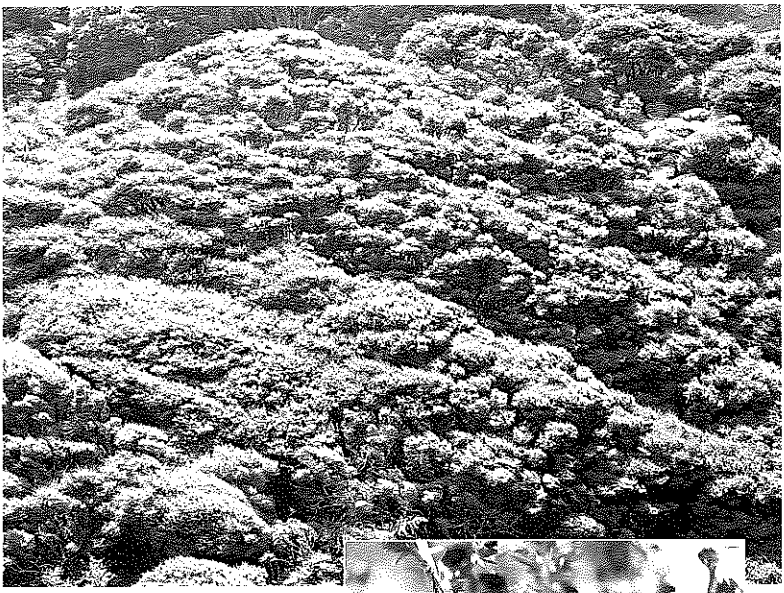
- Until you have tried and perfected the techniques used in this method do not attempt too large an area. (Start with, say, 20 square metres.)
- Always check the forest edge where it gives way to grass to ensure that native seedlings are not already successfully establishing themselves and that a quick hand weeding may be all that is needed to ensure their survival.

5.2.2 Direct Seeding

Direct seeding is a relatively cheap supplement to hand planting of native trees and shrubs.

For success this method requires:

- Sufficiently large quantities of viable seed.
- Time to do the work in the right season.
- That optimum conditions are maintained during germination.
- That competition from invading, unwanted exotic species can be controlled.



A fine stand of even-aged manuka on the slopes of Mt. Karioi, near Raglan.
(Queen Elizabeth II National Trust)

Manuka seed capsules.
(Herwi Scheltus)

Direct seeding involves the broadcasting or placing of seed directly into a prepared site where plants will germinate and grow. Because the conditions are inevitably less suitable for germination and early growth than a nursery situation, only a small percentage of seed will 'take'.

With many seeds, especially larger ones, there is a risk of damage by insects, birds, rodents and drying out.

However, where seed is plentiful or easily brought to a site, the method can be useful.

The most critical factors in direct seeding are the elimination of competing plants, especially grasses, and the maintenance of a microclimate suitable for seed germination and growth. Grasses compete for available moisture in the soil and often outgrow and smother native seedlings. The ground can be suitably prepared by spraying with knockdown-herbicide, screefing, rotary hoeing, ripping, discing or ploughing. Ploughing has the advantage of putting the surface layer of grass, etc. under the soil.

5.2.3 Establishing a Nurse Crop

Often existing vegetation on a site, whether native or exotic, is useful as shelter for establishing plants.

Where there is no vegetation existing, it is often advisable to establish a nurse crop to provide this initial shelter especially on exposed sites.

Commonly used nurse crop species include:

- Manuka
- Tree lucerne
- Eucalypts
- Radiata Pine

Succession to tall forest can be left to proceed slowly from wind or bird dispersed seed, or can be hastened by artificial manipulation of the stand by, for instance, thinning out some of the nurse crop plants and underplanting with native species.

5.2.3.1 Manuka

In many parts of New Zealand the native species which most often acts as a nurse plant in natural situations is the familiar manuka (*Leptospermum scoparium*). Manuka cover provides ideal conditions for the establishment of native trees and shrubs. Plants that can tolerate shade will grow up, overtop, and eventually eliminate the light-demanding manuka.

Manuka goes through a very dense "thicket" stage, when lack of light, and excessive competition for nutrients and water limits the growth of other species. When being used as a nurse crop, manuka stands need to be periodically checked to ensure that unfavourable growing conditions are not being produced and hindering or preventing the establishment of other species. The stand may have to be thinned to let in more light.

Species such as the beeches (*Nothofagus* spp.) are highly light demanding for maximum growth, and cannot be planted under the manuka cover until it begins to decay and open up, or gaps are made artificially. Generally, most canopy forming species will grow better under a manuka nurse crop if it is opened up to let in more light. However, increased light levels also favour the establishment of weed species. Regular checks will be required to ensure weeds do not establish themselves.

Characteristics that ensure the early and rapid establishment of manuka on a wide range of sites include:

- Its wide ecological tolerance.
- Vigorous growth.
- The ability to colonise inhospitable sites, especially those of low fertility and with low temperatures.
- Prolific production of light, wind-borne seed. Whole capsules are readily entangled or water borne so that humans, animals, and rivers also carry seed.

- Manuka seed fall occurs throughout the year, with a major peak in the late winter/spring and a minor peak in the autumn.
- Seed germinates over a wide temperature range and remains viable for several years.

Manuka forms a very dense ground cover with more than 400 plants per square metre in the beginning of a succession. As the stand develops and ages, the density declines, so that when the manuka is 5m high there are about 10 to 20 plants per square metre.

The time that it takes for a stand of manuka to regenerate to forest depends on the site and individual circumstances. Successions through manuka usually take less than 100 years and on fertile sites manuka can die out within 50 years. However, on some sites succession may be prolonged indefinitely, and stands of manuka can be permanent.

Manuka seed germinating under manuka brush laid to encourage vegetation establishment. (Herwi Scheltus)

a) Laying Manuka Brush

It is possible to establish high densities of manuka seedlings by laying branches of manuka laden with ripe seed (brush), which bear semi-mature seed capsules, over bare or cultivated ground. If there is other vegetation, such as grass, it should first be cleared by either cultivation, burning or spraying. The brush is laid over the cultivated ground in several layers in a criss-cross fashion. This should not be laid too densely or it will shade out the germinating manuka. On windy slopes or steep areas, brush should be pegged down, for example with number 8 wire.

As the cut plants dry out, the semi-mature capsules split open and release large quantities of seed. The leaves from the brush fall, covering the seeds

and forming an excellent germination bed. The matrix of cut stems will improve the growing environment for the young seedlings (providing shelter, increased humidity, warmth). This site improvement greatly increases the chances of both the survival of manuka seedlings and the establishment of other species.

Manuka is light demanding and forms even-aged stands with a closed canopy and more open conditions below. The uniform canopy height means that the younger or less vigorous manuka seedlings, and seedlings of the less vigorous and light-demanding species, are quickly suppressed. These may be weeds that are undesirable anyway.

b) Direct Seeding of Manuka

Direct seeding of manuka seed is another method of establishing a nurse cover. Ripe seed capsules are collected from trees and scattered over the newly burnt or cultivated ground. However, this method does not offer the same improved microclimate and growing conditions as the brush method. The less fertile the site the better are the chances that manuka will germinate and survive.

Without further assistance it will take up to 50 years before broadleaved species emerge through the manuka canopy. You can hasten the development of the stand by thinning and planting under manuka or kanuka. *(See Section 10.2: Planting under Manuka and Kanuka)*

Direct seeding of manuka seed on to open ground. (New Zealand Native Forest Restoration Trust)

c) Planting a Mixture of Manuka and Other Quick-Growing Species
The crown spread of many other quick-growing species, such as *Coprosma*, and *Pittosporum* species, is potentially greater than that of manuka. Canopy closure may be attained more rapidly if a mixture of all these species is used, including manuka.
(See Appendix I: Native Colonising and Nurse Plants)

5.2.3.2 Tree Lucerne

Tree lucerne (*Chamaecytisus palmensis*), an exotic species, is a short-lived legume that can establish itself on a wide range of sites although its preference is for free-draining soils. It is useful for revegetation because it is fast growing (up to 2m in the first season following planting out) not too heavily foliaged, tolerant of a range of conditions, and short-lived. It may be damaged by heavy frosts.

From June to September New Zealand pigeons (kereru) eat the flowers, shoots and foliage of tree lucerne, and, along with tui and bellbirds, eat the nectar from the flowers. Tree lucerne assists in the spread of the seeds of native trees and shrubs which are excreted by the pigeon. Tree lucerne also provides bees with pollen and nectar in early spring, when such bee forage is in short supply.

Tree lucerne is commonly supplied from nurseries in small peat pots or root trainers ready for planting out. Seed collected directly from trees can also be hand broadcast onto prepared sites.

Native pigeon (kereru) feeding on tree lucerne.
(Department of Conservation)

Tree lucerne as a nurse crop. Native trees and shrubs will be planted in the semi-shade under these plants in subsequent years. (Queen Elizabeth II National Trust)

5.2.3.3 Eucalypts

Eucalypts are suitable as a nurse crop because of their speed of growth in many parts of the country when young. They can attract native birds with their flowers. With careful planning it may be possible to plant species suitable for firewood or fenceposts and harvest them once a suitable understorey of native plants has established.

Suitable Eucalypt species include:

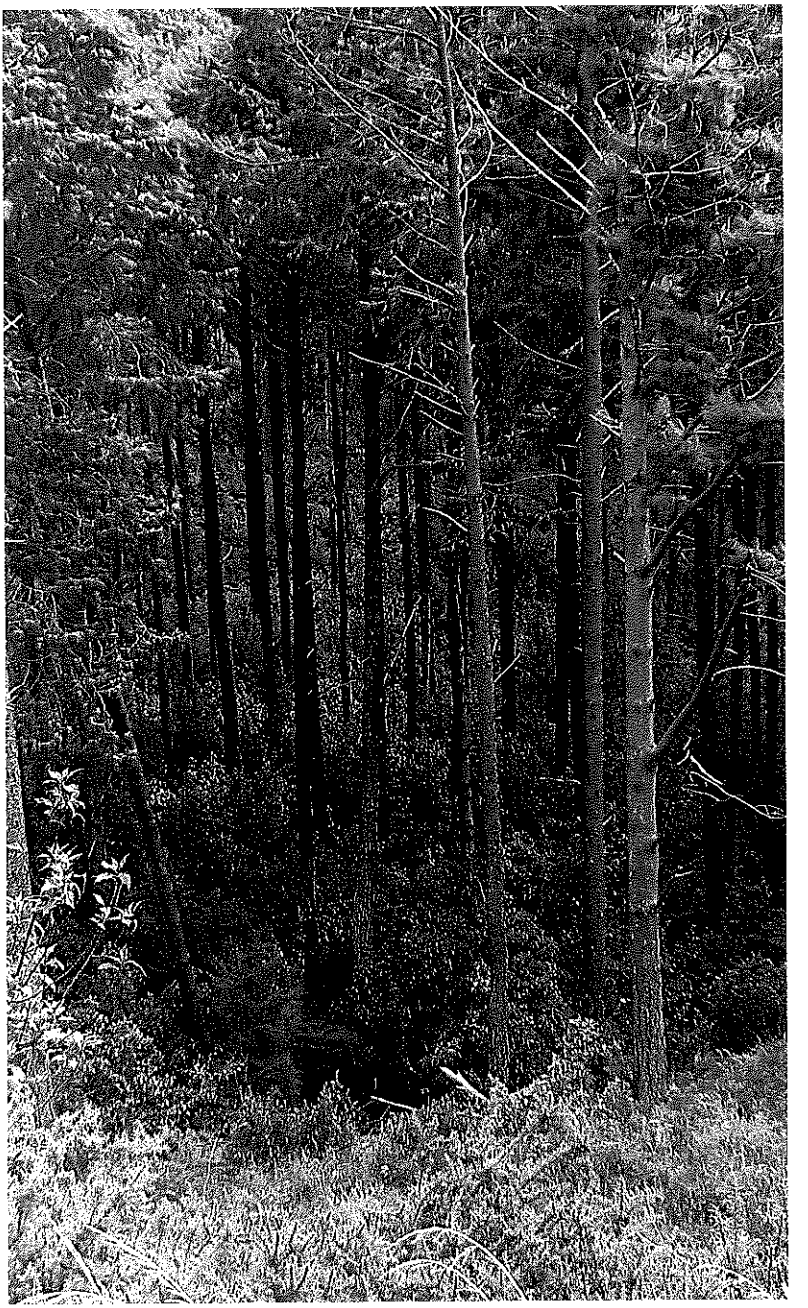
SPECIES	SUITABLE FOR
Eucalyptus botryoides	Coastal areas
E. delegatensis	Cold areas
E. nitens	Very cold inland areas
E. regnans	Warmer inland areas
E. saligna	Coastal areas

5.2.3.4 Radiata Pine

Radiata Pine (*Pinus radiata*) provides a fast growing nurse crop for the establishment of native species. There are examples in many parts of New Zealand of areas of native vegetation that have established under radiata pine.

The pines can be used for posts at a young age once suitable understorey plants have established. Alternatively, the pines can be managed through to maturity and harvested. Harvesting by conventional methods is likely to cause considerable damage to the native understorey but in most cases the increased light levels will result in the native plants recovering well in a relatively short time (two or three growing seasons).

Adequate light getting to the planted seedlings can be a problem under pines, and occasional pruning and thinning will be required. The alternative to removing the radiata pine nurse crop is to ring-bark it, or poison it, and let it die *in situ*.



Regeneration of native species under pine trees near Nelson. (Martin Conway)

5.3 Planting

The most common method of revegetation is planting native species directly into the site. The plants can be sourced from:

- existing forest areas (wild plants)
- commercial nurseries (under contract)
- your own 'backyard' nursery

(See Chapter 6 : Sources of Plants)

Further Sources of Information:

Bishop, Nic	*Natural History of New Zealand* Hodder and Stoughton, Auckland, 1992
Cockayne, L	*New Zealand Plants and Their Story* Fourth Edition edited by Godley, E. Government Printer, Wellington, 1967
Dawson, John	*Forest Vines to Snow Tussocks: the Story of New Zealand Plants* Victoria University Press, Wellington, 1988.
Scheltus, H.W.	Current Revegetation Techniques Used in the Central North Island *The Landscape*, July 1983. 11-14
TOPNZ	*New Zealand Native Plants* course The Open Polytechnic of New Zealand

Sources of plants 6.0

Plants in the Wild 6.1

With permission from the landowner or controlling authority, young seedlings can be taken from the wild and used for revegetation. They can be taken from roadsides, firebreaks, logging tracks, cleared fence lines, areas of exotic forest, from forest which is to be destroyed by earthworks or milling, or from bush areas where seedlings are very numerous. Wild plants can also be lifted from bush nurseries where the site has been prepared to allow seedlings to become established. Wild plants should never be removed from National and Forest Parks, Scenic Reserves, or other land set aside for conservation purposes.

6.1.1 Collecting Wild Plants

Wild plants in the 6-45cm height range are suitable, but best results have been achieved with plants in the range of 10-15cm tall. Generally, the smaller the plant the better they transplant. Often it is best to prune the plant roots to encourage the development of a compact fibrous root system. This is called wrenching and is best done 6 to 8 weeks prior to lifting. Wrenching is best done in autumn while there is still active root growth. It involves making spade cuts (with a sharp spade) around the plant 5-6cm out from the plant stem. *(See 7.7.2: Wrenching)* Lifting and transplanting are best done during winter, or early spring in frosty areas.

