WATER & SOIL MISCELLANEOUS PUBLICATION NUMBER 95

Plant Materials Handbook for Soil Conservation

Volume 3: Native Plants

National Water and Soil
Conservation Authority

ISSN 0110—4705

WATER & SOIL MISCELLANEOUS PUBLICATION No. 95

PLANT MATERIALS HANDBOOK FOR SOIL CONSERVATION

VOLUME 3: NATIVE PLANTS

by
K. M. POLLOCK

Soil Conservation Centre, Aokautere
Ministry of Works and Development
Palmerston North
(Now at Grasslands Division,
Department of Scientific and Industrial
Research, Lincoln)

WELLINGTON 1986

Plant Materials Handbook for Soil Conservation. Volume 3: Native Plants

K. M. Pollock, Soil Conservation Centre, Aokautere, MWD, Palmerston North.

Water & Soil Miscellaneous Publication No. 95, 1986, 66 p. ISSN 0110-4705

The Handbook comprises three volumes. Volume 1 deals with the requirements of soil conservation plants, their nursery production, field establishment and management in erosion problem areas. Volume 2 gives detailed information on more than 200 species, varieties and clones of introduced plants while Volume 3 discusses the use of some 70 native plants for soil conservation.

This part of the Handbook (Volume 3) prepared by K. M. Pollock discusses the selection of suitable *native plants*, sources of plant materials, their propagation, field establishment and maintenance, followed by specific comment on, and the requirements of, some 70 individual species when used for soil conservation.

Published for the National Water and Soil Conservation Authority
by the Water and Soil Directorate, Ministry of Works and Development,
P.O. Box 12-041, Wellington North, New Zealand.

Contents

FOREWORD

Erosion control may be effected by mechanical and biological methods. Mechanical methods such as terracing, debris dams and other engineering structures have an immediate effect and operate more or less at maximum design efficiency but their construction and maintenance costs are high. Biological methods, i.e. the use of live vegetation established from seeds, cuttings, rooted plants, etc, are relatively cheaper but their immediate effect is smaller. However, once established the vegetation provides a self perpetuating and increasingly effective permanent control. In New Zealand vegetation plays a major role in the stabilisation and rehabilitation of eroded lands, and in stream and river control works. Experience has shown that plants normally used in farming or forestry are not always suitable for inhospitable eroded sites. Special plants have had to be selected and appropriate establishment and management practices employed; it is the purpose of this Handbook to discuss these issues.

The Handbook comprises three volumes. Volume 1 deals with the requirements of soil conservation plants, their nursery production, field establishment and management in erosion problem areas. Volume 2 gives detailed information on more than 200 species, varieties and clones of introduced plants while Volume 3 discusses the use of some 70 native plants for soil conservation.

This part of the Handbook (Volume 3) prepared by K. M. Pollock discusses the selection of suitable *native plants*, sources of plant materials, their propagation, field establishment and maintenance, followed by specific comment on, and the requirements of, some 70 individual species when used for soil conservation.

Introduction

The term 'native' as applied to New Zealand flora refers to the species of plants which are not known to have been introduced by human agency. By definition New Zealand native plants must be native to the New Zealand Botanical Region. This region is described by Allan (1961) in Volume I of the *Flora of New Zealand* and includes the main inhabited islands—North, South, Stewart and Chatham Islands and their nearby islands—and the Kermadec, Three Kings, Snares, Antipodes, Auckland, Campbell, Macquarie and Antarctic Islands. The species referred to below are native to one or more of the North, South, Stewart or Chatham Islands but some also occur on other islands in the Botanical Region. Some of these species have much wider distributions than the New Zealand Botanical Region but these are not necessarily differentiated.

Often the decision to include native plants as part of an erosion control or revegetation programme is influenced, in part at least, by a desire to maintain or enhance the aesthetic and ecological integrity of the resulting vegetation. Equally important there is an increased interest in the conservation of native plants and the habitats which they form. There is also the common knowledge that native plants are generally well adapted to the soil and climatic conditions of New Zealand and have for many centuries kept most of the soil in place or at least provided sufficient stability for the present soils to develop from the original parent materials. But the New Zealand flora is not well endowed with species that can be regarded as early colonizers or pioneers. This point is illustrated by the relatively few species which were able to rapidly colonize bare soil once the native vegetation had been removed either by Polynesian settlers or later, on a much larger scale, by European settlers. On the other hand, several native species show a surprising tenacity and if not kept in check soon result in "reversion to scrub" on land cleared of bush and planted to pasture. The European settlers brought with them a number of northern hemisphere conifers and broadleaf trees and shrubs which were very good at colonizing bare or eroded soils and were generally preferred to native plants because of their relatively fast growth rates under New Zealand conditions. Despite the very real success of exotic species in soil conservation in New Zealand, many native species have an important part to play. So, although very few natives are suited to rapid recolonization of severely eroded land and few can be used to protect rapidly eroding surfaces, there are quite a number that can be used to revegetate denuded but generally stable surfaces or prevent potential erosion situations from becoming active.

Of the native species mentioned below a few have proven themselves in soil conservation, especially as windbreaks, and others have been frequently used in revegetation or restoration of impoverished vegetation. There are some which have received little attention in the past but which show definite potential for at least some soil conservation requirements.

The decision to include some and not other species in the present discussion is somewhat arbitrary since there is a point at which a given species may be uniquely suitable for a specific soil conservation problem but otherwise of limited value. It is not practicable here to discuss exact management techniques for each species. Instead, a general discussion is presented to demonstrate that native plants can be successfully managed for soil conservation purposes, followed by specific comment on and requirements of individual species in the section SPECIES DESCRIPTIONS. The information given below of course stresses the soil conservation value of many native plants but for general revegetation using native plants the booklet *Revegetation Manual: A Guide to Revegetation Using New Zealand Native Plants* by B. Evans (1983) should also be consulted.

The general principles of revegetation and soil conservation planting are given in Volume 1 of this Handbook and are developed further here in relation to native plants.

Selection of Suitable Species

General

As for any soil conservation programme, it is necessary to assess the type and severity of erosion or the likelihood and type of potential erosion, and to assess the climatic, biological and physical characteristics of the site. Once this is done it is possible to make a short list of species which may be useful or suitable for a particular combination of site conditions and erosion type. The Appendix lists a range of species, the erosion type each species is best suited to control, and information on the growth form, successional status and the main environmental tolerances of each species.

When making the species selection it is often useful to consider the natural and cultivated distributions of the species since this often gives some indication of their site and climate requirements (see the section SPECIES DESCRIPTIONS). Often, nearby native vegetation gives an insight into the most appropriate species to use. When planting in greatly modified landscapes, such as urban roadsides or farm shelter, that are far removed from any areas of native vegetation, the choice of suitable species is mainly determined by the site conditions and the desirable physical characteristics and environmental tolerances of the species. But whenever native vegetation is close to or surrounding the planting site, the choice of species may need to be restricted to those which are known to occur naturally in the area. The reason for this restriction is discussed next.

Genetic Pollution

This term, perhaps unfortunate in its conotations, refers to the unnatural introduction of genetic material or characters into a population. Genetic pollution occurs whenever a non-local species, subspecies, race or variety of plant, introduced by human agency, inter-breeds with the local population(s) and gives rise to fertile offspring capable of back-crossing and thereby, in time, introducing new genetic material into the local population. If the introduced genetic material, usually a new form of a gene (or genes) already present in the local population, dominates the expression of genetic characters then the characters displayed by the local population will eventually change. For example, populations of kowhai in the South Island display a divaricating juvenile stage, whereas some North Island populations do not have a distinct juvenile form. Some populations have a weeping growth form between the divaricating juvenile and upright adult whereas others, notably in the Taihape area of the North Island, retain the weeping form in the adult. If genetic pollution occurs in populations of this species, growth forms can be expected to be altered. In the long run this could result in the elimination of one or more growth forms. This example is not isolated. The New Zealand flora contains some genera and many species which hybridize or exhibit population or provenance variation in a wide range of characters. Population diversity in flowering time, seed set, growth rate, leaf form, growth habit and environmental tolerance is common and care needs to be taken not to threaten this diversity by genetic pollution or wanton destruction of isolated populations.

Another undesirable consequence of genetic pollution relates to the study of evolutionary history of the native flora. This history is not well known or well documented. As natural populations become more scarce the study of the evolutionary history becomes more difficult and can be further complicated if the natural evidence of evolution is confused by the artificial or unnatural addition of genetic material.

Genetic diversity within populations can also be lost through genetic pollution. This may not be a bad thing in the short term or on a limited scale where some diversity is sacrificed for higher productivity or greater competitiveness, but in the long term genetic pollution may reduce a population's ability to respond to selection pressure thus threatening its survival.

As distinct from genetic pollution, natural and human-assisted hybridization may be desirable and advantageous. Vigorous hybrids resulting from intergeneric or interspecific crosses, and other plants selected from wild populations for their culturally desirable attributes, can be a great benefit to soil conservators, horticulturists and gardeners. But it must be remembered that the original genetic diversity of any natural population should not be jeopardized by indiscriminate planting of selected lines.

It is important to realise that the genetic diversity present in natural populations, although often of limited or unknown value today, may be important to future developments in the plant industry with consequent benefits to society. Guidelines to help land managers compromise between the need to conserve soil and the need to protect and conserve the genetic resource contained in the native flora are given in the following section.

Restoration of Indigenous Vegetation

The greatest use of native plants in soil conservation is in the restoration of natural communities or impoverished remnants, and the revegetation of areas near indigenous vegetation so as to prevent the onset of soil erosion. It is important to preserve the floristic and ecological attributes of these areas by careful selection of species according to their ecological and successional roles, and by selecting propagating material from plants growing within or near the area to be restored.