Wild plants suitable for growing-on for revegetation use at another site.
(Queen Elizabeth II National Trust)

Wild seedlings with good root systems. (Bruce Treeby)

One successful method of lifting a wild plant is to make four sloping spade cuts, each about 8cm out from the plant stem, and lift out the clod of earth containing the plant. Try to retain as much earth around the plant as possible. Wrap the plant and clod in wet newspaper, or damp moss, and put it in a plastic bag or carton.

Often it is necessary to prune back at least a third of the above-ground plant to reduce the leaf area and stop the plant drying out too much when it is removed from the site. Plants lose moisture mainly through the leaves. By removing some of the leaves, moisture loss is reduced. Often the roots of wild plants are distorted and some root pruning will be necessary in order to stimulate a fibrous root system. The seedlings should be graded into size classes, carefully transplanted into prepared, fertilised and shaded beds, and left to grow.

Wild plants need protection against both wind and sun. Plants taken out of the bush are generally very tender with weak root systems and liable to sun scorch (having developed under sheltered conditions with low light intensities). Wild plants can be left to grow for 1 or 2 years in the nursery. This will produce well developed seedlings. Carefully transport and plant them at the revegetation site.

It should be noted, however, that wild plants planted out directly from the forest are no substitute for well conditioned nursery plants. The failure rate with directly planted wild plants is high, especially on exposed sites.

6.1.2 Transplanting Wild Plants

The success of transplanting wild plants depends on the skill of the individual and also on the species and age of plants. Most seedlings, or small plants of broadleaved species and of the native conifers (eg matai, kahikatea, rimu, kauri, totara, miro) transplant well if done carefully. Some general principles to follow are:

- Cut off one-third of branches and leaves of trees and shrubs to reduce moisture loss.
- Cut off all the fronds of ferns before replanting.
- Species with creeping underground stems (rhizomes) are often more easily transplanted than those without.
- Species which creep and root on the ground surface are also easy to transplant.
- Species such as flax, cabbage tree, native grasses, toetoe and sedges generally transplant well. For these species it is best to cut off the bulk of the leaves since this reduces moisture loss.

Contract Growing 6.2

A contractual arrangement with a reliable nursery will result in plants for your project being produced to a specified quality and size at a known unit cost. This unit cost is likely to be low as nurseries, aiming to produce high quality plants in the minimum time, have sophisticated techniques for the propagation and production of plants, and the seedlings and plants will be raised under optimum growing conditions. Check to see if there is a nursery specialising in growing native plants in your area.

The more plants that are grown under a contract growing scheme, the cheaper each plant will be. You could link up with other people who are also interested in revegetation, and share the plants and the cost. Conservation groups and schools, as well as individuals, may be interested. Involving your local school in such a scheme is a good idea as it encourages the children to interest their parents in similar work on their own properties.

If you decide to approach a nursery to grow specific kinds and numbers of plants over several years, it is essential to consider the following points:

6.2.1 Source of Propagation Material

The source of propagation material is still an important factor. *(See Section 2.4.4: Genetic Purity of Native Plants)* If a local source of seed and cuttings is to be used it may be necessary for you to collect and supply them to the nursery, or you could identify the site(s) and allow the nursery to collect.

All propagation material supplied to the nursery should be clearly labelled with the botanical and common name and you should ensure that the nursery understands the aim of the revegetation project. It is also important that the nursery understands that substitute plants from other areas are not acceptable for native revegetation and restoration projects.

Commercial nurseries are geared to produce large number of plants at a low unit cost. (Herwi Scheltus)

Planning is necessary to enable sources of propagation material to be identified, and sufficient seeds or cuttings to be collected a year or two in advance before the resulting plants are required.

6.3 Growing Your Own Plants

Growing your own plants for a revegetation project is an option worth considering. Expenses are likely to be lower than for commercially grown plants although there is an obvious time commitment.

Chapter Seven discusses propagating and growing your own plants.

Propagating native plants 7.0

Establishing a Nursery 7.1

Propagating native plants can be very satisfying. Most native plants are not difficult to propagate from seeds or cuttings if a number of basic procedures are followed.

The main requirements for a small nursery are:

- Covenient location close to normal daily activities.
- A place to comfortably undertake tasks such as seed sowing and potting up.
- A cool, shady, moist place to germinate seeds and grow plants once they have been potted up.
- An open, but sheltered, area where plants can be placed to harden off before being planted.

The facilities required will depend on the scale of the nursery operation, that is, the number of plants to be grown per year. It is possible to produce reasonable numbers of plants using space in the domestic garden. For larger numbers some sort of shade house is required in which to germinate seeds and establish small plants once they have been potted up.

Nursery potting bench. (Herwi Scheltus)

Small scale nursery. (Bruce Treeby)

Ideally the area chosen as a nursery area should be sunny, sheltered, partially shaded (by vegetation, buildings or trellis), flat, have easy access and a reliable water supply. Windbreak cloth can be used to create artificial shelter and shade if required. The margin of an existing forest remnant can provide suitable conditions.

7.1.1 Work Area

A garden shed is ideal for storing materials such as seed-sowing soil, potting soil, fertilisers and plant containers. A flat workbench is necessary on which to undertake the indoor tasks of sowing seed, 'pricking out' (planting out) seedlings and potting up plants into larger containers. For smaller operations, a laundry area or back porch may be adequate.

7.1.2 Shade House or Frame

A shade house or shade frame is essential for the germination of seeds and getting plants established when they have been potted up into containers. It creates its own microclimate, reducing evaporation and protecting against the extremes of heat, wind and sun, and minimising frost, rain and hail damage. It can be simple and on a small scale.

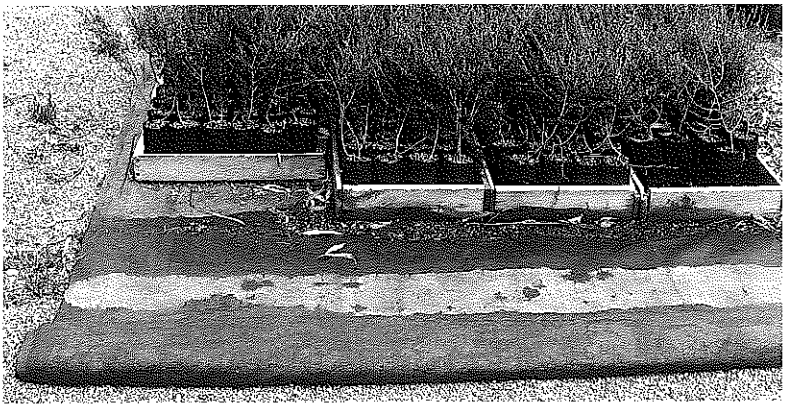
A shade house the size of a garden shed can be made from manuka brush, trellis or shade cloth. Fifty per cent shade cloth is the most common material used.

A shade frame is more the size of vegetable garden cloche and can be easily constructed using a timber frame with removable or hinged shade cloth covered top.

Simple, easily constructed shade frame. (Bruce Treeby)

7.1.3 Standing Out Area

Once plants have established themselves in their containers in the relatively sheltered conditions of the shade house or frame, they are then placed out in a standing out area to harden off. Weed control is necessary



Standing out area with weed mat visible. (Bruce Treeby)

in the standing out area. This can be done by:

a) Laying a thick coat of untreated sawdust. Boards should be fixed in place with pegs to form boxed areas of an appropriate size. The boxed in areas should be filled with sawdust to a depth of 150mm. Weeds will occasionally appear in the sawdust.

b) Laying polythene sheeting and gravel. The polythene sheeting is laid over the site and a layer of 5-10mm gravel chips is spread on that to a depth of about 5cm. The container-grown plants are stood on the gravel.

c) Commercially produced weed control mat. Although more expensive than the above, this strong, woven polypropylene fabric has the advantage of allowing water to seep through, and air to escape. It is also stabilised for ultra-violet light. Water seepage prevents standing puddles of water which often occur when sheet plastic films are used, and this minimises bacteria and fungus problems. The humidity rises through the woven fabric so preventing soil mould stench which occurs under plastic films. For best results the ground should be cleared before installation and the container stood directly on the mat.

7.2 Propagation of Native Plants from Seeds

Propagation from seed is the easiest and most commonly used method of propagating native trees and shrubs.

Assorted native seeds. (Martin Conway)

Totara fruit.
(New Zealand Forest Research Institute)

Kahikatea fruits.
(Queen Elizabeth II National Trust)

7.2.1 Seed Collection

(See Table II: Seed collection, cleaning and treatment, pages 116 to 121)
Seed collection times will vary from region to region and from year to year and those given in Table II are a guide only. From flowering onwards, a close check should be kept on species from which you intend to collect seed. It is useful to note flowering and seeding times in your area for future reference.

Seed can be stripped or picked off lower branches of trees and shrubs or collected off the ground. Where seed is prolific and the relevant permission is obtained, small branches can be pruned off with secateurs for stripping at a later time.

Where seed is out of reach, hessian or shade cloth sheets can be laid on the ground, or suspended above the ground (to deter rodents), during seed fall.

If seed is light and easily dispersed by the wind (for example, rewarewa or members of the daisy family), it is best to collect seed capsules shortly before they open. Seed can also be raked up with forest litter.
(See Section 7.7: Forest Duff)

7.2.2 Seed Cleaning

(See Table II: Seed collection, cleaning and treatment, pages 116 to 121)

Before sowing or storing seed for sowing later, some seed must be cleaned to remove material such as fleshy fruit and seed husks.

Table II lists suggested seed cleaning techniques for a range of native trees and shrubs. An explanation of the abbreviations is as follows: –

SFSD: Soak, Friction, Sieve, Dry

FSS: Friction, Sand, Sieve

FS: Friction, Sieve

Soak: Soak the seeds in water for 2-3 days. This technique is used to remove fleshy fruit from seeds such as *Coprosma* spp.

Friction: Rubbing the fruit together. This helps to break away husks and separate out the seeds. An example of a fruit treated in this way is titoki.

Sieve: Once fruit has been soaked or rubbed to remove fleshy or dry matter, it is put through a sieve to separate out the seeds.

Dry: Seeds should be spread out in a warm, dry place to dry and prevent fungal problems.

Sand: Sand is added to fruit with sticky seeds to help separate them and make sowing easier.

Collecting seed from a karo bush. (Herwi Scheltus)

7.2.3 Seed Treatment

(See Table II: Seed collection, cleaning and treatment, pages 116 to 121)

Special treatment of seeds can speed up germination in some species and/or improve the rate of germination in others.

There are two main types of seed treatments:

a) Mechanical

Some seeds have a hard exterior coat which prevents the entry of moisture essential for germination. Kowhai is an example. These seeds can be treated by dropping them into water which is just on boiling point; immediately remove the water from the heat and allow the seeds to soak for 12 to 24 hours before sowing. Alternatively, the hard outer coat of the seed may be broken by chipping with a knife, or a nail clipper or rubbing on sandpaper.

b) Cold Treatment (Stratification)

Some seeds have dormant embryos which will not germinate until certain changes have taken place. This is known as after-ripening. Germination can be stimulated by cold treatment (stratification). This involves subjecting moist seeds to low temperatures for a specified length of time. The seeds are soaked for 12 to 24 hours and then mixed with a moisture-retaining medium such as sand, peat or well-rotted sawdust.

The mixture of seeds and medium is then placed in a jar, plastic bag or container in a refrigerator or under shrubs in the coldest part of a garden over winter. In spring, or after the specified time, the seeds and medium are sown in the normal manner.

Table II lists those native trees and shrubs which benefit from stratification and the length of treatment required.

7.2.4 Storage of Seed

Seed that has been collected and cleaned but is not immediately required for sowing can be stored for future use. Store seeds in dry conditions, in airtight containers at 4.5° C.

Table II: **Seed collection, cleaning and treatment**

SCIENTIFIC NAME	MAORI OR COMMON NAME	COLOUR OF RIPE FRUIT	SEED COLLECTION TIME	SEED CLEANING	SEED TREATMENT		COMMENTS
					Sow Fresh	Stratify at 4°C (weeks)	
Agathis australis	kauri	dark green cone	Sep-Nov	FS	Yes	2	Good seed is flat and firm. Best sown fresh.
Alectryon excelsus	titoki	red-black	Oct-Dec	FS		4	Crack brown cases, being careful not to damage seed Prone to weevil attack.
Aristotelia serrata	makomako,	deep red	Jan-Feb	SFSD		3	Seed needs to be well dried. Treat with fungicide.
Beilschmiedia tarairi	tarairi	dark purple	April-May	SFSD	Yes	4	Seed collected from ground. Treat for weevils.
Beilschmiedia tawa	tawa	dark purple	April-June	SFSD	Yes	4	
Brachyglottis repanda	rangiora	off-white	Jan-Feb	FS		4	Light germination. Cover seed with thin layer of gravel.
Carpodetus serratus	putaputaweta	black	Mar-May	SFSD		6	
Coprosma foetidissima	stinkwood	orange	Feb-April	SFSD		3	
Coprosma grandiflora	konono	orange-red	Mar-April	SFSD		3	
Coprosma lucida	shining karamu	orange	Mar-April	SFSD		3	Often uneven germination.
Coprosma propinqua	mingimingi	blue	Mar-May	SFSD		3	
Coprosma repens	taupata	orange	Jan-Feb	SFSD		3	

SFSD = soak, friction, sieve, dry FSS = friction, sand, sieve FS = friction, sieve

Table II: **Seed collection, cleaning and treatment**

SCIENTIFIC NAME	MAORI OR COMMON NAME	COLOUR OF RIPE FRUIT	SEED COLLECTION TIME	SEED CLEANING	SEED TREATMENT		COMMENTS
					Sow Fresh	Stratify at 4°C (weeks)	
Coprosma robusta	karamu	orange	Mar-April	SFSD		3	Germination uneven
Cordyline australis	ti kouka, cabbage tree	cream	Feb-Mar	SFSD		3	Best results from fully ripened seed.
Cordyline banksii	ti ngahere/southern cabbage tree	bluish	Mar-April	SFSD		3	
Coriaria arborea	tutu	black	Dec-April	SFSD		3	Seed should be thoroughly dried to prevent fungal problems.
Cortaderia fulvida	toetoe	beige	Dec-Feb	FS		3	
Corynocarpus laevigatus	karaka	orange	Dec-Feb	SFSD		4	Flesh more easily removed from seed if soaked for 1 week.
Dacrycarpus dacrydioides	kahikatea	indigo-red	Mar-May	SFSD		6	
Dacrydium cupressinum	rimu	black/red	Jan-April	FS		3	Sets seed at irregular intervals, usually of 5-6 years.
Dodonea viscosa	akeake	brown	Jan-April	FS		3	Do not sow too thickly as plantlets quite leafy and fast growing.
Dysoxylum spectabile	kohekohe	green-brown capsule with orange segments	Mar-May	FS	Yes		Cannot be stored. Sow as soon as possible after collection. Remove seed carefully from capsules and segments.
Elaeocarpus dentatus	hinau	dark purple	May-June	SFSD		20	
Fuchsia excorticata	kotukutuku, tree fuchsia	dark red to black	Feb-April	SFSD		2	Plantlets very thin leaved and prone to drying out.

SFSD = soak, friction, sieve, dry FSS = friction, sand, sieve FS = friction, sieve

Table II: **Seed collection, cleaning and treatment**

SCIENTIFIC NAME	MAORI OR COMMON NAME	COLOUR OF RIPE FRUIT	SEED COLLECTION TIME	SEED CLEANING	SEED TREATMENT		COMMENTS
					Sow Fresh	Stratify at 4°C (weeks)	
Geniostoma rupestre	hangehange	black	Feb-April	FS		4	
Griselinia littoralis	kapuka, broadleaf	black	April-May	FS		3	Seeds prone to fungal problems. Viability falls off after 1 year. Semi-hard cuttings take well.
Hebe spp.	hebe	brown	Nov-March	FS	Yes	2	Sow seed on sphagnum moss. Semi-hard cuttings take well.
Hedycarya arborea	porokaiwhiri, pigeonwood	dark purple	Nov-Jan	SFSD		14	Not necessary to remove seed from seed shell. Discard seed that floats when in water.
Hoheria spp.	houhere, lacebark	brown	May-June	FS	Yes	3	
Knightia excelsa	rewarewa	brown	April-June	FS		4	Seed loses viability within year if stored at room temperature.
Kunzea ericoides	kanuka	brownish grey	Mar-April	FS	Yes		Sow through fine kitchen sieve.
Laurelia novae-zelandiae	pukatea	brown	April-June	FS		2	Does not store well. Germination highly variable.
Leptospermum scoparium	manuka	grey	Mar-May	FS	Yes		Sow through fine kitchen sieve.
Lophomyrtus bullata	ramarama	maroon	April-June	SFSD		8	
Macropiper excelsum	kawakawa	orange	Feb-Mar	SFSD		4	

SFSD = soak, friction, sieve, dry FSS = friction, sand, sieve FS = friction, sieve

Table II: **Seed collection, cleaning and treatment**

SCIENTIFIC NAME	MAORI OR COMMON NAME	COLOUR OF RIPE FRUIT	SEED COLLECTION TIME	SEED CLEANING	SEED TREATMENT		COMMENTS
					Sow Fresh	Stratify at 4°C (weeks)	
Melicope ternata	wharangi	black	Feb-April	FS		4	Give seed hot water treatment.
Melicytus ramiflorus	mahoe	purple	Feb-April	SFSD		6-8	
Metrosideros excelsa	pohutukawa	grey	Jan-Mar	FS	Yes	2	Viability drops off after 1 year.
Myoporum laetum	ngaio	purple	Mar-April	SFSD		8-10	Tip cuttings take root in 5-7 weeks.
Myrsine australis	red matipo, mapou	black	Jan-April	SFSD		4	Seed prone to weevil attack.
Nestegis spp.	maire	red	Jan-Mar	SFSD		20	
Nothofagus fusca	tawhai, red beech	brown	Feb-Mar	FS		8	For all beeches, may need to add some forest duff to seed tray to provide mycorrhiza.
Nothofagus menziesii	tawhai, silver beech	brown	Mar-April	FS		8	
Nothofagus solandri	tawhai, black beech	brown	Feb-May	FS		8	
Olearia spp.	tree daisy	off-white	Nov-Jan	FS		2	Light germination. Viability falls off rapidly. Seed attachment makes up much of the seed bulk.
Pennantia corymbosa	kaikomako	black	Mar-April	FS		12	
Phormium tenax	harakeke, swamp flax	black	Jan-Mar	FS		3	
Phormium cookianum	wharariki, coastal flax	black	Jan-Mar	FS		3	

SFSD = soak, friction, sieve, dry FSS = friction, sand, sieve FS = friction, sieve

Table II: **Seed collection, cleaning and treatment**

SCIENTIFIC NAME	MAORI OR COMMON NAME	COLOUR OF RIPE FRUIT	SEED COLLECTION TIME	SEED CLEANING	SEED TREATMENT		COMMENTS
					Sow Fresh	Stratify at 4°C (weeks)	
Pittosporum crassifolium	karo	black	May-July	FSS		8-10	Add a little sand to Pittosporum seed to reduce stickiness and improve separation from the shell. Or use 'Swarfega' handcleaner.
Pittosporum eugenioides	tarata, lemonwood	black	April-June	FSS		5-6	
Pittosporum tenuifolium	kohuhu	black	April-June	FSS		5-6	
Plagianthus regius	manutu, ribbonwood	fawn	Nov-April	FS		4	Treat seed well with fungicide and insecticide – prone to fungal and weevil attack.
Podocarpus totara	totara	green-red	April-May	SFSD		8-10	Sporadic seeder.
Prumnopitys ferruginea	miro	black-red	April-Nov	SFSD		20	Germination often slow – sometimes years.
Prumnopitys taxifolia	matai	dark bluish black	Feb-May	SFSD		20	
Pseudopanax arboreus	five finger	dark burgundy	May-July	SFSD		8-10	
Pseudopanax crassifolius	horoeka, lancewood	dark burgundy	Jan-Arpil	SFSD		8-10	
Pseudowintera colorata	horopito	black	Feb-April	SFSD		8	
Rhopalostylis sapida	nikau	red	April-May	SFSD		12	
Solanum spp.	poroporo	orange	Nov-Jan	SFSD		4	

SFSD = soak, friction, sieve, dry FSS = friction, sand, sieve FS = friction, sieve

Table II: **Seed collection, cleaning and treatment**

SCIENTIFIC NAME	MAORI OR COMMON NAME	COLOUR OF RIPE FRUIT	SEED COLLECTION TIME	SEED CLEANING	SEED TREATMENT		COMMENTS
					Sow Fresh	Stratify at 4°C (weeks)	
Sophora microphylla	kowhai	yellowish brown	July-Aug	FS			Nick seed with knife or rub with sandpaper or drop seeds into boiling water. Remove from boil and leave to soak for 24 hours.
Sophora tetraptera	kowhai	yellowish brown	July-Aug	FS			
Vitex lucens	puriri	crimson	Dec-May	SFSD		4	
Weinmannia racemosa	kamahi	brown	Jan-May	FS	Yes	2	

SFSD = soak, friction, sieve, dry FSS = friction, sand, sieve FS = friction, sieve

Seed-sowing mix being firmed down in seed tray. (GF Harris)

Seed trays in glasshouse. (Herwi Scheltus)

7.3 Sowing Seed

7.3.1 Sowing in Containers

Containers suitable for sowing seed include purpose-made plastic and wooden seed trays (available from horticultural suppliers and some nurseries), flower pots, old baking dishes and many household plastic containers. The main requirements for containers are that they have good drainage, hold the germinating medium and are easily handled.

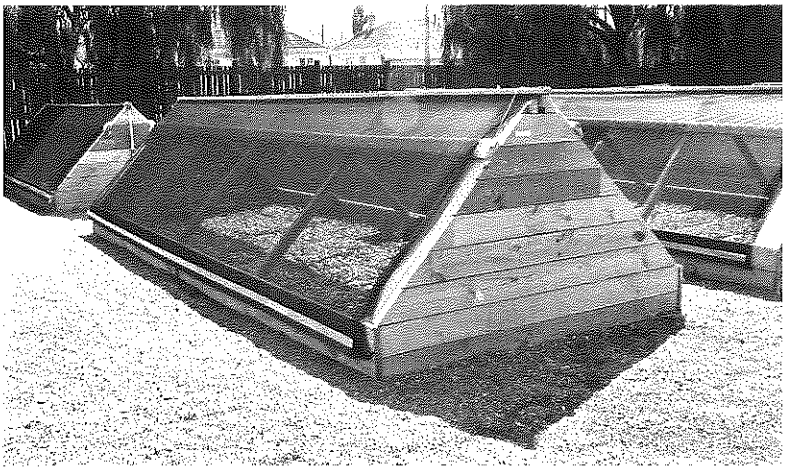
These seed trays have been sown and covered with glass and newspaper to provide optimum germination conditions. (GF Harris)

Sowing kowhai seed. (Herwi Scheltus)

Seed germinating soil can be purchased in bags from nurseries, or it can be made up using soil, coarse sand and sieved damp peat. Alternatively, mixtures of sand and peat in varying proportions can be used, as can materials such as perlite and vermiculite (obtainable from horticultural suppliers). "Home-made" soil mixes have the disadvantage that, unless sterilised, they may contain weed seeds and fungi harmful to germinating seeds.

The seed sowing container is filled with seed mix, smoothed and pressed down. When sowing, avoid spreading the seeds too thickly. With very fine seed, it is useful to mix them with fine, dry sand before sowing to ensure even distribution when sowing. Fine seeds should be simply firmed down into the compost using a flat wooden float. Other seeds are firmed down in a similar manner, then covered with compost to their own depth and lightly pressed down.

After sowing, the seed compost should be moistened either with a fine



Seedlings growing in a small shade house. (Bruce Treeby)

spray of water or by sitting the container in a tub or tray of water and allowing the compost to soak up the water. A sheet of glass or plastic film is then placed over the tray to reduce moisture loss. Newspaper is then placed over the glass. Containers should be placed in indirect light, **not** direct sunlight.

The material in the seed boxes should never be allowed to dry out. Spray weekly with fungicide to prevent "dampening off" fungus which kills young seedlings.

A glasshouse or cloche can aid germination by raising the temperature of the seeds and soil.

As soon as germination begins, the glass cover and newspaper should be removed.

7.3.2 Pricking Out

Once seedlings have germinated and have reached about 2cm, or have 2-4 leaves, they need to be transplanted from the seed tray and into individual containers. This is called 'pricking out' and should be done in cool, windless conditions.

7.4 Growing-on in Containers

Seedlings can be pricked out initially into small individual containers such as yoghurt containers or peat pots. Once they have grown, but before their roots become unduly constricted, they are then potted into larger containers such as plastic planter bags or planted out in the open ground in prepared beds. *(See 7.6: Growing-on in open ground)*

Rootrainer-grown stock showing well developed root systems. (Herwi Scheltus)

Commercially produced potting mix can be used. Alternatively, mix can be made up using ⅓ peat, ⅓ pumice, ⅓ sand. Slow-release fertiliser should be mixed into the potting mix. A range of household containers can also be used for growing-on, such as cut-down plastic and cardboard milk containers.

Rootrainers are a commonly used container system for growing-on plants. They are thermoformed sheet plastic containers in sets of four, or more, hinged along the bottom. The sides are spread apart to lift out the plant for planting. The individual containers have vertical grooves to discourage spiral growth of the root system. The containers fit into a wire basket and are held off the ground which air prunes roots as they emerge at the bottom of the container. Normally with rootrainers, seedlings are pricked out and left to grow through to planting out stage.

Sowing seed directly in open ground seeds beds.
(New Zealand Forest Research Institute)

7.5 Propagating Plants in the Open Ground

Plants grown in the open ground (or in nursery beds) are called bare-rooted plants. There is no restriction on root growth (unlike with plants grown in a container) and when the plants are lifted out of the ground for transport to the planting site, the roots have little or no soil around them.

Seedlings or cuttings can be transplanted into prepared beds or, alternatively, seed can be sown directly into the beds.

The beds should be rotary-hoed into a fine tilth then rolled or trampled firm. Use a rake to cultivate the top 5cm prior to seed sowing. The seeds can be sown in rows or broadcast over the whole bed. After sowing, moisten the seedbeds and place 50 per cent shadecloth over the seedbeds to help retain moisture, increase humidity and exclude rodents, birds and cats.

Once the seedlings have germinated they can be pricked out into containers or lined out in the open ground.

Growing-on in Open Ground 7.6

Plants propagated either in seed trays or in open ground seed beds can be grown-on in open ground and then planted as bare-rooted stock.

When the seedlings have reached 20 to 30cm in height, they are removed and replanted in a prepared bed. This is called lining out. In a small scale operation this bed may be the size of a small-medium sized vegetable garden. When lining out, plant the seedlings in rows about 20 cm apart and with about 20cm between rows. Between every four or five rows leave room to move down the rows to weed and maintain the plants.

To prevent drying out during hot weather and to encourage rapid upward growth, suspend 50 per cent shade cloth over the plants. This is stapled or battened onto timber frames which are supported on wooden posts above the plants.

Forest Duff 7.7

An alternative to collecting seed as it falls, or to transplanting wild plants is to use the seed lying on the forest floor. Forest duff (or humus) is an ideal beginning, or supplement to revegetation. It is possible to obtain material that produces up to 1200 seedlings per square metre with 40 different species from good collecting sites.

The selection of the area from which the forest duff is taken is the most important factor in determining the quantity and range of plants that can be expected from a sowing.

Duff should be collected from species-rich areas dominated by colonising species such as shrubland or areas on the edge of a forest. Such areas usually contain a great variety of plant species, many of which grow vigorously and produce large quantities of seed. These areas are much favoured by many bird species and receive bird-dropped seed of plant species not present in the vicinity.

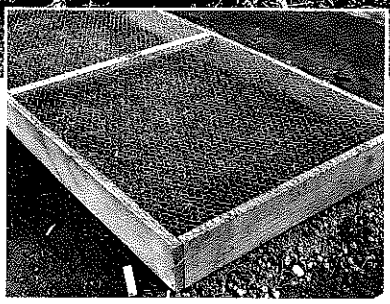
Avoid collecting duff which has seed of grasses or weeds in it.

7.7.1 Collecting and Propagating

Duff should be raked from the forest floor in the autumn, after most species have ceased seeding. Care should be taken to ensure that by hard raking the underlying moist, fragmented, humified material is collected as well as the coarse surface litter. This material produces a good seedbed and contains much of the seed.

The duff should be thoroughly sieved to remove the coarse material such as bark and twigs. Sieving through two layers of chicken netting is sufficient. Pack the sieved material loosely into polythene bags, making sure it is moist, and loosely tie the bags. Store them in a cool, shaded place – ideally between 2 and 4 degrees Celsius or in a refrigerator. If the

Seedlings from forest duff. (New Zealand Forest Research Institute)



Forest duff seed bed. (GF Harris)

material is collected in May/June, storing under the closed canopy of a shrubbery is probably adequate. The material should be stored for at least 8 weeks, but up to 14 or 15 weeks is preferable. This process is called stratification. *(See 7.2.3: Seed Treatment)*

Commercial nurseries normally stratify all their native seeds. The main advantage is that they germinate evenly and are at the same stage of development for handling and potting.

In spring, the seed bed should be formed and worked to a fine tilth, and be well drained. The raised seedbed should be about 10cm above the surrounding soil. Incorporate a slow release NPK fertiliser into the top 10 cm of the seedbed. The seedbed should be lightly rolled and the sieved duff spread over it evenly, about 2cm deep. Roll lightly again and then cover the duff with finely sieved soil to a depth of 3 to 4mm.

The beds must be kept moist and partly shaded – a woven shade cloth mesh providing 50 per cent shade is ideal. This is stapled or battened onto timber frames which are then laid on the seedbeds.

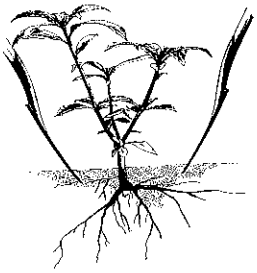
Heat may build up under the shade cloth as summer temperatures rise but by that time most of the seeds will have germinated and the threat from seed eating birds lessened. The frames may be raised on short wooden stakes to allow air circulation but still ensuring that the seedlings

are not in direct light. This simulates the shade conditions of the forest floor.