An important refinement of the preceding situation concerns the planting of natives in or near scenic or scientific reserves and national parks. These areas have been specifically set aside to preserve the landscapes, flora, fauna and their associations for plant and animal habitat, and for human recreation and study. The intrinsic values of these areas must not be compromised by introducing non-local species, subspecies, varieties, cultivars, ecotypes, or populations.

Restoration and revegetation within state forest parks, private or public reserves of indigenous vegetation (other than those mentioned in the preceeding paragraph), and large areas of native tussock grassland which have no formal reserve status, should make use of local species where possible. Protection forestry often requires the use of exotic species to stabilize or colonise bare soils, subsoils or screes, but, unless there is a specific management policy to introduce better forms or provenances of indigenous timber species, there should be no introductions of non-local native species or populations.

Guidelines adopted by the Department of Lands and Survey and Botany Division, DSIR, for planting in reserves are reproduced here to encourage the skillful planting of natives in or near all areas of indigenous vegetation.

(a) The aim should be to ensure that the proper kinds of plants are planted, not to completely prohibit planting in our reserves or national parks. The planted species should be:
  (i) native to the surrounding district;
  (ii) already present in, or known to have once been present in, the proposed planting area;
  (iii) planted in ecologically appropriate places.

(b) Propagation material should be obtained from the same patch of vegetation, or from the same catchment or island within 3–5 kilometres of the reserve or park.

(c) There may be exceptional circumstances which would involve introducing a native plant to an area where it does not exist at present, in order to prevent it (or another species of animal or plant dependent on it) from becoming extinct. Similarly, circumstances, such as extensive earthworks, may arise where native plant material not strictly meeting the above requirements must be used because the alternative is gorse, broom or other adventive weeds.

Mangatawhiri dam site, Hunua, at time of construction, 1970. Photo A. Dakin.

The same site as above in April 1974. Only native species were used to revegetate the site.
Photo A. Dakin.

Slope planted with *Leptospermum scoparium, Phormium tenax, Cordyline australis, Pittosporum tenuifolium.*

Establishment of colonising species on extremely hard and infertile site, Wairoa dam. Holes were drilled in the rock, and plants established with the aid of slow-release fertiliser. Successful species are *Coprosma robusta, Leptospermum scoparium, Kunzea ericoides* and *Hebe stricta.* Photographed seven years after planting.

Spillway construction area. Mangatawhiri dam, planted with *Pittosporum* species, *Hebe stricta, Hoheria sexstylosa, Carpodetus serratus, Dodonaea viscosa, Sophora tetraptera, Knightia excelsa, Coprosma lucida, Griselinia littoralis, Pseudopanax arboreus, Myrsine australis.*

Compacted and poorly drained area planted with *Cordyline australis, Coprosma robusta, Leptospermum scoparium* and *Pittosporum tenuifolium*. Photographed seven years after planting.

Pittosporum tenuifolium and *Cordyline australis,* planted 1974. Photo 1984.

Wairoa dam, Hunua. All earthworks and construction sites around this water supply reservoir have been revegetated using species which occur naturally in the area.

Lakeside planting of *Phormium tenax, Leptospermum scoparium, Cordyline australis, Hebe stricta.*

(d) The ornamental value of plants such as pohutukawa or kauri does not exempt them from these guidelines.

(e) All plantings must be documented on permanent files, giving location planted, species planted, numbers planted, and provenance of seed/seedlings.

If guidelines (a) and (b) above are followed then the need to follow guideline (e) is considerably lessened.

It is also advisable, especially when planting near reserves or national parks, to discuss the proposed soil conservation plantings with the appropriate reserves board or administrative authority. This will go a long way in assuring that the most suitable species are used.

Sources of Plant Material

Whole Plants

A few of the commonly grown natives are often in good supply from commercial nurseries and small orders can be placed and filled as late as the autumn before planting. However, in many cases the required species will need to be propagated from cuttings or seed and thus it will be at least one or two years before plants are ready (Table 1). At present much of the commercial production of native plants is for ornamental and landscape use. When ordering plants for soil conservation and revegetation it is important that the nursery manager and staff be informed of and understand the precise requirements with regard to species or varieties, the situation for which the plants will be used (e.g., farm shelter, roadside revegetation, restoration of natural vegetation), physical limitations at the planting site, logistical limitations (e.g., transport, labour, time of planting), and whether or not the propagation material needs to be collected from or close to the planting site. This information will help the nursery personnel to supply plants best suited to the requirements.

Table 1: Availability from commercial nurseries of native plants suitable for soil conservation and revegetation (cf. Appendix). Information presented here was supplied by the New Zealand Nurserymens Association and is offered as a guideline only. Details will of course differ from region to region and from year to year.

A. Species that are reasonably available from a number of nurseries

Coprosma acerosa
C. repens
Cordyline australis
Corokia spp.
Corynocarpus laevigatus
Dodonaea viscosa
Griselinia littoralis
Hebe spp. (mostly ornamental cultivars)
Hoheria spp.
Metrosideros excelsa
Myoporum laetum
Nothofagus spp.
Olearia paniculata
O. traversii
Phormium cookianum
P. tenax
Pittosporum crassifolium
P. eugenioides
P. tenuifolium
Podocarpus totara
Sophora microphylla
S. tetraptera
Weinmannia racemosa

B. Species that are grown by a small number of nurseries only, or due to lack of demand may not be readily available

Aristotelia serrata
Brachyglottis repanda
Carmichaelia spp.
Cassinia spp.
Coprosma spp. (other than above)
Coriaria spp.
Fuchsia excorticata
Leptospermum spp.
Olearia spp. (other than above)
Plagianthus betulinus
P. divaricatus
Pomaderris apetala
Senecio spp.

As an alternative to getting plants from commercial nurseries, NZ Forest Service production and research nurseries occasionally have some surplus stock of native species but they do not normally endeavour to fill orders outside their own requirements. However, the Department of Lands and Survey's Native Plant Nursery at Taupo will propagate and grow plants for use in soil conservation and revegetation. Because very little of their stock is uncommitted, orders must be placed sufficiently far ahead of intended planting date to allow for collection and propagation of material. Contact should be made through the District Commissioner of Crown Lands, Department of Lands and Survey, Hamilton.

Seed and Cuttings

Several nurseries carry an assortment of native seed and a few seed supply firms list a considerable number of native plants for which they have seed, but unless the source of this seed is known and can be guaranteed the seed will be of little use for the propagation of plants for soil conservation or revegetation.

When planting is intended in or near reserves or other native vegetation there may be little choice other than to collect cuttings and/or seed from the local populations. This can be time consuming but there may be no other option. In this case collectors and propagators will have to label and keep records of plant material to ensure that after bulking up it is returned to its proper site. Several government departments, including the Department of Lands and Survey, Ministry of Works and Development, and New Zealand Forest Service, have applied this practice and demonstrated that local plant populations can be successfully propagated for use in the restoration of natural vegetation. This may also involve sending plant specimens to Botany Division, DSIR, for accurate identification.

Propagation

A very useful general reference is *Plant Propagation: Principles and Practices* (3rd ed.) by Hartmann and Kester (1975). Propagation procedures for native plants are given by Metcalf (1972) in his book titled *The Cultivation of New Zealand Trees and Shrubs*. Special propagation procedures are described for podocarps and beeches by Cath (1972), Dakin (1974) and New Zealand Forest Service (1980a), and for mountain shrubs by Bodger *et al.* (1979). Propagation of a range of natives from seed contained in forest duff is described by Herbert (1976, 1977) and Summers (1980). Rennison and MacLeod (1981), based on experience in the Nelson region, present information on propagation and planting of a wide range of lowland trees and shrubs suitable for restoration in reserves and national parks. Generalised propagation procedures for native plants used in soil conservation, along with some specific information where applicable, are summarised below.

Seed or Cuttings?

Whether to use seed or cuttings and the choice of subsequent propagation methods depends on a number of factors. To maintain the genetic diversity, plants used for restoration of natural vegetation or other revegetation work should be propagated from seed or, if viable seed is very difficult to obtain in sufficient quantity, from cuttings taken from a large number of individual plants. However, if it is important to maintain uniformity, as in the case of shelterbelts, then it is best to use cuttings from selected individuals or seed from genetically isolated and uniform populations which have the desired characteristics. Other important factors include the propagator's particular experience and skill, nursery facilities, availability and quantity of viable seed, rate of germination and seedling growth, and availability and rooting characteristics of cutting material.

Many of the species listed in the Appendix produce abundant viable seed and are most frequently propagated by this means. The main exceptions are *Brachyglottis repanda* and *Pomaderris apetala,* and species of *Cassinia, Hebe* (some), *Olearia* and *Senecio* which, although normally producing at least some viable seed or seed with short viability, are more easily (and thus most frequently) propagated from cuttings. Beeches and podocarps are noted for their irregular seed production but in good (mast) years they produce abundant viable seed. However, beeches, most podocarps and *Knightia excelsa* are not readily propagated from cuttings. A large number of the species listed in the Appendix can be propagated equally well from cuttings and seed, which is fortunate if seed is unavailable, e.g., *Aristotelia serrata, Fuchsia excorticata, Griselinia littoralis, Myoporum laetum, Weinmannia racemosa* and species of *Carmichaelia, Coprosma* (mostly large-leaved and *C. acerosa), Corokia, Hebe* and *Sophora.* Species of *Coriaria, Pittosporum* and *Pseudopanax* usually produce large quantities of viable seed and, owing to the relatively more difficult propagation from cuttings, are almost exclusively propagated from seed.

The only other practical method of propagation of soil conservation plants is division. Species included here are the flaxes, tussock grasses (including *Cortaderia*) and *Acaena.* These species can also be propagated from seed although species of *Chionochloa* have slow seedling development.

Seed Collection

Always collect seed from healthy plants because this usually ensures larger seeds, better germination and more vigorous seedlings. Seed plants should also possess the characteristics which best satisfy the requirements of the soil conservation or revegetation project. Beware of hybridization and back-crossing, or variability in the parent population, because this will give rise to variable and perhaps unpredictable seedling characteristics. However, do not forget that for restoration of indigenous vegetation, the prime requirement is to collect seed from local populations only, regardless of genetic variability, so long as seed plants are healthy and show promise of producing healthy and vigorous seedlings.

It is essential to obtain ripe seed. (Viability is also very important and is discussed in the next section). Knowing when seeds will be ripe is very much a matter of local experience. There are many native species, especially those with wide geographical or altitudinal ranges, which have wide variation in times of flowering, seed-set and seed-ripening. Also, for any given population these times often vary from year to year. The length of time the seed remains on the plant before it falls, is consumed by birds, insects or rodents, or loses viability is also variable. Despite these variations the approximate span of time over which seed ripens is given for a number of species in the section SPECIES DESCRIPTIONS.

Seed from selected 'mother' plants in the wild or from specially grown plants in the nursery is normally collected by hand, placed in paper bags (*not* plastic bags or air-tight containers) then prepared for sowing or storage as soon as possible (see below). It is a good idea to ascertain the approximate percentages of sound seed to help ensure sufficient quantities are collected. In forested areas seed can be collected by placing hessian or 'Sarlon' cloth nets under selected trees or under tree canopies consisting of the sought-after species. These nets need to be of a manageable size, preferably held in wooden frames above ground level and cleared at regular intervals. Also, seed can be gathered from the forest floor by raking up the duff in late autumn after most species have shed their crop of seed. The seed collected in this manner will consist mostly of the local species with greater diversity of seed being collected at forest margins. Often there will be a quantity of seed from non-local plants which has been brought in by birds. Further information on this latter method can be obtained from articles written by the New Zealand Forest Service staff (Herbert 1976; Summers 1980).

Seed Viability and Storage

Seed of many of the species listed in the Appendix germinates readily after ripening but if not germinated may or may not retain viability for long periods afterwards. The seed of some species will require a period of after-ripening or stratification to encourage rapid and even germination. Species with seeds of short-term viability include mostly those of the daisy family, namely, species of *Brachyglottis, Cassinia, Olearia and Senecio*, the flaxes, and *Pittosporum crassifolium*. If properly stored, seed of most of the other species listed in the Appendix will remain viable for at least 6 months and some for a year or more. Examples of the latter include *Carmichaelia* spp., *Dodonaea viscosa, Leptospermum* spp., *Nothofagus* spp., *Pittosporum colensoi, Podocarpus totara, Sophora* spp. and some species of *Hebe*. Beech seed has been stored for up to 8 years in air-tight containers at 5–10°C and 6% moisture content (NZFS 1980a).

Generally speaking the precise storage requirements for maintaining viable seed are not well or widely known for individual species since the practice is to collect fresh seed each year and sow it soon afterwards. Short-term storage requires that seed from dry fruits be kept dry, cool and free of insects. It is rather disappointing to open a seed container to find that some insect has been having a feast in quiet seclusion. Dusting with fungicide and insecticide is a reasonable precaution but not often necessary. Before seed of fleshy fruits can be stored the flesh or pulp can be removed. This is done by soaking the fruit for several days to soften and loosen the flesh which is then rubbed off by hand or mechanical means, or rubbed through a sieve. Fermentation has been used but is not generally recommended except when the seed will be sown soon afterwards. Seeds are then air dried and stored in dry containers at room temperature or lower. Many seeds that are contained in fleshy fruits can also be cleaned then stored moist at 2–7°C for several months or over winter. This treatment is very similar to stratification or moist chilling which is discussed in the next section.

Seed Preparation

Seed of many of the species listed in the Appendix requires little treatment or preparation other than possibly cleaning to remove the fleshy pulp or sieving to separate out the debris and small infertile seed. If damping-off fungi are expected to be a problem during germination the seed can be coated with a 50% thiram, captan or benomyl and talc mix.

Seed with short viability should always be sown fresh without additional preparation (e.g., *Corynocarpus laevigatus, Griselinia littoralis*). Also, seed which remains viable for 6 months or more can often be sown fresh, but if germination is slow, uneven or otherwise poor the seed would most probably benefit from stratification or moist-chilling. This consists of soaking the seed for 12–24 hours, mixing it with moist compost (1 part seed to 2 parts compost by volume) or other non-toxic moisture-retaining media, then storing it in open or aerated containers for 1–4 months at 2–7°C. If winter temperatures are cool enough the containers can be placed outside in a shady position. If preferred, layers of seed-containing mix alternating with layers of seedless media can be placed in the containers. It is essential to keep the mix moist, well drained and oxygenated. Polythene bags are very suitable because they prevent moisture loss yet allow some exchange of oxygen and carbon dioxide. Seeds treated in this manner tend to germinate more rapidly and evenly when exposed to slightly higher temperatures but are very sensitive to drying out.

Hard seed coats (e.g., *Sophora* spp., *Carmichaelia* spp.) will require special treatment to allow uptake of water for germination. Such seed can be placed in boiling water to soften the seed coat then left to cool. Successful treatment will usually be shown by the seeds beginning to swell within an hour or so. Mechanical scarification is preferred in some cases. The best method is rubbing or tumbling the hard seed

on sandpaper. The effectiveness of various intensities of scarification is best monitored by soaking samples of scarified seed for 24 hours. Overly intense scarification can completely destroy the seed coat and damage the embryo. Acid scarification can only be recommended to those people familiar with the method and the necessary precautions and procedures. Seed of *Sophora* spp. can be collected and sown when it becomes just mature but before the seed coat hardens. Scarification is not then required.

Seed dormancy, which is defined as the failure of a viable seed to germinate despite having absorbed sufficient water and having been exposed to favourable temperature and oxygen levels, is not generally a problem even though there are a number of species which do appear to produce a small percentage of dormant seed (e.g., *Aristotelia serrata, Coprosma* spp., *Cordyline australis, Fuchsia excorticata, Hebe stricta, Melicytus* spp., *Pittosporum colensoi, Podocarpus totara, Pseudopanax arboreus*). If a large percentage of the seed fails to germinate after sowing and still appears to be viable but dormant, stratification or additional stratification may be helpful. Dormancy problems are usually not worth solving unless a large percentage of seed is affected and the seed is in short supply.

Germination Media and Sowing of Seed

Preferred media for the sowing of native seed consist either of sand, or of pumice-sand, or of pumice mixed with an equal volume of either peat, or leaf mould, or rotted sawdust. These media are suited for either germination trays or nursery seedbeds. If peat or pumice has been used the pH may need to be adjusted to 5.5–6.4 by addition of lime or dolomite (NZ Forest Service use 250 kg/ha on the peat/pumice soil at the Rotorua nursery). Slow-release fertilizer and trace elements may need to be mixed into the top 5–10 cm if seedlings are to remain in the beds for long periods.

Media in germination trays or nursery seedbeds do not need to be sterilized unless a particular problem with pathogenic fungi occurs. Damping-off is the major pathogenic problem but is usually kept in check by good nursery hygiene. Preventative measures include coating seed with a 50% thiram, captan or benomyl and talc mix, or treating the media with terrazole (0.6 g/ℓ then apply 1 ℓ of this solution to 60 ℓ of media). Remedial action consists of drenching beds with a solution of benomyl ('Benlate') at a concentration of 0.7 g/ℓ. Germination media should not be allowed to dry out or become waterlogged at any stage.

Sowing density and depth will be determined by seed size. When sowing into germination trays, seeds should be scattered to give 15–25% cover then covered with lightly firmed germination media to a depth equal to seed diameter. Fine seeds (e.g., pohutukawa) can be mixed with fine dry sand to allow more even spreading. They may also be sown onto sieved sphagnum moss. Large seeds can be placed individually. The seed density in seedbeds will depend on the species (for podocarp seed the New Zealand Forest Service uses 250–300 viable seeds/m^2). The seed is then rolled into the bed and covered with sieved soil to a depth equal to twice the seed thickness. Seedbeds need to be kept moist, covered with shade cloth (50% shading), and protected from wind, birds and rodents. Shade cloth also protects the young seedlings from overheating and from frosts.

Preparation of Cuttings

Many natives that are useful in soil conservation can be propagated by hardwood or semi-hardwood cuttings.

Hardwood cuttings are collected in late autumn so that the current season's growth has hardened but not too late such that there will be insufficient time to allow callus and root formation before spring. Cuttings should be 10–15 cm in length and may include two seasons' growth. A sharp knife is used to remove the growing tip and

60–80% of the foliage, and to make a straight cut across the base 5–10 mm below a node. For species that are more difficult to root, a vertical cut 2–3 cm long up from the base will provide more sites for callus formation. For easily rooted species, such as those of *Brachyglottis, Hebe, Myoporum, Olearia, Pomaderris* and *Senecio,* basal cuts can be made with secateurs. Hardwood cuttings are normally planted in open ground. (It has been suggested that some *Hebe* cuttings can be planted directly in the field on favourable sites). The nursery soil should be well-cultivated, friable, and firmed by rolling after cultivation. A narrow trench approximately 7–8 cm deep is then formed and cuttings inserted singly to half their length and firmed in by foot. With heavy soil it is better to fill the trench with sand and insert the cuttings into this. Beds need to be kept moist in winter but not waterlogged. Normal nursery maintenance applies during the following spring and summer. A programme of summer and autumn wrenchings (2–3 times) will help to develop a fibrous root system and condition stock for lifting and planting the following winter.

Semi-hardwood cuttings are prepared from the partially hardened wood which is present after a growth flush. It is normally present during the period December to April. Cuttings from species which produce flowers on the new growth will need to be taken early after a flush of growth before the flower primordia develop. Cuttings need to be 8–15 cm long, and the growing tips and 30–50% of the foliage removed. Large leaves should be trimmed back accordingly instead of removing only entire leaves. It is very important to keep these cuttings moist, cool and out of direct sunlight at all stages. Cutting material should be taken from shaded parts of the plant in the early morning, or on cloudy or slightly damp days, and kept cool and moist in polythene bags. The sooner cuttings are prepared for planting out the less the risk of their drying out. The prepared cuttings are inserted into sand or a peat/pumice/sand mix in propagating frames. They need to be inserted to half their length and firmed in. It is necessary to maintain high humidity using shade cloth, shade frames and/or intermittent mist. Bottom heat is not recommended. Once roots have started to form, the cuttings are potted up or lined out into irrigated and sheltered beds. If mist is used the plants will need to be carefully hardened-off when potted up or planted out.