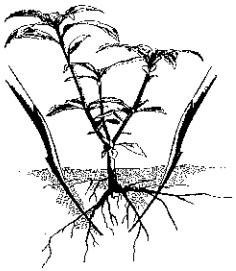
Shade cloth on frames also serves to keep out birds. Rodents must also be kept out; rodent poison can be put in a plastic tube along the inside edge of the frame. *(See 3.3.6: Rats)*

7.7.2 Wrenching

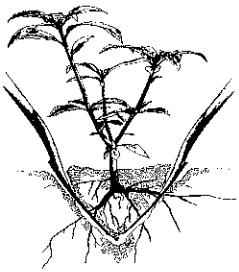
The following autumn or spring, the seedlings can be carefully lifted and the roots trimmed to about 12cm. Then the seedlings are lined out (placed in rows) in the nursery beds at a wider spacing. The spacing depends on the species. Fast growing, shrubby species need at least 15cm between plants, the tree species a minimum of 10cm. The rows must be spaced



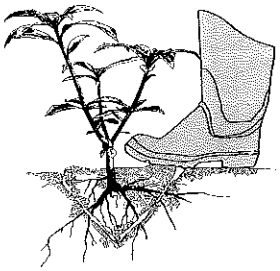
(a) usually, two people work together with spades on either side of the row. Insert the spades about 15cm from the stem.



(b) push the spades into the ground at an angle of about 45°, cutting the lateral and tap roots.



(c) to lift the plants a little the spade handles are slighty depressed.



(d) settle the plants back in by tramping with your feet.

Wrenching. (The Open Polytechnic of New Zealand)

widely enough to allow for wrenching and lateral root pruning (about 20cm). If seed fails to germinate in the first season it is worthwhile maintaining the bed, for a number of species are likely to germinate in the second year.

7.7.3 Depositing Duff Directly

Although the best results will be obtained if the duff is cultivated under nursery conditions, direct depositing of duff on the site should be considered. These duff beds can be overlaid with manuka brush or similar, to provide the necessary shade and suitable microclimate for the seedlings, once germinated.

7.8 Propagation of Native Plants from Cuttings

Many New Zealand trees and shrubs can be raised from cuttings. There are three types of cuttings: hardwood, semi-hardwood, and softwood. In taking cuttings the following points should be noted:

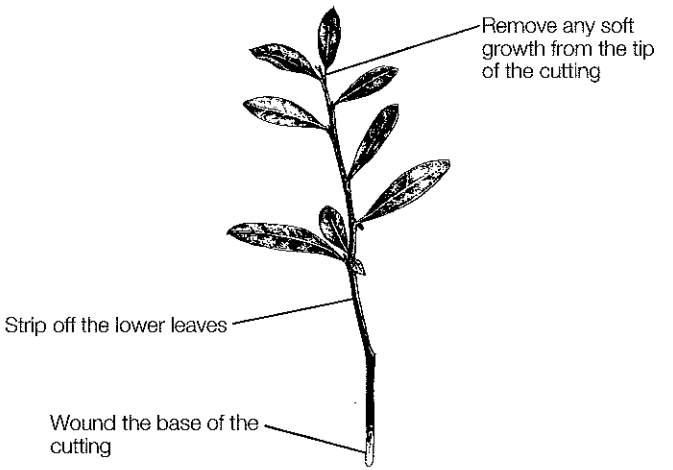
- Take cuttings from a range of plants to ensure greater genetic variation.
- Always take cuttings from healthy plants.
- Short side shoots should be used rather than rapidly growing terminal shoots.
- Always use a clean sharp knife or pair of 'parrotbeak' secateurs.
- Keep cuttings cool and moist at all times during preparation.
- Cuttings can be grown-on in containers or in the open ground *(See 7.4: Growing-on in Containers and 7.6: Growing-on in Open Ground)*
- Keep detailed records of all aspects of the process and the results.

7.8.1 Hardwood Cuttings

Hardwood cuttings are made from shoots which have grown during the preceding growing season and are generally taken during the early part of winter, normally May. Hardwood cuttings should be woody, bear mature leaves and be 25 to 30cm in length.

Preparation:
Approximately two thirds to three quarters of the foliage and side branchlets are removed and the soft, sappy growing tips trimmed off with a knife or secateurs. The base is cut with a sharp knife at right angles to the axis of the shoot 3 to 7mm below a node or joint.

Lining Out:
The cuttings are lined out in the open ground to take root. The soil



a prepared hardwood cutting of mairehau *Phebalium nudum*.

a softwood cutting of kotukutuku *Fuchsia excorticata*.

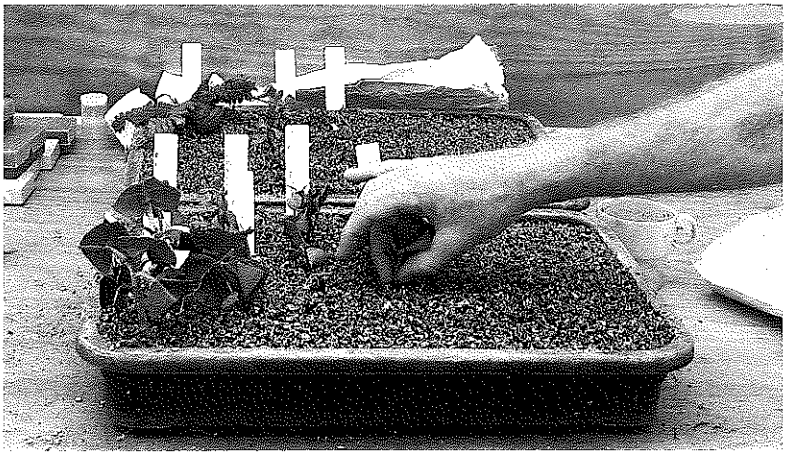
Preparing cuttings. (The Open Polytechnic of New Zealand)

should be well cultivated and of a friable texture for best results. Lightly tramp the soil down. Dig a narrow trench 10 to 15cm deep and place approximately 2cm of clean river sand in the bottom, then plant the cuttings to about two thirds of their length. Firm the soil around them. Weed and water during spring and summer and by the following winter they should have developed roots and be ready for planting out.

7.8.2 Semi-hardwood Cuttings

Semi-hardwood cuttings require the use of a glasshouse or frame to maintain high humidity.

Cuttings are made from partially matured or ripened wood taken from the plant between January and April, after the flush of growth. They are normally 7 to 15cm in length.



Pushing cuttings into the root mixture. (Bruce Treeby)

Preparation:
Leave on the young tips but remove one half to two thirds of the foliage with secateurs or scissors. With large leaved plants (eg rangiora) the leaves are reduced in size to prevent excessive moisture loss. Keep the cuttings moist and covered with plastic film while working with them.

Planting:
The cuttings are inserted into the rooting medium (normally a mixture of sand and peat) in the propagating frame, box or pot with at least half of the stem inserted in the sand. Firm around them. Roots will form in some cases in a matter of weeks, other species take longer. Pot up rooted plants.

7.8.3 Softwood Cuttings

Softwood cuttings are made from the soft, succulent, new growth which appears at intervals throughout the growing season. Late spring or early summer are the best times to take these cuttings. They should be well developed but should snap easily when bent sharply. Normally they are 3 to 23cm in length. Prepare and plant as for semi-hardwood cuttings.

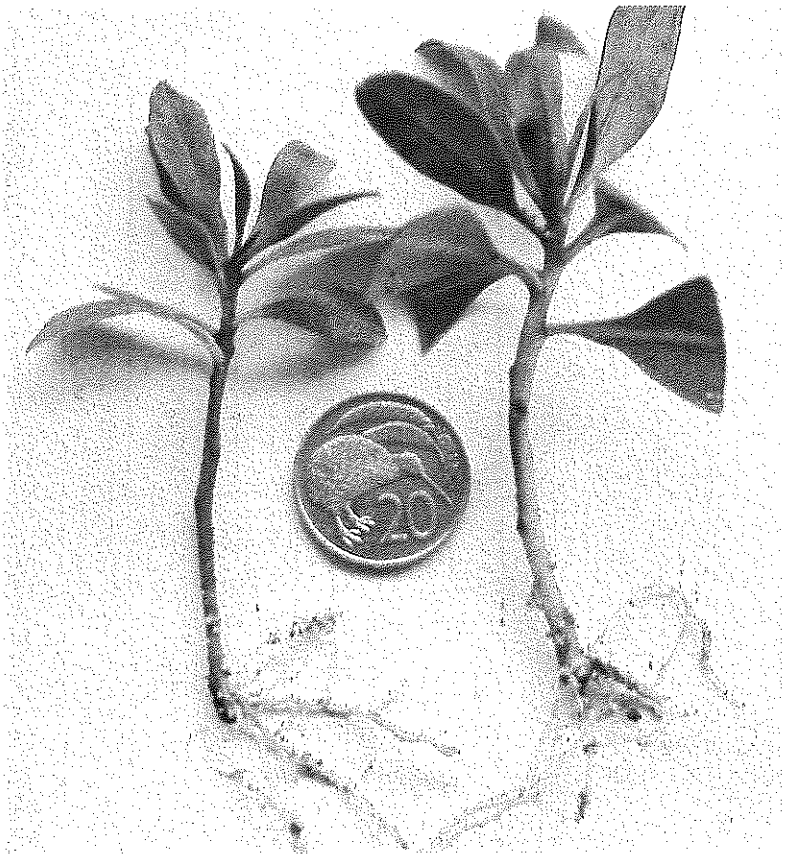
Roots are normally produced in 2-6 weeks with the rooting medium at a temperature of 18°C to 24°C. Spraying with water during hot weather

may be necessary.

Once rooted and potted up, the plants should be kept in the same conditions for a week or two to ensure the roots establish adequately in the potting mix.

7.8.4 Growth Regulators

There are various root-inducing chemicals that can be used to encourage root formation. Normally, the base of the cutting is dipped in the material before it is inserted into the rooting medium. These growth regulators are available for each of the three types of cuttings. With many species of native plants the use of growth regulators is unnecessary as the cuttings will 'take' well unaided. Experimentation is the best way to determine which cuttings they help.



Rooted cuttings. (Herwi Scheltus)

Further Sources of Information:

Forest Research Institute	Raising Native Trees and Shrubs from Seed *What's New in Forest Research* No. 158 Forest Research Institute, Rotorua, 1988
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Matthews, Barbara	*Growing Native Plants* AH and AW Reed, Wellington, 1979
Metcalf, L.J.	*The Cultivation of New Zealand Trees and Shrubs* Reed, Auckland, reprint, 1991
Pollock, K.M.	*Plant Materials Handbook for Soil Conservation* Volume 3: Native Plants. National Water and Soil Conservation Authority, Wellington, 1986
TOPNZ	*New Zealand Native Plants* course The Open Polytechnic of New Zealand

Site preparation and planting

8.0

Site Preparation

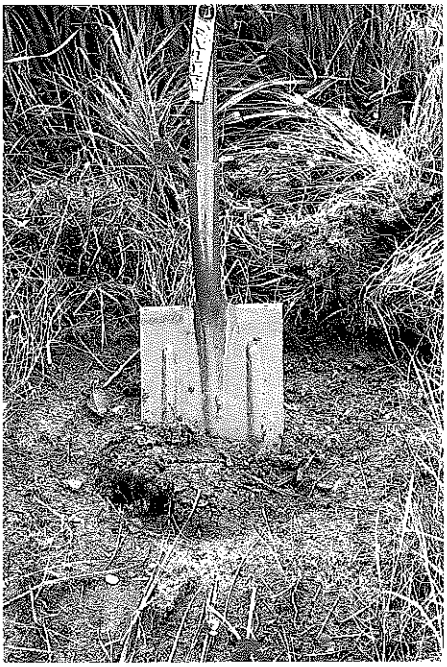
8.1

The success of plantings is dependent on good site preparation. Plants grow best if there is no competition from other plants for light, soil nutrients and water. Removal of competing plants can mean the difference between survival and failure, and will certainly result in faster growth rates of the planted trees and shrubs.

The most common methods of pre-planting preparation are screefing (chipping off the surface vegetation with a spade or grubber to expose the soil) and the use of herbicides.

8.1.1 Screefing

Screefing is a cheap and safe method of controlling weeds using a spade or grubber. After screefing, dig a wide hole (50cm x 50cm) and turn the soil well. This buries weed/grass seed and slows their return. Use a mulch, if possible, as well. Great care needs to be taken with any second screefing to remove regrowth as it is easy to damage the plant or remove too much soil around the roots of the plant.



This area has been screefed in preparation for planting.
(Bruce Treeby)

Herbicide prepared planting site. (Herwi Scheltus)

8.1.2 Herbicides

(See Section 4.6: Using Herbicides Efficiently and Safely)

Using herbicides to prepare areas for planting is a quick and efficient method, especially in preparing larger areas. Herbicides are safe if the label instructions are carefully followed and care is taken with spray drift onto 'non-target' plants. While spraying, 'non-target' plants can be temporarily protected by a sheet of iron or cardboard, a 2 litre plastic drink bottle with the bottom removed or a 4 litre bucket which can be slipped over the plant. The most common herbicide is a contact (knockdown) one, which has the same effect as screefing. A widely used contact herbicide is Roundup®.

By adding a residual herbicide to the herbicide mix applied, new weed plants are prevented from germinating for several months. This has obvious time-saving advantages in that it avoids having to clear around or spray around plants shortly after planting.

It is important to note that if a spray with residual herbicide has been used, the top 5cm of the planting hole soil must be carefully removed and placed to one side. Soil dug out of the planting hole should be placed in a separate pile. If possible, after planting, replace the soil with residual herbicide back around the newly planted plant to prevent weed germination.

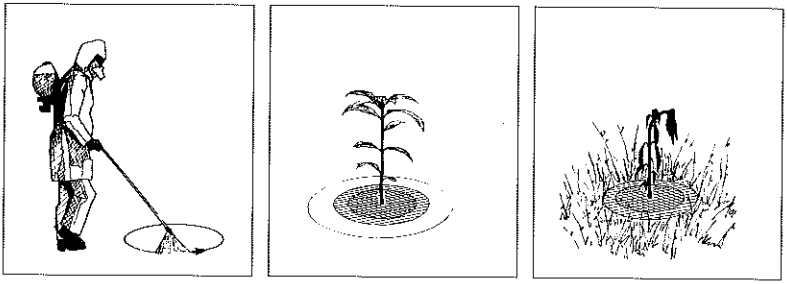
(See Section 8.3: Planting Successfully)

When spraying individual planting sites, the minimum size of the area sprayed should be one square metre to allow for the collapse of surrounding rank grass which can smother young seedlings.

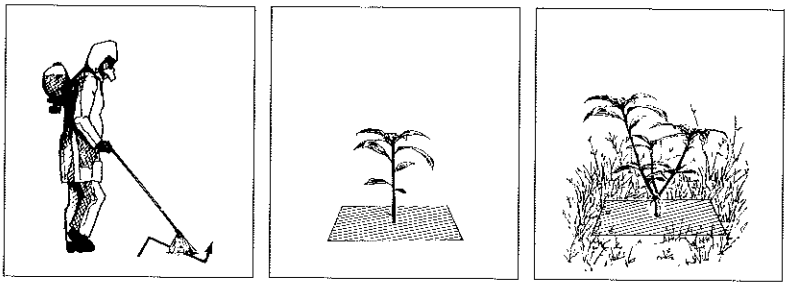
Do not over-clear as this reduces shelter effects and increases the chance of animal pests, such as possums and hares, discovering new plantings.

Spot removal of grass using knockdown herbicide. (Queen Elizabeth II National Trust)

Correctly applying herbicide for spot spraying.