Division

Mat-forming or clump-forming herbaceous species can often be propagated by division (e.g., *Acaena* spp., *Cortaderia* spp., tussock grasses and flaxes). Mats of *Acaena* can be cut into clumps, soil included, with side and depth dimensions of 5–8 cm. Tussocks and clump-forming grasses can be divided into groups of 6–12 tillers. Flaxes are divided into their constituent fans and the leaves cut back to 30–40 cm. During division care must be taken to ensure that at least some healthy, undamaged roots remain with each new clump. The divided material is then lined out in the nursery for a year or can be planted immediately on favourable sites. Division should normally be undertaken in winter so that the new plants do not become stressed and so that they benefit from vigorous spring root growth.

Containerised and Open-grown Nursery Plants

Whether it is preferable to grow seedlings or rooted cuttings in containers or in outside nursery beds often depends on nursery facilities and preferred management practice as much as what is best for the plant. Fortunately most natives can be grown equally well in containers or open nursery ground provided the chosen method is properly carried out. Containerized plants are more easily managed if only small numbers are being handled. These grow to a plantable size more quickly and at the planting site can tolerate being left exposed to wind and sun for brief periods before planting. Some of the faster growing species can be ready for planting within 7 or 8 months from seed or cuttings without incurring the expense of repotting. In this

class are some of the larger *Hebe* species, *Corynocarpus laevigatus*, *Pomaderris apetala* and species of *Coprosma*, *Corokia*, *Hoheria*, *Olearia* and *Pittosporum*. These species can be grown in root-trainers of 200–400 ml capacity or polythene bags of 800–900 ml capacity to reach a plantable size of 20–40 cm in one growing season. Close spacing in the nursery can result in leggy plants if they are left to grow too tall. Plants left in containers beyond the optimum planting time will not establish well when planted out. Containerised stock is, of course, bulky to handle and expensive to produce if held for more than one growing season and requiring repotting. Also, root systems can become weak and disfigured in under-sized containers. Carelessly discarded containers can be a litter problem at the planting site.

Open-grown stock is often preferred when large numbers of plants are required for a single job or common planting time. Advantages of open-grown stock include better opportunities for conditioning stock, lower production costs for large numbers, and less bulk and weight because this stock is bare-rooted for transport to the planting site. Open-grown stock is conditioned by a program of undercutting, wrenching and side-pruning of roots. Procedures developed and used by the New Zealand Forest Service (Bodger *et al.* 1979; NZFS 1980a) are summarized here. Plants which will spend only one season in the nursery should be undercut at 10 cm depth in late December and wrenched two to four times during the summer and autumn. Inherently fibrous roots like those of *Hebe* spp. need little wrenching but may require side-pruning. Side-pruning of lateral roots should be done before lifting but not as frequently as wrenching. Box-pruning produces very well conditioned fibrous roots but is labour intensive. Podocarps and other slow growing species which remain in the nursery for more than one year need only be undercut in the late summer or autumn immediately preceding the winter in which they are to be planted. Monthly wrenching and occasional lateral root-pruning is necessary between the time of undercutting and lifting. When box-pruning, only two sides should be cut at any one time. Lifted plants are immediately stored in kraft multi-wall bags and kept cool and moist until planting.

Size of Plants for Planting Out

The desirable plant size will mostly depend on the young plant's growth rate and conditions at the planting site, especially weed competition. Small healthy plants with good root systems are preferred because they will suffer less setback or stagnation when transplanted. The faster growing species, which can produce 20–40 cm of top growth in one season in the nursery, are ready for planting out in the first winter. Slower growing species should be at least 50 cm tall. Podocarps should be as much as 80 cm tall and well conditioned before planting in the field. Large transplants will stand a better chance in competition with weeds, and large hardwood shrubs are less likely to be seriously damaged by hares, rabbits and possums. The cost of producing well conditioned large plants has to be compared with the economics of using perhaps smaller stock and an effective programme of weed and pest control that is required when small stock are used. Certainly, on some sites the cost of weed control may be much greater than holding plants in the nursery for another year. Also, nursery seedlings are not at great risk from browsing during the extra time they spend in the nursery.

Site Preparation and Planting

Site preparation depends on the type of erosion and site factors including soil fertility, other plant growth and exposure to wind, frost and sun. In many cases it may be desirable and necessary to promote initial stability and create a more favourable microclimate by sowing or hydroseeding a grass-legume mixture on the site (but not in scenic or scientific reserves or national parks). Compacted soils or subsoils

Propagation of native species, Department of Lands and Survey nursery, Taupo. Extensive use is made of 'Rootrainers'.

Leptospermum seedlings packed for despatch at Department of Lands and Survey nursery, Taupo. The plants are removed from the 'Rootrainers' prior to despatch.

Propagation of *Agathis australis* seedlings for enrichment planting, Hunua nursery, Auckland Regional Authority.

Growing-on area for native species at New Zealand Forest Service Sweetwater nursery.

need to be deep-ripped to at least 400 mm. Including native seed in sowing or hydroseeding mixes or sowing native seed into grass-legume swards is unsuitable because the native seedlings cannot compete successfully with the more vigorous species. Pure legume swards are probably not as harmful to native seedling establishment but neither have they been shown to greatly enhance establishment. Attempts to sow only native seed have been few but seedlings of *Leptospermum* spp., *Weinmannia racemosa*, *Cassinia fulvida*, *Hebe stricta and H. salicifolia* are capable of establishing on bare, infertile soils. Seed-bearing *Leptospermum* slash has been spread on bare infertile sites in the North Island to provide seed and protection for the resulting seedlings. Despite the relatively high cost, early results indicate this method is very successful in establishing *Leptospermum* seedlings (H. Scheltus, Department of Lands and Survey, Taupo and M. Stevens, Maui Pipeline Project, MWD, Hamilton, pers. comms.).

Before planting containerized or bare-rooted stock the competing vegetation will need to be removed. This is usually done by spot-spraying with knock-down and pre-emergent weedicides to control current and future weed growth. Residual herbicides should not be used in high rainfall areas unless it has been proved that they are retained in the top soil layer and not leached into the rooting zone. The planting hole needs to be larger than the root system and the soil in the bottom of the hole should be lightly worked with a spade to permit easier root penetration. Many plants may benefit slightly from slow-release fertilizer (20–40 g per hole) if the soil is infertile. Broadcasting the fertilizer is not recommended because this method will result in more vigorous weed growth. Planting in forested areas is described by the New Zealand Forest Service (1980b). Planting on sites devoid of topsoil is described for the Auckland area by Dakin (1976a,b, 1977).

Certain species, including *Aristotelia serrata*, *Coprosma* spp. *Hebe* spp., *Leptospermum* spp. and *Pittosporum* spp., are useful nurse crops for other natives and should be planted early in the revegetation programme. Natural groups containing several native species are often preferred in revegetation and restoration work (see Evans 1983).

Maintenance of Plantings

The most common maintenance is control of weeds and competing vegetation. Generally, if proper pre-planting chemical weed control has been carried out there should be little problem with weed growth in the first year but it is still important to regularly observe the plantings so that release spraying or hand weeding can be done promptly if weeds are becoming a problem. Unless there is good evidence to the contrary, it must be assumed that all native plants are sensitive to weedicides used in release spraying. Therefore, precautions are essential to ensure the spray does not contact the transplant.

If browsing is a problem an effective programme of animal control is required until the young plants are out of reach of hares, rabbits or deer. Further control of possums, goats and deer may also be necessary because these animals can damage large shrubs and trees through debarking and defoliation. As a precaution, the animal browse problem should be properly assessed, and corrective action taken, *before* any planting is done.

Plantings should be kept under observation for the first two or three years or until well established; maintenance problems should be promptly attended to. A balanced fertilizer applied to individual plants during the second growing season may be necessary on infertile sites but otherwise fertilizer is not usually necessary.

Manuka *(Leptospermum scoparium)* slash used to provide initial cover on eroded pumice soil, enabling the establishment of *Leptospermum* plants and tussocks by natural seeding. Rangipo, November 1984 (see also photo below, left).

Coprosma acerosa is useful in the restoraton of disturbed areas in sandy soils or sand dunes. It is not a primary stabiliser, and initial planting with lupins and marram is usually required.
Photo P. Newsome.

Coastal revegetation project at Milnethorpe, Golden Bay. Successful native species include *Dodonaea viscosa, Pittosporum tenuifolium, P. crassifolium, Myoporum laetum.*

Species Descriptions

The following list includes many species which have been useful or show potential in soil conservation, revegetation and restoration.

For each species, a very brief description of height, form and distinctive characteristics is given. This is followed by comment on the natural and cultivated distributions throughout New Zealand, the general habitats or vegetation type in which the species normally occurs and very brief information on the ecology and environmental tolerances. Then suggestions, and in some cases recommendations, are made as to the type of erosion control to which each species is best suited. Specific information on the use of natives for erosion control is lacking and often only general statements can be made. Finally the preferred methods of propagation are given; often this is very brief and the reader must refer to the earlier general discussion under PROPAGATION. When specific information on propagation is known, it is given. Planting procedures are mentioned only if special techniques apply, otherwise the general procedures given above apply.

For further descriptive information the reader is referred to Cockayne (4th ed., edited by E. J. Godley 1967), Allan (1961), Metcalf (1972) and Salmon (1980). These texts also contain a great deal of information on the taxonomy, identification, general ecology and cultivation of the species listed below.

Trees and Shrubs

Aristotelia serrata (J. R. & G. Forst.) W. R. B. Oliver

Makomako, Wineberry

Shrub or erect to spreading small tree up to 9 m. Deciduous in colder regions and often semi-deciduous on open sites in warmer regions. Dioecious.

Aristotelia serrata is common and widespread throughout the North, South and Stewart Islands in lowland and montane forest and scrub, and is found from sea level to 1000 m.

It is primarily a colonizing species in secondary successions. It often occurs abundantly on forest margins, clearings, slip faces and cut-over bush or after fire. It does not establish readily on bare or compacted infertile soils. However, it grows well in most soils except those which are very poorly drained or drought prone. Wineberry is often considered a weed where attempts are made to clear forest for agriculture or forestry. It is not suited to drier climates and will not tolerate very dry desiccating winds or exposed positions. It is frost hardy except when plants are young. The species is palatable to stock and possums.

Wineberry is very suitable for planting on road batters and other disturbed sites throughout the forest zones of New Zealand. It is good for gully erosion control and slip-face revegetation on non-pastoral or retired land. The species is suitable for low- to mid-tier shelter in multi-row shelterbelts but *not* for windbreak shelter on its own. It provides rapid canopy closure when planted at 2 m spacing. Wineberry is not a long-lived species and can die out after 10–15 years; therefore, plantings of it should be used to provide shelter for more permanent species.

Propagation is usually by seed but, if selected forms are desired, semi-hardwood cuttings can be used. Trees start fruiting at around six years. Seed is ripe from January to March in most areas but can be later in cooler districts. Wineberry's rapid and rank growth will retard growth of less vigorous species but over the years will allow the natural succession of other forest species if their seed sources are present.

Brachyglottis repanda J. R. & G. Forst.

Pukapuka, Rangiora

Spreading shrub or small spreading tree up to 7 m. Large leaves up to 30 × 15 cm have irregular sinuate margins and are most distinctive.

Brachyglottis repanda is common in coastal and lowland forest and scrub of the North Island and in the South Island as far south as Kaikoura and Greymouth, and occurs from sea level to 800 m. It is commonly cultivated in most lowland districts throughout but not in areas susceptible to heavy frosts.

Rangiora prefers open spaces in forest and scrub and is often abundant along streamsides and roadsides. It grows well in most soils except extremely dry or water-logged soils. Once established, it can tolerate quite dry conditions but growth is very slow. It is very wind hardy. Young plants tolerate only a few degrees of frost.

The species is useful for filling in the gaps under medium and tall shelter. It is also useful for planting on streamsides for bank protection. It is not suitable for planting on drought-prone sites, although short drought periods can be tolerated once plants are well established. It forms a dense stock-resistant cover.

Rangiora is easily propagated from hardwood or semi-hardwood cuttings. Seed production is not reliable in some years. Flowers and leaves are poisonous to stock but few cases of poisoning have been reported.

Carmichaelia spp.

Native Brooms

A diverse assemblage of about 39 species in New Zealand. A few species are small, often leafless, shrubby trees of 3–5 m but most species are erect to depressed and prostrate shrubs.

Various species are found throughout New Zealand in a wide range of open and, frequently, early successional habitats from coastal to alpine regions, and in forests, grasslands and rocky places. Habitats frequently include moist streamsides, dry hill-slopes and dry river beds. Many species and varieties have very narrow habitat and/or geographical ranges.

Carmichaelia species have not been used specifically for erosion control but, being legumes with nitrogen-fixing nodules, the various species could be used more in areas of low soil fertility where it is desirable to restore the natural vegetation. Otherwise, they are of little use in erosion control planting. Plants are generally slow growing and are not good primary colonizers nor do they afford much protection for other plants. They provide low density cover but cannot be expected to provide soil protection on their own. They are useful in providing floristic diversity of restored sites. Several species are found in drought-prone regions but only a few occur in the semi-arid regions (e.g., *C. petriei, C. ramosa, C. flagelliformis, C. enysii, C. monroi, C. orbiculata*). Most species have a slow growth rate and are very palatable to stock, hares and rabbits.

The native brooms can be raised from seed, which ripens in summer to early autumn depending on species and locality, but germination is variable. Semi-hardwood cuttings root readily in a cold-frame. Plants will not tolerate weed competition and *Carmichaelia* species will not normally be recommended for planting where weed growth is already prevalent or likely to become prevalent. Browsing and grazing animals must be excluded. Native brooms are often confused with adventive species and wrongly treated as noxious weeds. Some species are under threat of extinction through injudicious use of sprays to control European broom (*Cytisus scoparius*) and gorse (*Ulex europaeus*).

Cassinia fulvida Hook. f.

Golden Tauhinu, Golden Cottonwood

Much branched but erect shrub up to 2 m. Distinguished by its small (1 × 6 mm) coriaceous leaves and tawny coloured (fulvous) tomentum on stems and undersides of leaves.

Cassinia fulvida is found in lowland and mountain shrubland from the central North Island to Stewart Island, from sea level to 1100 m. It occurs most commonly in open places such as grassland, riverbeds and sandy coastal country. It performs well on poor soil that is well drained and dry. It is mostly an early to intermediate species of secondary succession and is regarded as a good colonizer on yellow-brown earths. Established plants on sand dunes can spread by layering as branches become buried by drifting sand. It is very drought and frost hardy. *C. fulvida* var. *montana* is a more compact shrub with shorter and broader leaves and is found mostly in shrub and grassland vegetation of montane regions of Canterbury and Otago.

The species is suitable for use in controlling wind erosion on sandy surfaces but is not a colonizer of shifting sand; thus in such situations, some initial stabilisation is required. It is probably suitable for control and revegetation of gully erosion in dry montane areas but this type of use has not been tried. The shrub is generally suitable for revegetating disturbed surfaces in dry montane areas and for dune stabilisation. It is always best to propagate local material for these purposes if at all possible.

Propagation is by cuttings. Seed can also be used when procurable. It is regarded as a weed in some areas. In places it competes successfully with marram grass.

Cassinia leptophylla (Forst. f.) R. Br.

Tauhinu, Cottonwood

Shrub up to 5 m tall with greyish white tomentose branches and undersides of leaves.

Cassinia leptophylla occurs on dunes and dry hillsides from the East Cape to Nelson and Marlborough, mostly in open places and grassland, or in shrubland from sea level to low montane. It is frost and drought hardy.

The shrub is suitable for gully control on retired or non-pastoral land and for revegetation of roadsides or other earthworks. It is regarded as a weed in some places and has been difficult to eradicate from pastureland, especially in Marlborough Sounds. It is generally unpalatable and fairly resistant to a number of herbicides.

Propagation is by hardwood or semi-hardwood cuttings, or by seed. The seed ripens during summer to early autumn but the percentage of sound seed varies. The closely allied species *C. retorta* has slightly larger leaves and is restricted to coastal areas and dunes from North Cape to East Cape.

Cassinia vauvilliersii (Homb. & Jacq.) Hook. f.

Mountain Cottonwood

Shrub up to 2 m. Branches erect and often sticky.

Cassinia vauvilliersii is found mainly in drier areas of scrubland and grasslands from Auckland southwards, from sea level to 1400 m. It prefers dry sites with good drainage, and often provides cover and shelter for herbaceous plants and seedlings.

This species is suitable for revegetation of roadworks and other earthworks in drier regions, especially intermontane basins. Only local plants should be used for propagation because many populations are probably well adapted to local conditions only. There are several recognised varieties.

Propagation is by seed or cuttings. Semi-hardwood or hardwood cuttings root well but additional wounding on the cut end improves callus formation and root initiation. Taking cuttings in March is advantageous in that it allows good root initiation before winter. Since roots are not naturally fibrous, a programme of wrenching of open-grown plants is preferable to growing plants in containers. Plants grown from seed are slower but appear to transplant more readily. Seed production is variable. Care in selecting only sound seed is often necessary.

Coprosma acerosa A. Cunn.

Prostrate shrub but some forms reach 2 m.

Coprosma acerosa is found sparingly on coastal sand dunes throughout the North, South, Stewart and Chatham Islands. It is also grown in gardens as a ground cover. The species is moderately frost hardy.

It is suitable as a complementary species in the restoration of disturbed areas on sandy soils or sand dunes. *C. acerosa* is not a primary colonizer so initial stabilisation by other plants or means will be required. It does not always form a dense cover and is easily buried by drifting sand but prostrate stems readily root when only partially buried.

Propagation is by cuttings or seed.

Coprosma lucida J. R. & G. Forst.

Karangu, Karamu

Stout branched shrub or small tree up to 6 m. Leaves commonly about 12 cm long by 4 cm wide and glossy.

Coprosma lucida is common in lowland to montane forests and scrublands of the North, South and Stewart Islands, and occurs from sea level to 1100 m. It is often found growing on old logs or on large trees but does well on well drained but not necessarily fertile soils. It is adaptable to open, fully-lit areas, but is mainly a species of the forest undergrowth. On wetter or higher altitude sites it tends to grow in open situations. Occasionally it is common near the treeline. It is moderately frost hardy but not drought hardy.

It is suitable for stabilising slopes or earthworks with a southerly aspect or otherwise shaded, and also suitable for low-tier shelter in an integrated shelter system. It tolerates trimming very well.

Propagation is usually by semi-hardwood cuttings grown in cold frames. Seeds ripen in late summer to early autumn and germinate readily. Where topsoil has been removed slow-release NPK fertiliser will be required. It is very susceptible to browsing by hares, rabbits and deer.

Coprosma parviflora Hook. f.

Leafy Coprosma

Shrub or small tree up to 5 m. Small narrow leaves less than 1 cm long, mostly close set. This species is very variable in both form and site requirements. Therefore, it is always best to use the local populations.