WRONG Spraying in a circle gives too much in the centre and too little at the edge



RIGHT A 'Z' pattern produces a square spot

(The Open Polytechnic of New Zealand)

8.2 Planting

8.2.1 Time of Planting

Planting in winter or late autumn is more likely to overcome the problem of dry spells and takes advantage of the soil being damp. In those parts of the country with relatively mild winters, roots of many trees continue to grow in the cooler months. If the plant has developed a good root system in winter, it is more likely to survive dry spells the following summer.

With planting in late autumn or winter the plants are more likely to be exposed to damaging frosts, particularly on level, exposed sites in inland areas. Well conditioned, bare-rooted planting stock can often tolerate frost but conditioning of potted stock, especially with large seedlings liable to root distortion from containers, is more difficult. Hardy, pioneer species should always be used as initial plantings to provide the required shelter before the less hardy species are established.

Container plants can be planted at any time of the year but because dry

These mahoe seedlings will be unable to compete with the surrounding grasses in this unprepared site. (Herwi Scheltus)

spells are unpredictable, planting outside the cooler, wetter months means that an intensive watering programme may be required to keep the plants alive. Mulching greatly increases the chances of survival for planting undertaken at any time of the year, especially on open sites.
(See Section 9.1: Mulching)

To lessen the risk of plants drying out, planting should be avoided on bright sunny days or excessively windy days.

8.2.2 Planting Strategies

There are various planting designs that are alternatives to mass planting in lines at regular intervals. You can plant in an irregular manner. This allows you to select the best planting sites (or microsites), i.e. sites with

Spot removal of grass using knockdown herbicide. (Martin Conway)

the best shelter, light, and general growing conditions. Even within several metres, planting sites vary considerably in soil fertility, competition with other vegetation, and shelter.

The best planting strategy is group planting.

8.2.3 Group Planting

a) Natural Spread of Vegetation

Group planting is based on the way that plants naturally establish and spread. Initially, clumps, or groups of plants are established on the best sites, for example, the tops of undulations and in places with the least frost. These groups may be of one or several species.

Fruit-eating birds are attracted to groups of plants (particularly those made up of several species), rather than to single plants. The birds distribute seed under the plants, and this hastens revegetation.

The tree crowns, or the tops of the trees, grow outward, and new seedlings grow at the edge of the group or clump. The group expands.

Eventually different clumps of plants expand towards each other and merge. Then the entire area is covered with woody vegetation. Also at this stage, the tree crowns are dense and have merged. This is called canopy closure.

b) Canopy Closure

The time it takes for canopy closure is dependent on a number of variables such as site conditions, species used and their rate of growth, spacing of plants, the aftercare.

Attaining a canopy closure as quickly as possible is very important. Once a complete canopy has developed, the environment under the canopy is radically different from that outside, providing conditions better suited to many native plants. The more tender species, requiring shelter and less light, can then be planted under them and will have a greater chance of survival. Canopy closure ensures that summer water stress is much reduced, the problem of sun scorch to delicate plants, particularly ferns, is eliminated, frost intensity is much reduced or eliminated, and the problems caused by strong drying or cold winds are minimised. For this reason it is important that the margins (edges) of stands be protected to develop a vegetation cover right to the ground.

(See Section 2.4.6: The Forest Edge)

A complete canopy ensures a greater likelihood of attracting fruit-eating birds, and the seed they deposit will have a greater chance of survival once they germinate.

8.3 Planting Successfully

Planting failures can occur due to the planting of poor stock, inadequacies or mistakes in site preparation, poor handling of plants or bad planting techniques. These can be avoided by careful planning, organisation, and proper planting methods. The method of planting depends on whether the plants are bare rooted or container grown.

8.3.1 Planting Bare Rooted Plants

The final root system after planting will depend on the root system at the time of planting. Short-rooted stock generally show less distortion than long-rooted stock. If planting stock has been properly conditioned, there should be no problem with root distortion. The planting hole needs to be large enough to ensure that the roots are not cramped, which would result in high mortality and/or instability. The plant must be planted at the depth at which it was growing in the nursery. In dry stony soils that are free draining, plants can be planted deeper. Place a small mound of soil in the base of the planting hole and spread the roots over the mound. If the roots are evenly spread through the potting mix, the plant can be placed straight in the hole without disturbing the roots. Back-fill about three quarters of the hole and give the plant a little upwards lift to set the roots in a 'natural' position. Complete filling the hole and firm the soil.

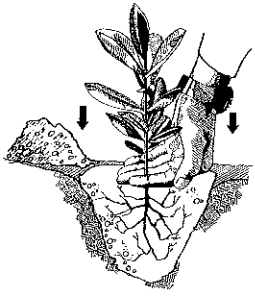
The soil should be firmed, layer by layer, during the process of back filling. However, the surface of the soil should be left light and loose.

If possible, the plant should be thoroughly watered at the time of planting.

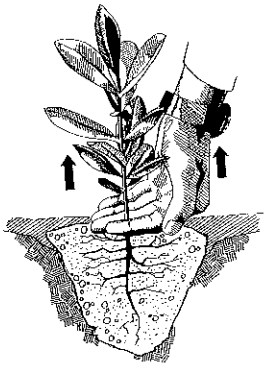
It is best to mould soil to form a basin around the base of newly planted trees, especially on sloping ground, to trap water.

Planting bare-rooted plants.

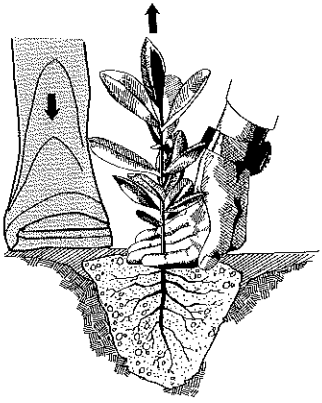
A. Planting bare-rooted plants in sites that have been screefed or treated with knock-down herbicide.



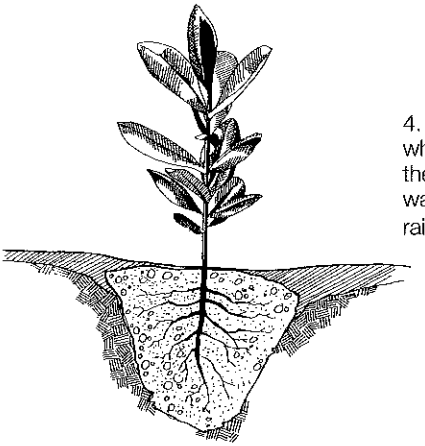
1. Place the seedling in the slot about 10cm deeper that the final position you want.



2. Replace the soil round the roots, and pull the seedling up about 10cm. This will straighten any roots that are twisted or swept up.

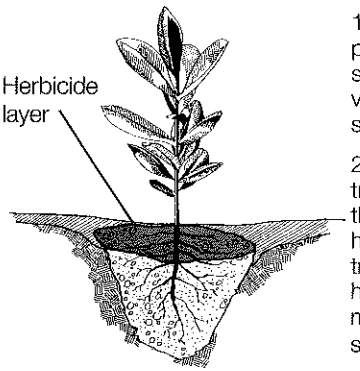


3. Only now do you firm the soil round the seedling using the soles of your boots, **never your heels**. If you use your heels you are more than likely to over-compress the soil and damage the seedling.



4. Leave a small depression when you firm the soil around the seedling to help retain any water you add and any rainwater.

B. Planting bare-rooted plants in sites that have been prepared with a residual herbicide.



1. Carefully cut around the planting site and remove the surface layer of soil and vegetation and place it to one side. Don't break it up.

2. After you have planted the tree, carefully replace the soil that contains the residual herbicide back around the tree. This will ensure that the herbicide kills any weeds that might compete with the seedlings.

8.3.2 Planting Container Grown Plants

The hole dug for container grown plants needs to be at least twice the size of the container. Remove the plant from the container. Polythene planter bags have folds in their base which you can hold with one hand while you remove the plant with the other. If it is difficult to remove, the bag can be slit with a knife. If the roots are cramped, slit the root ball with a knife down the length of the roots, in three places, cut the bottom 10mm from the root ball, and spread the roots out. Badly root bound plants are not worth planting as their roots will not develop in a normal manner.

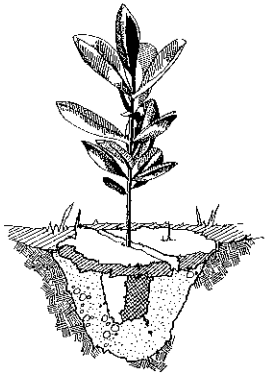
Transplanting of rootrainer grown stock is simpler. The rootrainer container is opened by removing or folding back one side, and the plants lifted out and placed in previously prepared holes. Before planting, cut 2 to 3cm off the bottom of the plug. This removes the concentration of roots at the end and initiates new root growth.

Planting container-grown plants.

A. Planting sites that have been screefed or prepared with knockdown herbicide.

Make the planting hole at least twice the size of the container, and plant in the same way as for bare-rooted stock. The top of the root ball should be no more than 3cm below the soil.

B. Planting sites that have been prepared with a residual herbicide.



Make sure that any treated turf you remove is placed back the right way up.

(The Open Polytechnic of New Zealand)

8.3.3 Staking

Well conditioned plants with a good root-ball should not require support by staking. However, stakes are very useful for locating plants for releasing or fertilising.

8.4 Fertiliser

Many native plants grow well and rapidly in fertile soils on sheltered lowland sites without added fertiliser. It is on the "hard" sites with poor soils that the use of fertilisers is likely to get the best response, but many native plants appear to grow satisfactorily even on these sites.

Little is known about fertiliser requirements of most native species in the field. Some species have responded well in nursery beds, containers, and in favoured garden situations, but responses in forest and scrub plantings have often been insignificant. However, in the latter, growth may have been limited by factors other than nutrition, possibly lack of moisture. Too much fertiliser can be toxic and may lead to poor growth especially on sandy soils. If you do use fertiliser, apply only small amounts, and frequently. (Check the instructions on the label.)

8.4.1 Organic Fertiliser

One of the safest fertilisers is blood and bone. This can be mixed with the soil used to fill the planting hole, or scattered around the plant at planting time. In spring and autumn more can be added.

Composts and animal manures can be used as fertilisers. Well-rotted compost should be mixed with soil used for filling the planting hole. It also acts as a mulch. Fresh animal manure must not be brought into close contact with plant roots or it will burn them.

8.4.2 Chemical Fertiliser

A wide range of granulated and powdered fertilisers contain the main elements needed for plant growth. Some also contain minor elements. Some fertilisers dissolve rapidly and are relatively quick acting, others dissolve more slowly and release nutrients over a longer period. A mixture of the two can be used. They can be mixed with the soil used to fill the planting hole and also can be scattered around the plant. Make sure that none comes in direct contact with the roots. Like organic fertilisers, chemical fertilisers can be added in spring and autumn, but only relatively small amounts are required for each plant. Cut a slit with a spade alongside the plant and place fertiliser down the slit. Surface application can boost weed growth if weeds have not been adequately controlled.

In view of the generally unknown fertiliser requirements for maximum

health and growth rates of native plants it is best to apply it cautiously; too little is better than too much. Observation of the effects of fertilisers on health and growth will determine the most effective amounts.

8.4.3 The Use Of Fertiliser

FERTILISER	PLANTING HOLE	GROUND SURFACE	APPLICATION
Blood and Bone	1 handful	2 handfuls	Spring and autumn
Compost	½ volume used to fill planting hole	Any amount around tree	Spring and autumn
Granulated	10 g	30-60 g	Spring and autumn
Powder	10 g	30-60 g	Spring and autumn
Granulated slow release	Cupped handful mixed with soil	-	At planting

9.0 Post-planting treatment

9.1 Mulching

Mulching involves spreading loose, readily permeable material, such as wet straw, bark or sawdust, around newly planted trees and shrubs to protect the roots and trap moisture. Mulching will greatly increase the rate of survival on dry or open sites, yet is not generally required on sheltered forest sites.

Mulching should only be done when the soil is moist. The ground about the plant should be thoroughly watered before applying the mulch. Lay the mulch at least 10cm deep around the plant in a weed-cleared area, about a metre across.

The advantages of mulching are:

- Controls weed growth.
- Reduces loss of moisture from the soil, helping to keep planted trees and shrubs alive during a dry summer or drought.
- Provides insulation and thus stabilises soil temperature.
- Organic mulches may add nutrients to the soil and make it friable.

There can be disadvantages to mulching:

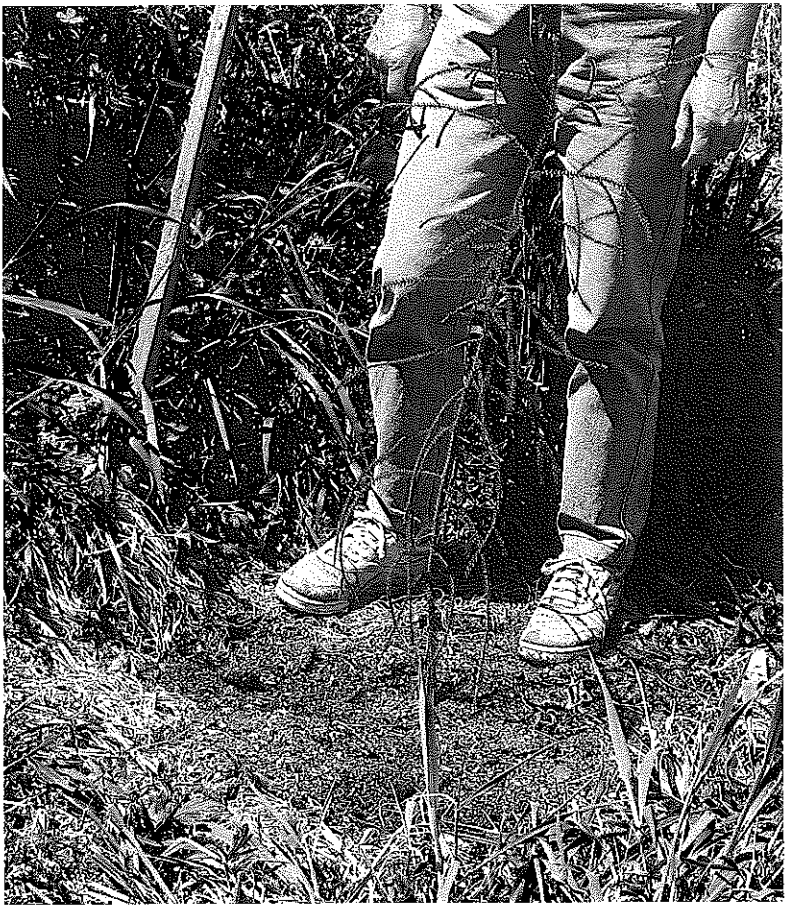
- May be a source of plant diseases or a home for insect pests.
- May prevent water from reaching plant roots.
- It takes time and money.
- Can increase frost damage.

9.1.1 Types of Mulches

Many materials can be used as mulches including bark chips, sawdust, wood shavings (but make sure that these are from untreated timber), compost, grass clippings, mushroom litter, well rotted hay and straw, leaves, peat, pine needles and almost any plant material. Materials such as shingle, stones, rocks, building paper, wet newspaper, weed mat and even old carpet can also be used.

A nitrogenous fertiliser needs to be incorporated with an organic mulch at planting time because decomposition of organic material creates a nitrogen deficit. Organic mulch must not touch the stem of the plant as it may damage the stem and foliage as it decomposes.

Sawdust and bark chips can produce substances toxic to plants. These materials should be well rotted and used from the bottom of heaps.