Coprosma parviflora is common throughout the North, South and Stewart Islands in lowland to montane forest, scrub and grassland, often in swampy or boggy places, from sea level to 1400 m. In forests it is common in the shrub understorey. It is one of the primary colonizers of secondary successions leading to kahikatea swamp forest, thence to podocarp-mixed hardwood forest. It tolerates heavy, wet and infertile soil very well. It is frost tolerant but not very drought hardy. Tolerances can be expected to vary between populations.

The species is suitable for general revegetation of heavy clays where waterlogging may occur. Compacted clays will need to be loosened up. It is useful as a fringe or margin species to add diversity to wetlands and riparian strips. *Coprosma propinqua* and *Phormium tenax* are probably more suitable on more fertile sites.

Propagation is generally by seed, which ripens in autumn and early winter. It is important to collect from the local populations and from within habitats most similar to the planting site.

Coprosma propinqua A. Cunn.

Mingimingi

Similar to *C. parviflora* but generally larger (up to 7 m). Some forms are nearly prostrate. It hybridizes with *C. parviflora* and *C. robusta.*

Coprosma propinqua is common in lowland forest, scrub and swamp throughout New Zealand including the Chatham Islands. It has similar successional roles and tolerances to *C. parviflora.*

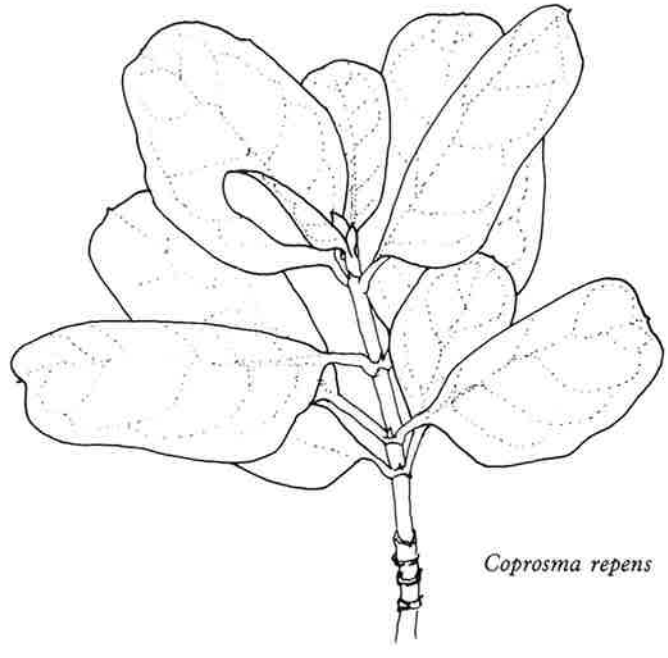
Being widely distributed, it is often a good choice for general revegetation of earthworks and for restoration of depleted vegetation on wet ground. Several varieties are recognised and populations are likely to be adapted to local conditions.

Propagation is generally by seed or cuttings but it is important to use local material or plants carefully selected for the conditions of the planting site.

Coprosma repens A. Rich.

Taupata

Densely foliaged, glossy leaved shrub of variable form, from prostrate to a much branched small tree of 8 m. Despite its specific name (repens = creeping) it is not generally a prostrate or creeping plant.



Coprosma repens

Coprosma repens is found on coastal rocks and in coastal and lowland dunes and forests of the North Island, and the South Island as far south as Greymouth and Marlborough. It is commonly found in gardens and hedges or shelterbelts throughout lowland districts but not where moderate or severe frosts occur. It tolerates exposure to salt spray and strong winds very well, but does not tolerate heavy wet soils. It can withstand considerable dryness for short periods but will not thrive on dry gravelly soils.

The species is excellent for low shelter in most lowland districts. Plants for shelter are best selected for good upright growth form. If it is desired to keep the shelter narrow, it will tolerate regular trimming very well, but heavy pruning only once in 3–4 years will need to be done with care. The shrubby and prostrate forms are very good for planting on exposed sand or rocks in coastal areas. It will not establish well on shifting sand but once established it will provide dense foliage to ground level which will help prevent blowouts. It will also spread by layering when partially covered by sand.

Propagation is by seed. Fresh seed, collected in summer, germinates very readily. Semi-hardwood cuttings can also be used. Early growth is rapid and plants can be ready for planting out after one season in the nursery.

Coprosma robusta Raoul

Karamu

Erect or spreading shrub, or small tree up to 6 m. Leaves 5–12 cm long, eliptic-oblong in shape.

Coprosma robusta is common in lowland and montane forest throughout the North and South Islands although in Southland plants are usually referred to as *C. lucida.* It occurs also in coastal and lowland swamp and scrubland. Its altitudinal range is sea level to 1200 m. The species is grown in many gardens in most lowland districts but not in great numbers. Karamu is commonly found on roadsides throughout forest regions. It grows well in most soils except very dry soils, and tolerates shade or full sun equally well. It is wind hardy, but does not thrive where it is exposed to persistent and strong winds.

Early growth is fast so it provides good shelter for other plants on barren sites. It is suitable for general revegetation on bare infertile soils or subsoils and also for planting to provide low-tier shelter under taller shelter. On infertile subsoils it will respond well to slow-release fertiliser. It is a good soil stabiliser because its roots are very dense and fibrous.

Propagation is by seed or semi-hardwood cuttings. Seed is ripe in the autumn. Plants older than three years produce abundant quantities of seed which is very attractive to birds thus aiding its dispersal. Birds will often bring in seed of other forest species which will help the natural succession.

Because they are very palatable, plants will need protection from rabbits, hares and deer. However, plants are only slightly palatable to possums.

Cordyline australis (Forst. f.) Endl.

Cabbage Tree, Ti Kouka

Small tree of variable growth form, 5–13 m tall. Generally sparingly branched with leaves clustered at branch tips. Occasionally plants are more numerously branched which gives them a more bushy habit.

Cordyline australis is common throughout open places and scrubland of the North and South Islands but rare on Stewart Island. It is found at altitudes from sea level to 800 m. Habitats vary from wet swampy ground to dry windy hillslopes on heavy to light soils. It can even grow reasonably well in pure sand or gravel if moisture is not too limiting.

The tap-root of the cabbage tree is believed by some to aid in holding steep slopes from soil slip erosion. If this is so, it may have limited use in pastoral hill country but protection of young plants would normally be too costly. The tree is suitable for planting on other, ungrazed slopes where stabilization is required. It is also suitable

for low to medium height windbreaks but will need to be under-planted with *Cortaderia* spp., *Phormium tenax* or leafy shrubs. Young seedlings are easily damaged by hares and rabbits. In dry scrubland areas of Marlborough and Otago where more palatable species are locally absent it can be highly favoured by possums.

Propagation is by seed, which germinates readily. Careful selection of seed source is important because there is considerable variation within the species. Seed ripens in the autumn. Selected forms can be vegetatively propagated from lateral shoots which are produced from near the stem base when the main shoot tip is removed.

Seedlings as small as 30 cm high can be successfully transplanted if they are well protected from hares. When planting, care must be taken not to damage the thick fleshy tap-root.

Coriaria spp.

Tutu

Members of this genus in New Zealand are useful in soil conservation and revegetation because they have root nodules containing nitrogen-fixing fungi. However, the plants contain poisons in the sap and berries and should not be planted where livestock will eat them. Also, because they may be a source of toxic honeydew, they should not be planted near beehives. This honeydew is excreted onto tutu leaves by the passion vine hopper and may be taken by bees when nectar and other sources of moisture are in short supply. Tutu pollen is often taken by bees but is not poisonous.

New Zealand species of *Coriaria* are notoriously variable, mostly due to hybridization, therefore it is always best to propagate local material only.

Coriaria arborea Lindsay

Tree Tutu

Stout shrub, branching from base, up to 6 m tall. Occasionally grows to a small tree with a stout trunk up to 3 m.

Coriaria arborea is found throughout coastal to montane forests of mainland New Zealand and the Chatham Islands. It is often locally abundant in scrublands and forest margins and on alluvial ground. Its altitudinal range is sea level to 1100 m. It is a pioneer species and frequently colonises burnt-over areas, pumice, alluvial gravels and road batters. The species does not tolerate extreme drought conditions.

It is very suitable for revegetation of road batters, bare pumice, gravel or other free draining soils low in fertility. It suckers freely and produces a fibrous root system which makes it an ideal plant for stabilising bare, friable soils or subsoils. *C. arborea* often hybridizes with other species of *Coriaria*, thus plant material should be propagated from local populations.

Propagation is best accomplished using fresh seed. It ripens from summer to late autumn depending on locality. Seeds need to be separated from the black pulp by maceration for best results.

Stratification for two months often ensures more even germination, especially when seed is to be sown directly into nursery beds. Plants are ready for planting out after one growing season. Field sowings of seed can be accomplished by laying down seed-bearing branches as described for manuka and kanuka.

Coriaria plumosa W. R. B. Oliver

Mountain Tutu

Summer-green, spreading to prostrate shrub, up to 0.5 m, with branching rhizomes.

Coriaria plumosa is found from Mt Egmont and Mt Hikurangi southward in the North Island and throughout the South Island in montane and low-alpine open

habitats. Its altitudinal range is 300–1500 m. It is a common early successional species of alluvium, colluvium, streamsides, avalanche paths and damp rock outcrops of grasslands, herbfields and moraines. Mountain tutu is found mostly in wetter climates.

The species is possibly suitable for establishing on bare slopes and earthworks up to elevations of 1300–1400 m.

Propagation is by seed as described for *C. arborea.* Plants should be propagated from local material and be sufficiently hardened if they are to be transplanted to higher and colder sites than the nursery.

Coriaria sarmentosa Forst. f.

Tutu

Nearly prostrate, spreading semi-woody shrub with short, often erect, deciduous reddish stems arising from perennial, branched rhizomes. Up to 1 m tall.