A site mulched with untreated sawdust after planting. (Bruce Treeby)

Hay and straw may introduce weeds or competing plants into an area (e.g. straw may contain barley seeds, which, once germinated, may temporarily suppress small plants). Lucerne hay is excellent as mulch because it does not have many weed seeds.

Watering 9.2

Most revegetation sites are unlikely to have a reticulated water supply. It may be possible to water plants at the time of planting if water can be brought to the site in a tank.

However, watering will often be impractical and undesirable, as it encourages surface rooting. Plantings on forest and most scrub sites in winter will not require watering. Good conditioning of nursery stock and good planting practice may be all that is required in the field, and mulching will usually make watering unnecessary.

The best solution is to plant the correct species for the site at the right time of the year and the need to water can often be avoided.

9.2.1 Irrigation Systems

A few situations may justify setting up a full irrigation system. The first requirement is a reliable water source. A design ensuring correct pipe size, position and flow rates is necessary, and design advice on irrigation systems can be provided by service firms or private consultants.

One frequently used irrigation system is the trickle system, comprising a low pressure water supply which feeds a main line. The main line delivers water to lateral lines, which feed the microtubes, which water the plants. A trickle or dripper irrigation system can be quite simple. Drippers have the advantage that they do not block up as often as microtubes.

9.3 The Importance Of Weed Control (Releasing)

Releasing is the control or removal of unwanted competitive plants, such as weed or nurse species, from around planted trees and shrubs. These unwanted plants compete for moisture and nutrients. Releasing is an expensive substitute for good site preparation and planting healthy stock. However, if there are competing plants, releasing is necessary to ensure survival and rapid early growth of the seedlings. For fast-growing species, releasing may be necessary in only the first year of establishment, but slower-growing species may require releasing for up to three years. There are two releasing techniques:

- By hand.
- Using herbicides.

9.3.1 Releasing By Hand

Releasing by hand is very time consuming and laborious, especially when you are dealing with a large vegetation project. Use a tool such as a grubber or a slasher for cutting back vegetation. It is important to be careful not to damage the tree roots by heavy, deep grubbing, or to strip bark from the trees, making them susceptible to fungal attack and disease.

9.32 Releasing Using Herbicides

(See Section 8.1.2: Herbicides)

Herbicides have an advantage over releasing by hand as they are cost-

This area of one year old plantings has been released using a knockdown herbicide. (Queen Elizabeth II National Trust)

effective and large areas can be treated relatively quickly.

Knapsack sprayers should be used for release spraying because they give better control than spot spray guns. To apply the herbicide evenly, spray in an "Z" pattern rather than in a circular motion which increases the concentration close to the plant. Careful calibration of spray equip-

Areas in semi-shade normally require less post-planting treatment than open areas. (New Zealand Forest Research Institute)

ment and following the manufacturer's instructions are essential to obtain optimum weed control without damaging the plants. Avoid any spray contact with the stems and leaves, preferably by using a shield and spraying on a calm day.

To achieve maximum kill with a herbicide, weeds should not be allowed to grow more than 10cm high. If weeds do become rank, it may be necessary to hand grub or stamp them down before spraying to avoid contact between the sprayed weeds and the planted trees and shrubs.

A wetting agent added to the spray will help the spray's effectiveness by making the spray stick to the waxy surfaces of leaves.

Spray when it is cooler. If you spray in hot sun the spray evaporates too rapidly before it is absorbed through the plant leaf surfaces.

Further Sources of Information:

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Forest Research Institute	Establishing Nursery Raised Native Trees *What's New in Forest Research* No. 86 Forest Research Institute, Rotorua, 1980
TOPNZ	*New Zealand Native Plants* course The Open Polytechnic of New Zealand

Revegetation on specific sites 10.0

Planting in Shrubland 10.1

The important role of shrub communities, both native and exotic, in vegetation succession is often ignored. Native shrub communities, such as those dominated by manuka and kanuka, *Coprosma* species or mixed shrub hardwoods, and exotic species such as gorse and broom, can be used to advantage as a nurse cover and are part of the natural process of restoring the forests.

If animals are well controlled and there are suitable seed sources nearby, one option is to merely fence, protect from fire, and allow natural regeneration to proceed, with perhaps limited planting of species that establish naturally. Unwanted invaders like blackberry, Himalayan honeysuckle, and Buddleia need to be controlled.

To ensure that areas will succeed into advanced plant communities:

- Exclude fire
- Exclude domestic stock
- Reduce the other browsing animals to the minimum possible number.

Planting Under manuka and kanuka 10.2

Manuka (*Leptospermum scoparium*) and kanuka (*Kunzea ericoides*) are important early colonisers of unmanaged pasture or areas of cleared forest. Kanuka is found only on the drier and more fertile soils, whereas manuka colonises both these sites and also infertile or poorly drained soils. Both plants are the beginning of natural plant succession and are ideal nurse crops. *(See Section 5.2.3)*

There are several options for planting under manuka and kanuka. These depend on the age and development of the stand.

a) When the manuka or kanuka has grown to about 1m high (two to five years old, depending on the site), clear gaps of about 1m across and plant with a range of species.

b) When the manuka or kanuka has reached about 2m to 3m high (five to ten years old), clear gaps and underplant. Underplanting may still involve some thinning of the manuka or kanuka cover.

Planting under tall and open manuka. (New Zealand Forest Research Institute)

c) When the stand is well developed and self-thinned, underplant. This is when the stand is about 40 years old. This stage requires the least effort on your part, considering that bird and wind distributed seeds constantly arrive and the process, if uninterrupted, occurs naturally anyway.
(See Flowchart 10.1, pages 160 to 161)

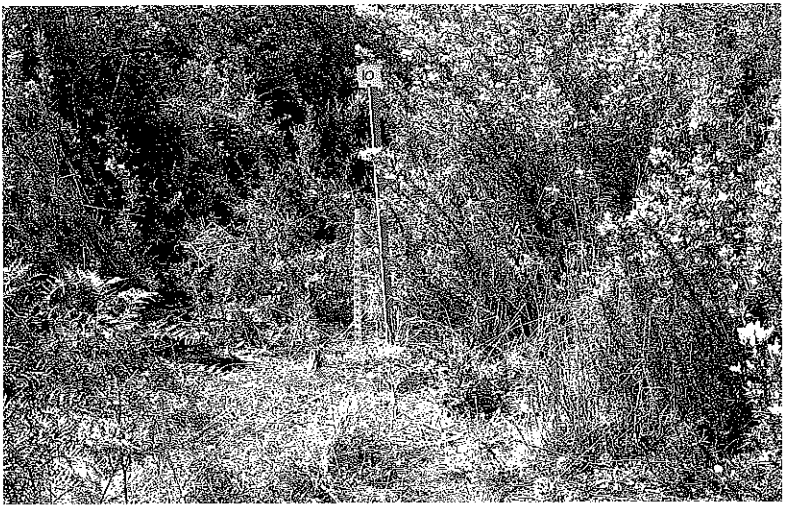
10.3 Planting Under Tauhinu

Tauhinu (*Cassinia leptophylla*) can be used successfully as a nurse crop. It occurs naturally on fertile coastal land where it can grow as high as 5m. It does not live much beyond 15 years.

Depending on the density of the tauhinu, appropriate coastal species such as akiraho, coastal flax, taupata, cabbage tree and ngaio can be planted in between the tauhinu, or planted in gaps or lines that have been cut.

10.4 Planting Under Gorse

Gorse has a prolonged flowering period (from autumn through winter and into spring) and a high annual seed production, which can lead to soil concentrations of up to 14 million seeds per hectare under mature gorse



Clearings within dense gorse provide ideal sheltered conditions for planting native species. (New Zealand Forest Research Institute)

stands. Temperature of 100° C or more and sustained for at least 15 minutes are necessary to kill gorse seed. Lower temperatures and shorter heating periods actually stimulate germination, and gorse seed has the ability to remain viable in the soil for more than 30 years.

Burning is the traditional method of gorse control. However, problems occur:

- Gorse regrows rapidly from the base of the stem.
- There is prolific germination of the gorse seedlings, for even though a burn-off may produce high temperatures, the heat penetrates only a small distance into the soil and stimulates germination.
- Through the establishment of weeds or the resprouting of any other fire resistant weeds such as blackberry or hawthorn.

This has led to gorse's dominance in many pioneer plant successions throughout the country.

There are several ways to use gorse as a nurse crop:

a) Without Cutting Down or Spraying the Gorse

Planting under gorse without cutting it down or spraying it lets the live gorse cover provide protection and a suitable microclimate. However, access is always a problem because of the gorse prickles. There are two methods:

• *Planting under gorse without clearing a space*

Plant in the (accessible) most open parts of the gorse cover, away from

the trunks and the dense crown. Microsites where the soils are moister should be used. The species used should be fast growing and shade tolerant such as:

BOTANICAL NAME	COMMON NAME
Brachyglottis repanda	rangiora
Coprosma lucida	karamu
Coprosma robusta	karamu
Geniostoma ligustrifolium	hangehange
Melicytus ramiflorus	mahoe/whiteywood
Pseudopanax arboreum	five finger
Pittosporum spp	kohuhu, tarata, karo

These shade tolerant species will overtop the gorse and eventually replace it. Light demanding species cannot be used.

Once the native plants are established, you should remove any gorse seedlings or other weeds from around the base to give them growing space. Given protection from fire, the planted trees will replace the gorse cover in about 20 years. Mulching, fertilising and watering (except the initial watering at planting) generally will be unnecessary.

• *Planting in Cleared Spaces*

Cut either: Spaces about 2m across

or: Lines (access tracks) 1m wide in short gorse

or: Lines 2m wide in tall gorse

Then plant. The gap must be maintained until the plants overtop the surrounding gorse cover. This may be done by either trimming back regrowth or careful spraying (i.e. releasing). Painting the cut stumps with herbicide at the time of cutting will help keep the gap open. The advantage of planting along the access lines is that the plants can easily be located when releasing is necessary. Always ensure that the lines are at right angles to the prevailing winds.

b) Cutting, Spraying, Planting

Cut the gorse and leave it until new growth and new gorse seedlings appear.

Spray both the new growth and the seedlings. *(See Table I, Chapter 4)*

Wait until herbicide has acted, then plant native seedlings.

c) Spraying then Planting

November/January is the period of active gorse growth. If the gorse has reached 1.5 to 2m high, spray with a herbicide.

Close planting of tree and shrub species should be done the following winter. Ideally, plant species which appear in the early stage of succession, such as manuka, kanuka, *Coprosma* spp, and wineberry should be used. Plantings should be at a maximum of 1 to 2m apart. Mulch, if in a dry region. The tall, sprayed, disintegrating gorse will act as a nurse cover over the first two to three years, and then the native plants growing underneath will take over. The larger and long lived tree species can then be planted under this canopy. Once these are established, the initial cover plants will need to be cleared to permit light through to the seedlings.

Take care with fire in gorse, because dead gorse can be a fire hazard and can burn at any time of the year. Burning, following cutting or spraying, will only accentuate the gorse problem by promoting massive seed germination.

The newly germinated gorse seedlings can be sprayed, *(See Table 1, Chapter 4)* but this second spraying makes this an expensive option. *(See Flowchart 10.2, pages 162 to 163)*

Planting under Broom 10.5

Broom (*Cytisus scoparius*) is a shrub growing to about 4m and is found throughout New Zealand. It favours moister and more fertile sites than gorse, and is characterised by very rapid growth. Its lack of thorns, and its shorter life span (10 to 15 years, c.f. 30 to 40 years for gorse) make broom much easier to work with than gorse.

After burning there is often a prolific germination of broom seedlings and other weeds, but these can be controlled by spraying with herbicides. *(See Table I, Chapter 4)* Follow planting recommendations as for gorse.

Planting Under Bracken 10.6

Bracken (*Pteridium aquilinum* var. *esculentum*) is a native fern with stout underground stems (rhizomes) creeping to 4m or more. Protection of bracken covered areas from fires, and excluding stock and browsing animals, will eventually result in succession to native trees and shrubs.

Natural regeneration can be more rapid on bracken covered sites which are lightly grazed by stock than on continuously ungrazed areas. The absence of grazing animals leads to tall, dense bracken, which occupies a site almost indefinitely and permits few seedlings to grow on the densely shaded ground, strewn with fronds from previous seasons. Where stock

This area was invaded by broom after fire. Planting has taken place after the broom has been controlled by first cutting and then spraying the regrowth.
(Queen Elizabeth II National Trust)

have access, the fronds are shorter and the debris does not accumulate so freely, but there is sufficient protection for the seedlings to establish. By the time the seedlings have reached above the bracken, the area generally has little attraction for the stock.

a) Burning Bracken
The main problem with burning bracken is that the underground stems survive fire, and in the spring new fronds grow from these, and the area quickly returns to its former cover. A slow back burn is more effective in killing more of the underground stems than a fast forward burn. Burning in autumn will give a few months without the new fronds appearing. The area could be planted with fast growing native plants which would need to be at least 1m high, or the area closely managed to see that smothering does not occur.

b) Spraying Bracken
There are herbicides that kill bracken if applied correctly.
(See Table 1, Chapter 4)

c) Cutting
Cutting lines or spaces in the bracken stimulates bracken growth and frequent releasing of new plantings will be required. Underplanting suppresses and finally replaces the bracken. See instructions in the sections on manuka, kanuka and gorse.
(See Flowchart 10.3, pages 164 to 165)

Planting in Grassland 10.7

A grass cover, because of its dense root system, competes with planted native trees for water, light and nutrients and is likely to retard growth. The grass cover can be removed from the whole area to be planted, or removed only from individual planting sites.

a) Complete Removal of Grass Cover

- *Cultivation*

  Grass and flatweed cover can be broken up and dug into the soil. This should be done before seed heads appear, otherwise the soil provides an ideal seedbed for the weeds. However, even after thorough cultivation, new grass plants will grow as there are always seed or stolons (underground roots) in the soil.

  The site should be planted straight away.

- *Spraying*

  The most useful non-residual herbicide for controlling grasses and perennial weeds is a glyphosate-type herbicide such as Roundup®. This should be applied two to three weeks before planting.