Coriaria sarmentosa occurs from the central North Island to Stewart Island, mostly in wetter climates, from sea level to 1300 m. It often forms large patches and occasionally forms extensive communities on open ground especially on alluvium and colluvium in coastal to subalpine and even low alpine regions. It is usually a pioneer species, being one of the earliest plants to colonise the open ground once initial stabilisation has occurred.

The species is suitable for revegetation of road works and other earthworks in areas where populations of this species are normally found. Protection Forestry Division of FRI, Rangiora, has successfully planted this species on road batters in the Canterbury high country.

Propagation is as for *C. arborea.*

Corokia buddleioides A. Cunn.

Korokio

Erect much branched shrub up to 3–4 m. Branches slender and not divaricating.

Corokia buddleioides is common, but not abundant, in forests and along forest margins from Mangonui to Rotorua and East Cape. Its altitudinal range is sea level to 900 m. The species is commonly planted in gardens as a hedge in lowland districts. Plants tolerate most soil conditions but best growth is obtained on good soils. Dry conditions, strong winds and moderate frosts are tolerated.

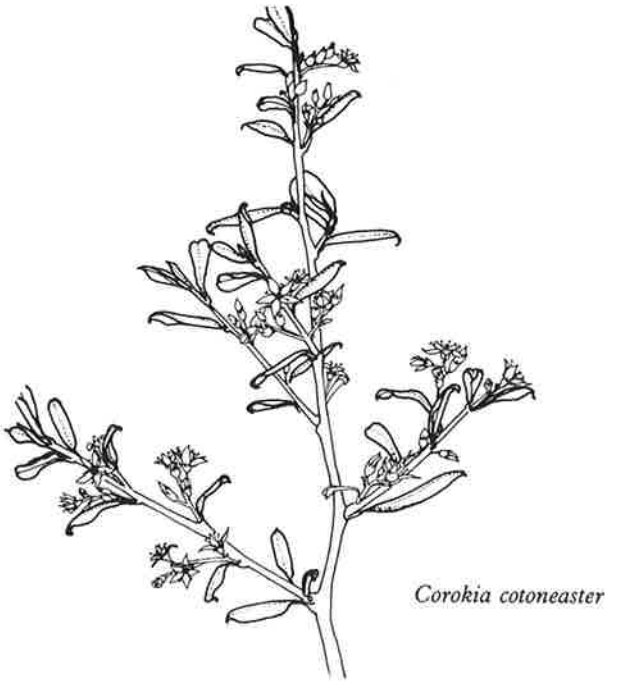
It is suitable for low-tier shelter or for hedging. Where it occurs locally, it can be used for revegetation of disturbed sites but in combination with other species.

Propagation is by seed or cuttings. Ripe seed appears from January to autumn. Drupes are dark red to black.

Corokia cotoneaster Raoul

Densely divaricating shrub up to 3 m.

Corokia cotoneaster is found throughout the North and South Islands, except for the West Coast of the South Island, commonly in scrubland along river flats and in rocky places. It is more common in drier regions, and is often associated with manuka or kanuka scrub. The species is drought and frost tolerant and withstands exposure well. It is cultivated widely as a hedge plant.



Corokia cotoneaster

This shrub is suitable for low-tier shelter in dry regions and perhaps useful for gully erosion control. It is seldom a dominant species in natural vegetation and its use in revegetation should reflect this.

Propagation is by seed or cuttings. Ripe seed appears from as early as January through to May. Fruits are most commonly orange, but also red or yellow.

Corokia* x *virgata (Turrill) Metcalf

This natural hybrid of *C. buddleioides* x *C. cotoneaster* in the wild has forms varying between its two parents. Generally, a much branched but erect shrub up to 2–4 m.

Corokia x *virgata* occurs as a natural hybrid only in the lowland forest and along forest margins of the northern half of the North Island, but selected cultivars and hybrids are grown throughout the lowland areas of the North and South Islands. Habitat preference will vary depending on the genetic contribution of the parents. Generally plants will tolerate exposed situations and poor, dry soils although better growth can be expected in more fertile and moister soil.

The shrub is very well suited for low shelter where trimming or side-trimming is used. Selection of natural hybrids should give good plants. Named cultivars useful in shelter include *C.* x *virgata* 'Cheesemanii' and *C.* x *virgata* 'Linearis'. An unnamed *C.* x *virgata* is being used in gully erosion control trials in Canterbury. *C.* x *virgata* should also perform well in general revegetation of roadsides and earthworks.

Propagation by seed will give an assortment of seedlings so selected forms need to be propagated by cuttings. When planting in the wild only local material should be used for propagation. Seed ripens in summer and autumn and fruits are red, orange or yellow.

Corynocarpus laevigatus J. R. & G. Forst.

Karaka

Medium sized tree up to 16 m, with bushy habit. Often densely foliated with large, dark green, glossy leaves.

Karaka is abundant in coastal and lowland forest of the North Island and in coastal areas as far south as Greymouth and Banks Peninsula. It is cultivated as far south

as Dunedin and Invercargill. Although the uncooked fruits are poisonous, the Maori people valued the well-cooked fruits as a food source and at least some of the present-day distribution arises from Maori cultivation. It is essentially a plant of the coastal forest margins and lowland forest, often forming the canopy but not extensively. Its growth is rapid (1 m per year) in deep rich soil but it also tolerates adverse conditions, except long periods of drought. Seedlings are rather frost tender but shade tolerant. Older plants are tolerant of light frosts and very tolerant of strong winds and salt spray.

The species is good for shelter, especially in coastal areas where hard frosts do not occur. It establishes well on humus-enriched back dunes under a nurse crop of tree lucerne or tree lupin. Seedlings require some protection when planted on exposed sites, but trials currently under way indicate that hardy seedlings can be established in poor and heavy soils prone to summer drought and winter waterlogging. Its tolerance of shade makes it suitable for planting under taller shelter.

It is easy to propagate by seed, which germinates readily. Seeds are ripe in early summer in warmer regions and late summer and autumn in cooler regions. The large orange-red berries are best collected off the ground and their flesh removed. Seed should be germinated soon after the ripe berries fall from the branches.

Dacrycarpus dacrydioides (A. Rich.) de Laubenfels

Kahikatea, White Pine

Tallest of native tree species; up to 60 m tall, more commonly 25 to 50 m.

Kahikatea is noted for its upright form and longevity but it does pass through several stages. Seedlings are erect but are sparsely branched and straggly in appearance. After a few years strong apical dominance is developed and by 10 to 15 years an open pyramidal shape develops. This is retained for many years then slowly changes to a conical then columnar shape. Eventually the top spreads out in maturity to form a tight but spreading crown and stout trunk.

Kahikatea is common throughout the lowland and hilly forests of the North, South and Stewart Islands, from sea level to 700 m. It prefers moist, fertile sites and is often dominant on lowland swampy ground. Seedlings are reasonably shade tolerant but do best in sheltered positions with full overhead light. The best tree specimens are mostly found in forest situations, but a number of fine trees also occur throughout the countryside either in small groves or as isolated trees that were left during the clearance of the original forest and subsequent conversion to pasture. Kahikatea is not a colonising species but is certainly a very successful early seral species in primary succession on heavy, wet soils. On better drained but moist sites it readily establishes under a hardwood canopy. It can be damaged by defoliating caterpillars, stick insects and browsing animals. It is frost hardy.

Use of kahikatea specifically for soil conservation is unknown but its successional role places it well for use in revegetation where long-term erosion control is required. In hill country, isolated trees left by forest clearance probably improve slope stability to some degree. However, spaced-planting of young kahikateas in the hill country pasture situation has not been done and would require relatively expensive techniques. Use of kahikatea in shelterbelts can also be advocated but again little information is available on this.

Propagation is by seed. Mature trees bear abundant viable seed in some years and negligible seed in others. Seed with flesh removed can be stored moist at 4°C for 12 months but may start to germinate if temperatures fluctuate. Seed is best held over one winter only and sown in beds in early spring. The germinated seedlings are treated as for other podocarps (NZFS, 1980 publications *What's New in Forest Research: No. 85, Raising Native Trees,* and *No. 86, Establishing Nursery-Raised Native Trees*) but seedlings should remain in the seedbed for 2 years before lining out.

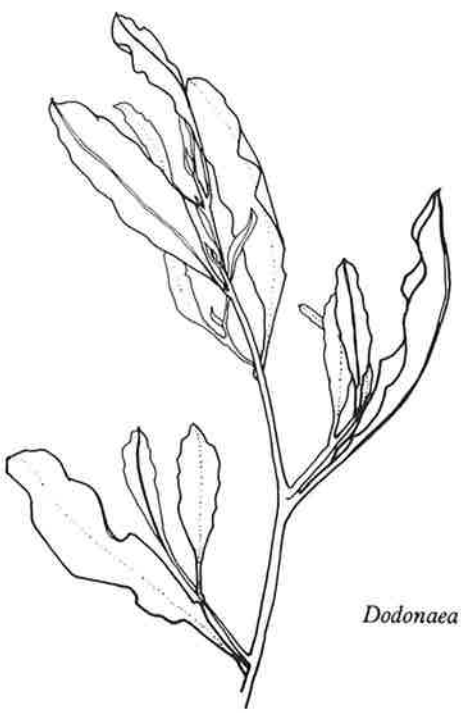
Seedlings can be ready for planting out after a total of 3 years in the nursery. Kahikatea can be planted on open sites in forest or on farmland providing young plants are not fully exposed to wind. Weed and grass competition needs to be kept to a minimum for several years. Good nurse crops can be provided by *Coprosma* and *Pittosporum* species.

Dodonaea viscosa Jacquin

Akeake

Erect but spreading shrub or small tree with a fairly open crown, up to 7 m.

Akeake is common in coastal and lowland scrub and forest thoughout the North Island and in the South Island as far south as Greymouth and Banks Peninsula. It also occurs on the Chatham Islands. Its altitudinal range is sea level to 550 m. Akeake is grown in most lowland districts where frosts are not a problem although some plants have grown where frosts are moderate to severe (e.g., Taupo). It occurs on coastal sites where it withstands strong winds and salt spray, and occasionally very dry conditions. On Banks Peninsula it grows well on drought-prone loessial soils. It also grows well on coastal dunes. It will not tolerate heavy or waterlogged soil.