  Grass killed by spraying can be left as mulch. Periodic release spraying of the planted trees and shrubs to reduce competition for water and nutrients may be necessary. Roundup® is suitable for release spraying.

b) Spot Removal of Grass Cover

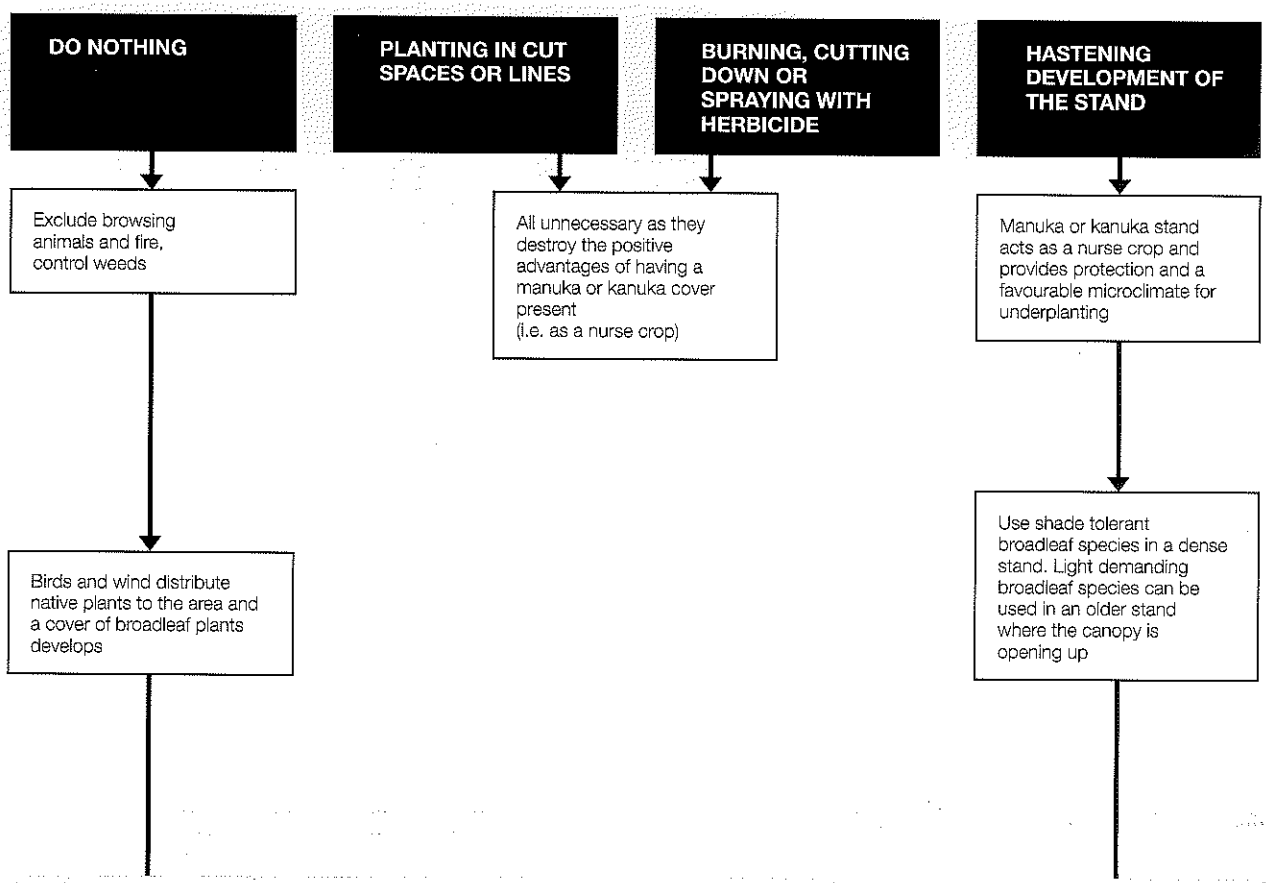
- *Grubbing*

  Grubbing is labour intensive and must be regularly followed up. Clear an area about one square metre and break up the soil using a spade. After planting, releasing will be required to reduce weed competition and to maximise growth. Continue this until canopy closure.

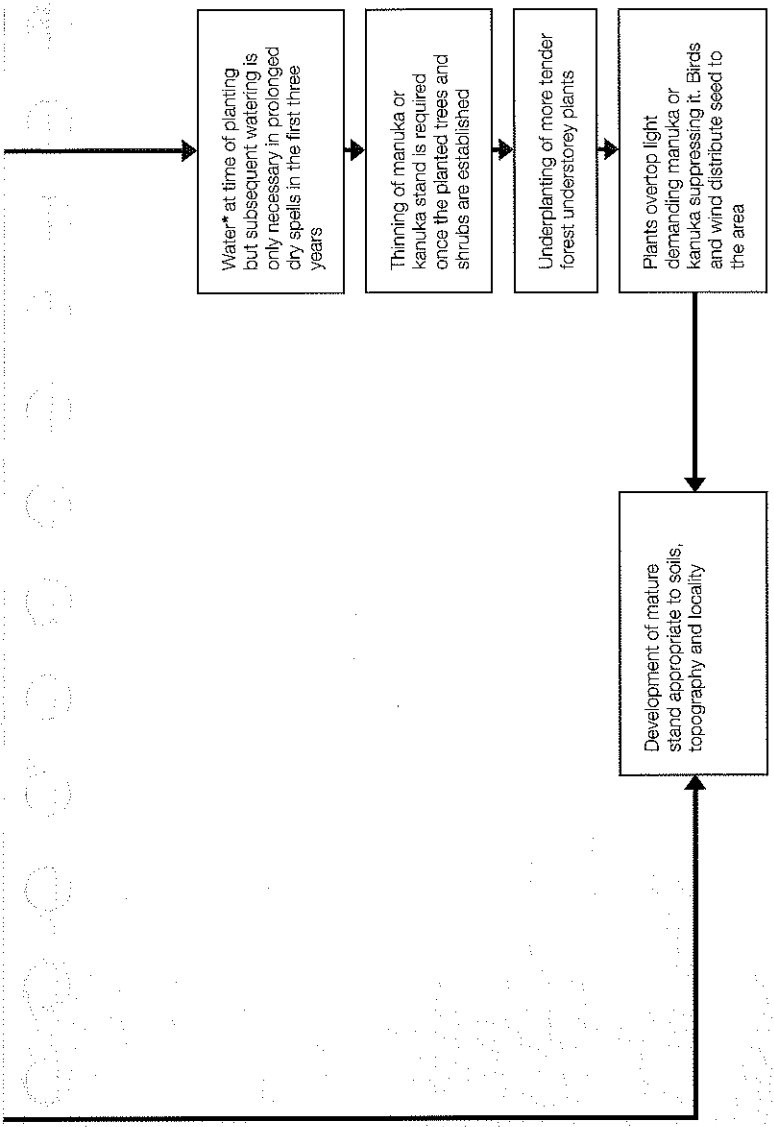
- *Spot Spraying* Refer to Spraying (above).

(See Flowchart 10.4, pages 166 to 167)

Flow chart 10.1: Planting under manuka and kanuka

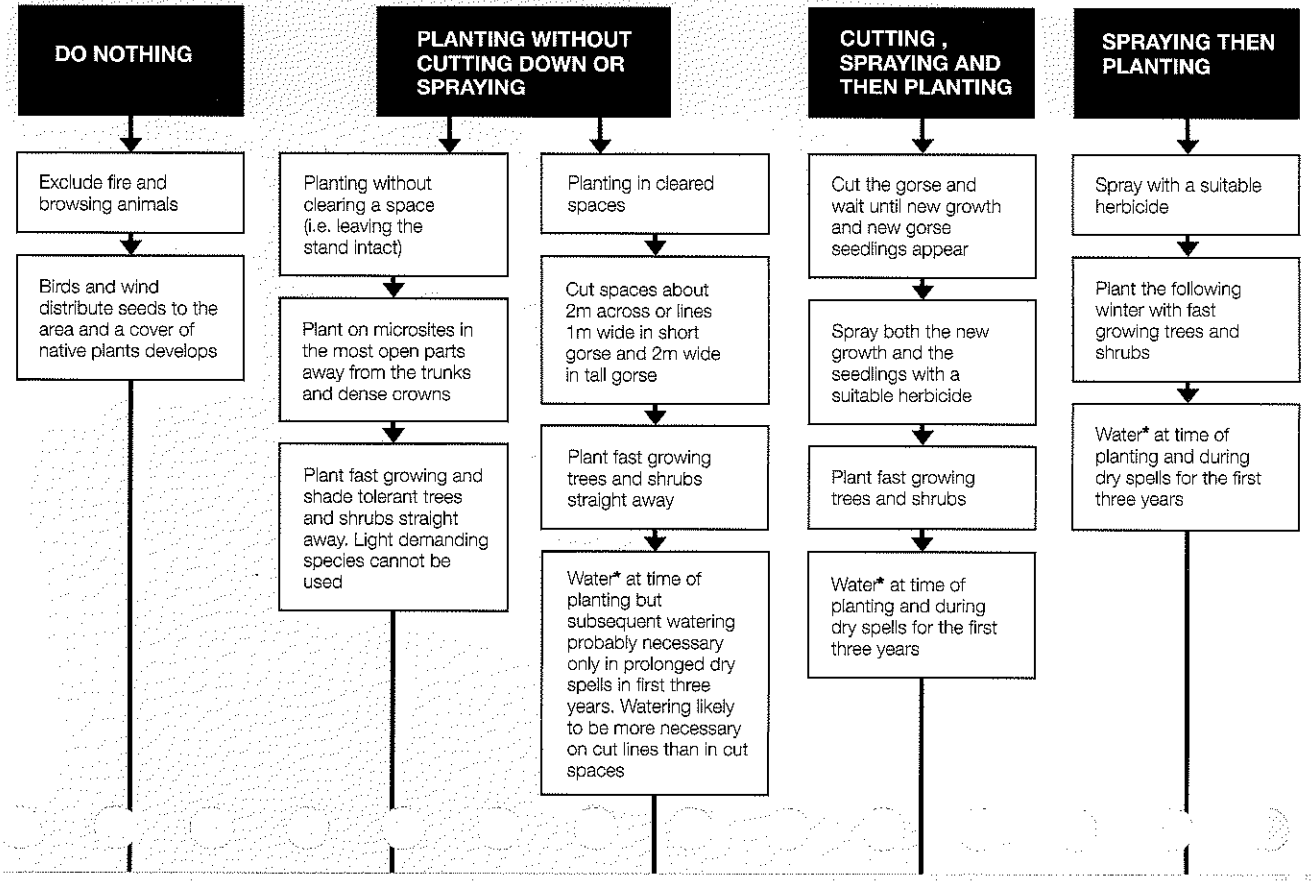


Flow chart 10.1: Planting under manuka and kanuka

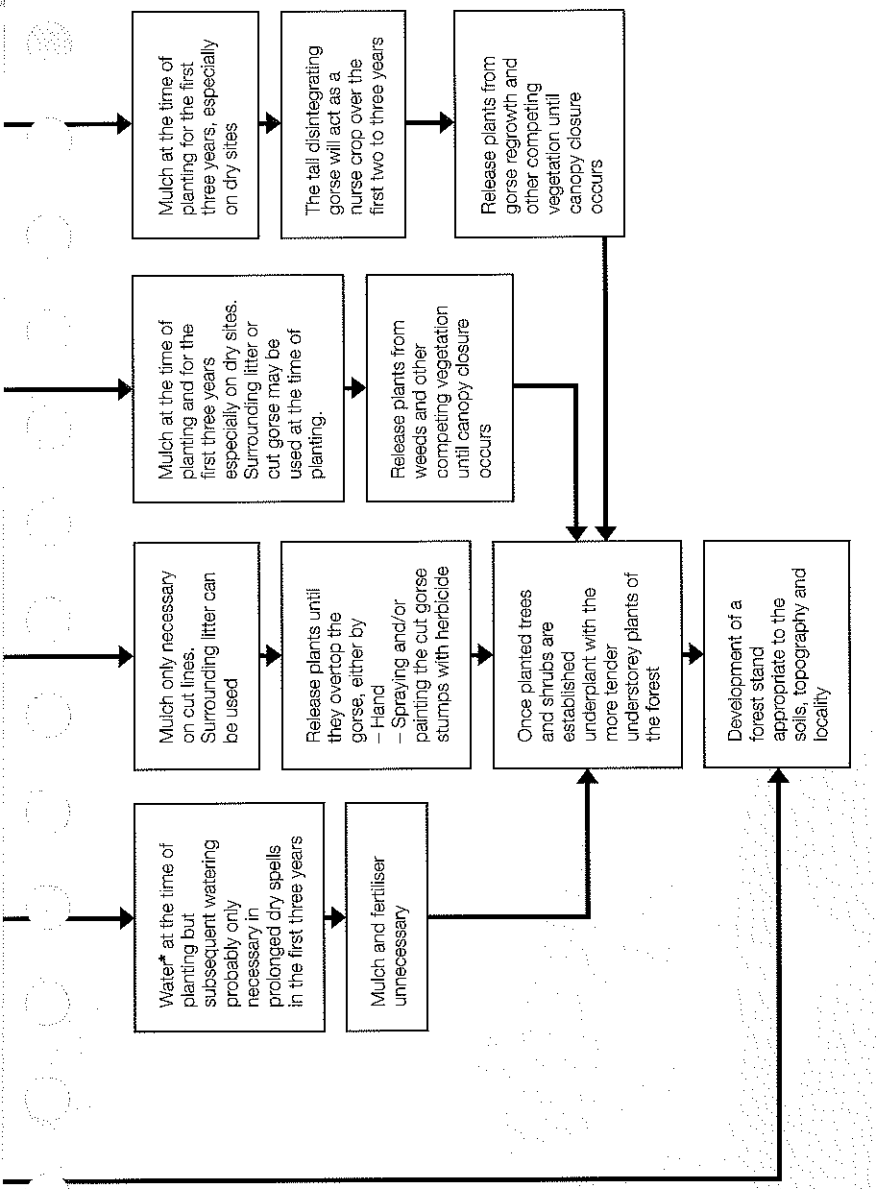


* If practicable

Flow chart 10.2: Planting under gorse

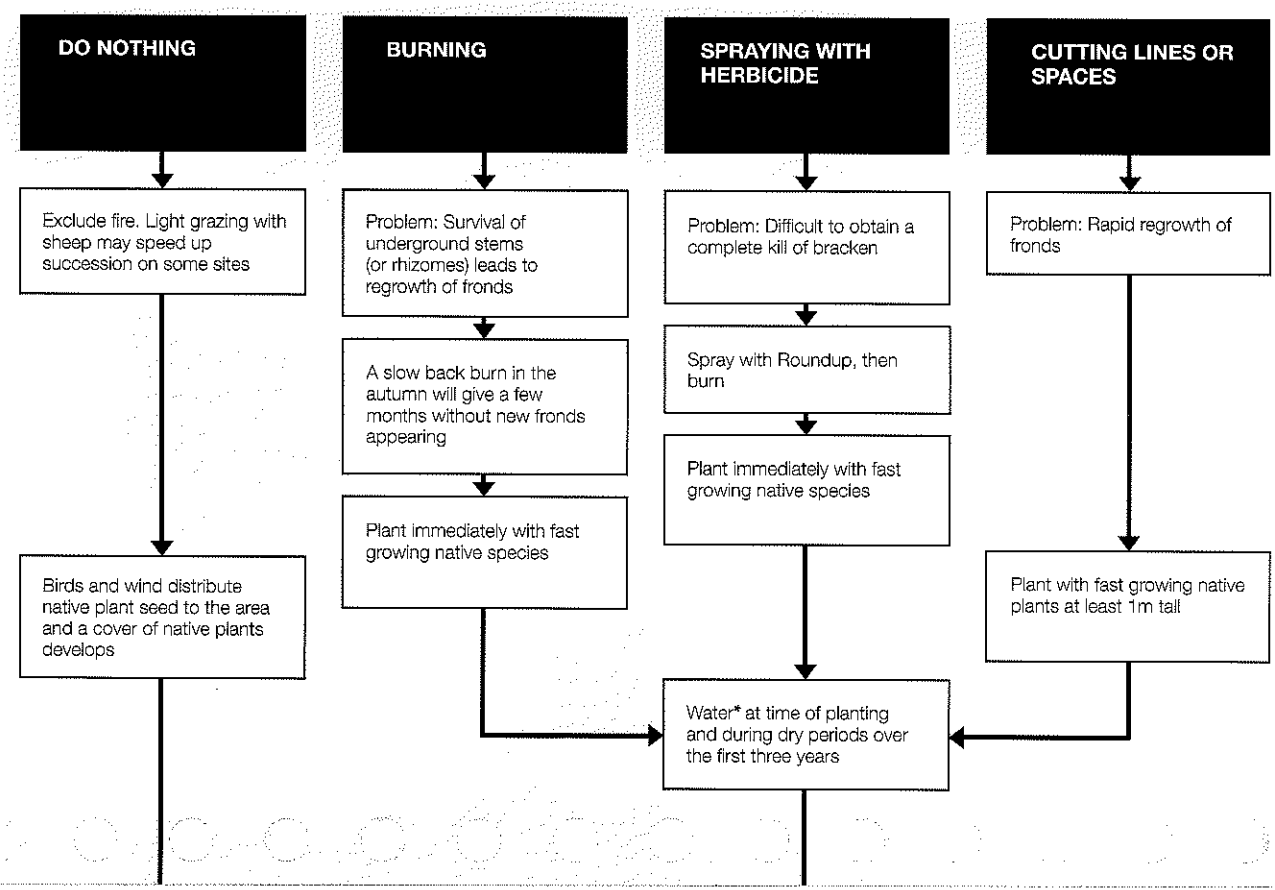


Flow chart 10.2: Planting under gorse

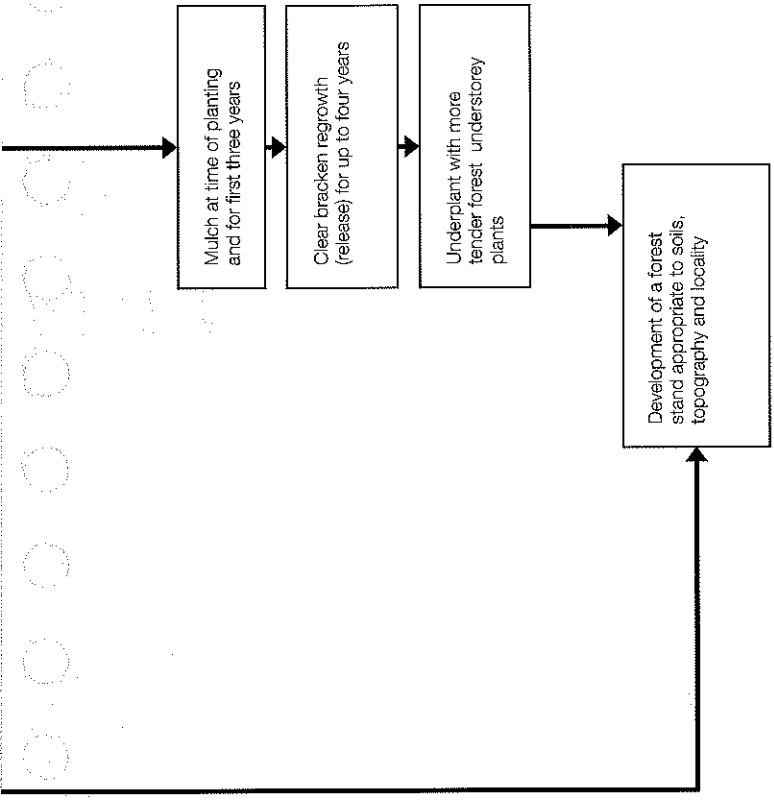


* If practicable

Flow chart 10.3: Planting under bracken

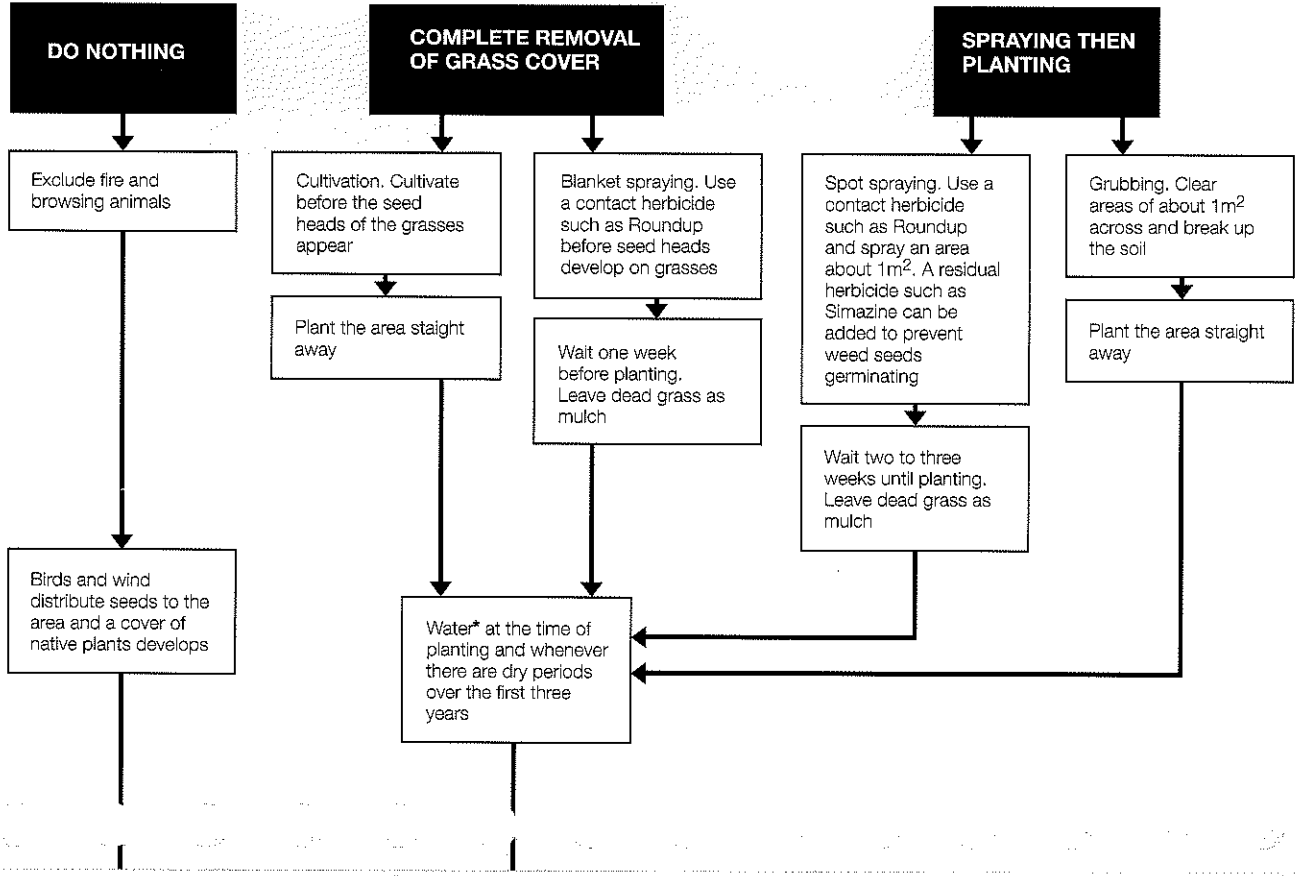


Flow chart 10.3: Planting under bracken

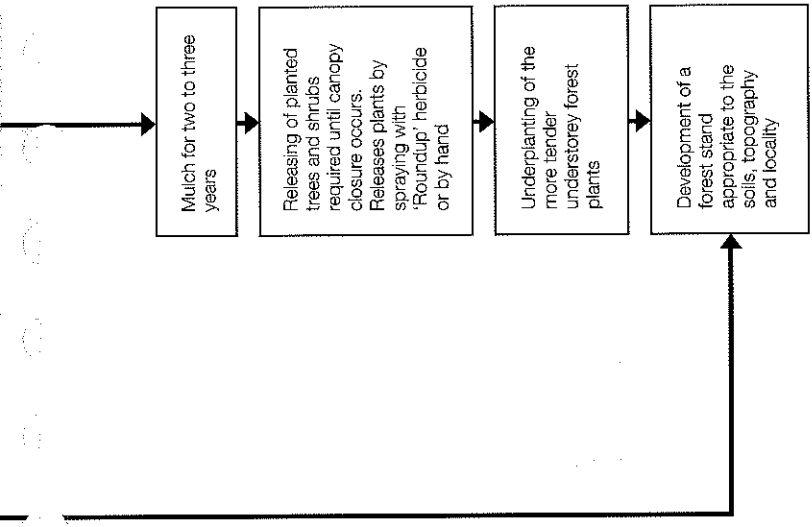


*** If practicable**

Flow chart 10.4: Planting in grassland



Flow chart 10.4: Planting in grassland



* If practicable

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Appendix

Native colonising and nurse plants

These are plants that are quick growing, capable of being planted in full sun and moderately exposed conditions. Once established, less hardy species can be planted amongst them, taking advantage of the microclimate created.

Scientific name	Common name	Growing conditions
Aristotelia serrata	wineberry	Most sites, some shelter
Cassinia fulvida	coastal cottonwood	Coastal, dunes, dry, exposed.
Cassinia leptophylla	tauhinu	Any dry site.
Coprosma parviflora	mingimingi	Anywhere, especially swampy.
Coprosma propinqua	mingimingi	Similar to above.
Coprosma repens	taupata	Exposed seasides, frost tender.
Coprosma robusta	karamu	Most sites, especially moist.
Cordyline australis	cabbage tree	Most sites, hardy.
Coriaria spp.	tutu	Nitrogen fixing; stony, mineral soils.
Cortaderia fulvida	toetoe	Dry, poor, disturbed, compacted sites.
Cortaderia toetoe	toetoe	Wet to swampy.
Dodonea viscosa	akeake	Exposed, dry sites.
Hebe salicifolia (S.Is)	koromiko	Some shelter, streamside.
Hebe stricta (N.Is)	koromiko	Moist, exposed site.
Kunzea ericoides	kanuka	Most well drained, exposed sites.
Leptospermum scoparium	manuka	Anywhere, according to seed source.
Macropiper excelsum	kawaka	Partial shelter, most sites.

Appendix

Melicytus ramiflorus	mahoe	Anywhere, according to seed source.
Metrosideros excelsa	pohutukawa	Exposed seasides, frost tender.
Myoporum laetum	ngaio	Exposed sites, including coastal. Very hardy.
Olearia avicenniaefolia	tree daisy	Dry to moist, poor ground, shelter.
Olearia paniculata	akiraho	Exposed dry sites, including coastal.
Olearia solandri		Dry, partial shelter.
Phormium cookianum	mountain flax	Coastal, rocks, mountains, exposed.
Phormium tenax	lowland flax	Exposed, swamps and streamside.
Pittosporum crassifolium	karo	Exposed.
Pittosporum eugenioides	lemonwood	Some shelter.
Pittosporum tenuifolium	kohuhu	Some shelter.
Pseudopanax arboreus	five finger	Some shelter.
Pomaderris kumeraho	kumerahou	Poor, dry clay soils, frost tender.
Solanum aviculare	poroporo	Some shelter, frost tender.
Solanum laciniatum	poroporo	Best in partial shade, hardier.

Appendix

Bird distributed native plants

These are plants that are commonly distributed by birds and, therefore, are attractive to birds. The process of natural regeneration can be hastened by planting such species to encourage birds.

Scientific name	Common name
Aristotelia serrata	wineberry
Beilschmiedia tarairi	taraire
Beilschmiedia tawa	tawa
Carpodetus serratus	putaputaweta
Coprosma robusta and other *Coprosma* species	karamu
Cordyline australis	cabbage tree
Cordyline banksii	forest cabbage tree
Coriaria arborea	tutu
Corokia cotoneaster	
Corynocarpus laevigatus	karaka
Cyathodes fasciculata	mingimingi
Cyathodes juniperina	mingimingi
Dysoxylum spectabile	kohekohe
Fuchsia excorticata	kotukutuku
Griselinia littoralis	broadleaf
Melicytus ramiflorus	mahoe
Myrsine australis	mapou
Pittosporum eugenioides	lemonwood
Pittosporum tenuifolium	kohuhu
Podocarpus totara	totara
Prumnopitys ferruginea	miro
Prumnopitys taxifolia	matai
Pseudopanax arboreus	five finger
Rhopalostylis sapida	nikau
Solanum aviculare and *S. laciniatum*	poroporo
Vitex lucens	puriri

IIIa Appendix

Fire resistant native plants

These plants are relatively fire resistant and can be used as a buffer between likely sources of fire and a forest remnant.

Scientific name	Common name
Coprosma grandiflora	raurekau
Coprosma repens	taupata
Coprosma robusta	karamu
Cordyline australis	ti kouka/cabbage tree
Coriaria arborea	tutu
Cyathea and *Dicksonia* spp.	tree fern
Fuchsia excorticata	kotukutuku
Geniostoma rupestre	hangehange
Hebe salicifolia and *H. stricta*	koromiko
Melicytus lanceolatus	mahoe wao
Melicytus ramiflorus	mahoe/whiteywood
Myoporum laetum	ngaio
Phormium cookianum and *P. tenax*	flax
Pseudopanax arboreus	five-finger

Appendix IIIb

Native plants capable of recovering from fire

These plants have the ability to recover from fire by responding from the base of the plant. Therefore they are useful in areas prone to fire.

Scientific name	Common name
Aristotelia serrata	wineberry
Dicksonia squarrosa	wheki
Fuchsia excorticata	kotukutuku
Melicytus ramiflorus	mahoe/whiteywood
Phormium cookianum and *P. tenax*	flax
Pseudopanax arboreus	five-finger
Weinmannia racemosa	kamahi

Glossary

Bait station:	Place where poison bait is laid.
Bare-rooted plant:	A plant that is dug up without soil around its roots and replanted.
Bovine tuberculosis:	A disease of cattle spread by possums.
Broadleaf:	Forest trees and shrubs with broad leaves compared to the needle leaves of conifers such as pines. Commonly used to refer to plants that are not conifers.
Colonise:	Refers to the spread of plants onto a new site.
Ground cover:	Vegetation covering the ground densely, preventing the growth of seedings.
Growing-on mix:	A plant mix (growing medium) for plants that have been transplanted into containers for eventual transfer to a planting site. It usually contains a slow release fertiliser.
Lining out:	Planting propagated plants in open ground at a nursery.
Microclimate:	A very localised climate.
Microsite:	A very localised site.
Nurse crop:	Plants that provide a sheltered environment for other plants.
Open Ground:	An area where plants are raised in the soil as opposed to growing in some form of container.
Open Space Covenant:	A protective agreement entered into by the landowner and the QEII National Trust to legally protect areas of landscape (frequently native forest remnants) in perpetuity.
Plant association:	A group of plant species that are usually found together in the same habitat.

Plant succession:	The different plant associations that grow in sequence.
Planting out:	The process of planting propagated plants into growing-on beds or out into the final planting site.
Pot up:	To transplant seedlings into containers.
Potting mix:	The growing medium used for growing plants in containers.
Pricking out:	Transplanting very small seedlings into trays or small containers.
Releasing:	The removal of unwanted vegetation from around a plant releasing it from competition for light and nutrients.
Revegetation:	Restoration of native vegetation.
Root pruning:	The pruning of roots to encourage the development of more roots, to reduce shoot growth and produce a tougher plant and to make the lifting of open ground plants easier.
Rootrainer:	A type of container that encourages the roots to grow downwards without spiralling.
Screef:	To chip off the vegetation on a planting site.
Seedbed:	A specially prepared nursery site or container of seed mix where seeds are placed to germinate.
Shade frame:	An unheated propagating structure used to control humidity and to shelter young plants.
Spot spray:	To spray only the area where the plant is going to be planted.
Stratification:	The nursery practice in which seeds are exposed to chilling temperatures, often in refrigerators at 4°C.
Understorey:	The plants that grow under the canopy of any vegetation.
Wrenching:	The process of lifting the pruned root system to encourage more root development.

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