Dodonaea viscosa

Akeake is very good for coastal low shelter. The fibrous spreading root system, rapid growth and spreading canopy make it an ideal soil stabiliser in coastal dune areas. It may also be used in the control of gully erosion and for general revegetation where hard frosts are not likely to occur.

Propagation is normally from seed which is usually ripe by late summer.

It tolerates trimming.

D. viscosa 'Purpurea' is a popular purple-coloured cultivar. It is generally as suitable as the main species except where the plants have to blend with surrounding natural vegetation. It can be severely defoliated by insects but usually recovers well.

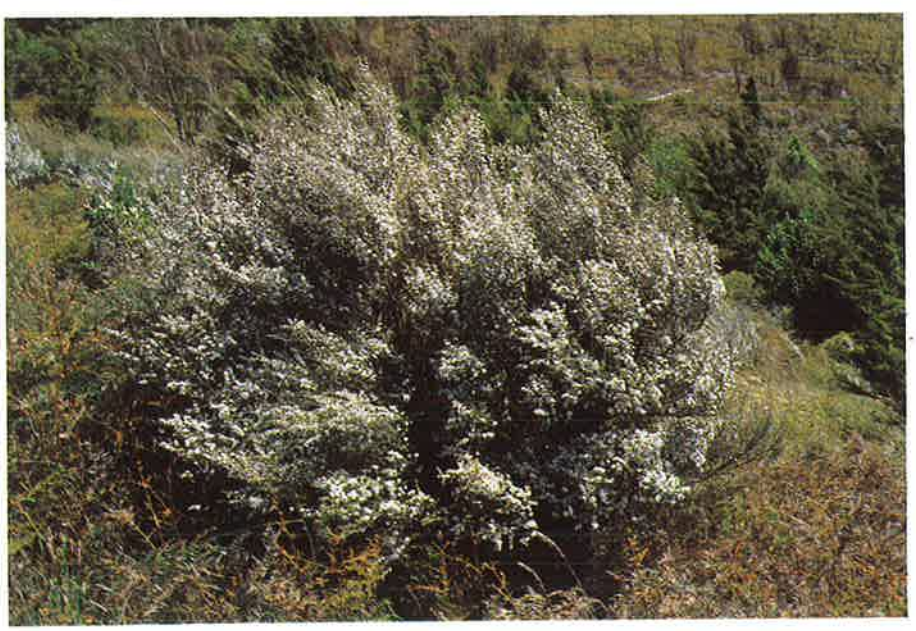
Nothofagus fusca

Pittosporum eugenioides

Pittosporum colensoi

Olearia virgata var. *lineata*

Hebe stricta



Leptospermum scoparium

Coprosma robusta

Fuchsia excorticata (J. R. & G. Forst.) Linn.

Tree Fuchsia, Kotukutuku

Small to medium sized spreading tree up to 12 m. Deciduous in all but the warmer northern regions.

Tree fuchsia is common throughout the North, South and Stewart Islands in lowland and montane forests and is found from sea level to 1050 m. It is an early species in secondary successions, especially canopy gaps in wetter forests. The species is also common on streambanks, slips and roadsides. It is often abundant in second growth and is frequently a garden weed in suitably moist and cool climates. Tree fuchsia tolerates most soil types except droughty soils. It has quick early growth and can re-sprout from the basal crown when the trunk is cut. It can sucker freely or, in wetter areas, it can spread by layering. It is fire resistant. Sometimes it is heavily browsed by possums and deer; the combination of these on any one plant usually being devastating. Seedlings do not tolerate frost or drought but older plants are very frost tolerant.

Tree fuchsia can be used for low- to mid-tier shelter under taller open trees but its best use is for revegetation of earthworks, especially road batters in forest regions. It is also good for gullies and slips where it is desired to establish or restore the indigenous bush vegetation. The species is suitable for planting on screes that have stabilised to some degree. Like willow, it can help to fill and stabilise erosion-prone mountain streams and gullies. Although not tried in hydroseeding mixes the seed should germinate well on wetter sites. Grass competition, when present, will restrict the growth of the seedling tree fuchsias.

It propagates best from cuttings but seed also germinates readily. Ripe seed appears during summer. Plants can be slow to harden but otherwise they are ready for planting after one growing season. Direct seeding on bare soils could be successful in the absence of grasses or legumes, but more trial work is required.

Griselinia littoralis Raoul

Broadleaf, Papauma, Kapuka

Medium sized tree up to 10–15 m with stout branches and spreading, round-topped crown. Bright green, glossy foliage.

Griselinia littoralis is common in lowland, montane and subalpine forests and subalpine scrub from the Bay of Islands to Stewart Island. It occurs mostly upland in the northern extent of its range and is very abundant in the South Island. Its altitudinal range is sea level to 1150 m. It is not regarded as a pioneer species but it is quick to establish in open areas of forest provided browsing is minimal. It grows well on all but very infertile soils and is not tolerant of prolonged drought conditions. It is frost tolerant, and withstands strong winds and salt spray. It has a life span of at least a century.

The species is very suitable for coastal shelter in all parts of the country. It can and should be planted on the seaward side when the shelterbelt consists of more than one row. It is a useful species for revegetating roadsides in forested regions but will need to be protected from browsing and grazing animals. It will not establish well on dry or gravelly soils. It can thrive in the most exposed situations when mature but will benefit from shelter when young.

The species is easily raised either from seed that is collected in summer-autumn and sown immediately, or from semi-hardwood cuttings. Its berries are deep purple or black when ripe.

A closely related species, *G. lucida*, is a coloniser of old lava flows around Auckland and exposed greywackes rocks in the Manawatu Gorge. It is often epiphytic.

Hebe spp.

Hebes

There are about 80 species of *Hebe* in New Zealand and a considerable number of hybrids and cultivars. A few species can be readily suggested for use in soil conservation on the basis of their larger size, robust growth and wider distributions, but they are short-lived and require other species to effect long-term revegetation. These species are *H. elliptica* (coastal), *H. odora*, *H. salicifolia* and *H. stricta*. This list is somewhat arbitrary and many other species, perhaps a dozen or more, will also be suitable for revegetation in restricted areas. Many species and cultivars are commonly cultivated throughout the lowland districts of New Zealand, but for revegetation in frosty inland and higher montane to low alpine areas only the local populations should be propagated.

Propagation is by seed or cuttings. Seed supply in the wild varies from year to year but plants growing in favourable situations often produce an abundant supply. Seed ripens in late summer to autumn but collecting expeditions have to be well timed because ripe seed is quickly shed. Properly stored seed of some species remains viable for up to two years. Seed of most species germinates readily at 15–25°C but seed of some alpine species will germinate at lower temperatures more readily (Simpson 1976). Some seed benefits from stratification. Propagating from cuttings is easily done with most species. March is a good time to collect cuttings although the time of collection is not critical. The procedure outlined below, which has been used by the New Zealand Forest Service for the propagation of *H. odora* using cuttings, can be recommended for most species.

1 In the field select healthy 'mother' plants with strong terminal branchlets. Fertiliser can be used to promote healthy growth. Younger plants are better.
2 Select non-flowering shoots for cuttings. These should be 15–20 cm long and 3–5 mm diameter at the base. In *H. odora* the base will usually consist of 2-year-old wood.
3 Cut off tip growth (approx. 5 cm).
4 Strip foliage off the bottom 10 cm.
5 To aid callus formation make a vertical wound 2–3 cm long on the base using a sharp scalpel. Rooting hormone is not required.
6 Insert cutting 10 cm into nursery beds and firm in well.
7 Cover with shade frames and keep moist until winter.
8 Apply a general nursery fertiliser in the spring if the nursery soil is depleted.
9 In the following summer and early autumn a couple of wrenchings (10–13 cm depth) will help to condition stock even though hebes naturally form a very fibrous root system.
10 Box pruning in autumn will make lifting in winter easier.
11 Lift in August (or early September in colder regions) and pack in multi-wall kraft paper bags.
12 If planting in a colder environment than the nursery, keep plants in a cool store until the site is ready for planting, but no longer than 2 months.

Hebe elliptica (Forst. f.) Pennell

Kokomuka

Much branched, erect to spreading shrub up to 5 m.

Hebe elliptica is found on the western coastlines from Cape Egmont to Fiordland and around to the east coast of Otago, and on Stewart Island and sub-antarctic islands. It is most abundant along the shores of Foveaux Strait, often forming a dense canopy in the shoreline scrub. The species withstands strong winds and salt spray. It is generally very hardy but only moderately frost tolerant.

The species is excellent for low coastal shelter, especially as the first line of shelter behind which other hardy coastal species can be established. It is probably suitable for general revegetation of disturbed sites within its natural range and habitats.

Propagation is by seed or cuttings. Large quantities of viable seed are produced each year especially in favourable years.

Hebe odora (Hook. f.) Ckn.

Boxwood

Shrub, usually forming a compact, round-headed bush 1–2 m tall. Wild populations tend to be variable.

Hebe odora is common throughout the montane to low alpine regions of New Zealand, from sea level (rarely) to 1450 m. Its most common habitat is the subalpine and low alpine scrub and mixed scrub-grasslands. It is usually found on moister sites although it does occur in places where occasional mild droughts are experienced. It is otherwise very hardy.

Like most hebes, *H. odora* has a fibrous root system which makes it a suitable species for planting on disturbed sites or in depleted subalpine vegetation to protect the soil surface. Its lack of deep roots makes it difficult to establish on dry sites or sites prone to frost heave.

Propagation is by seed or cuttings. Stratification of seed for 10 weeks at 2°C has been used successfully by New Zealand Forest Service (Bodger *et al.* 1979).

Hebe salicifolia (Forst. f.) Pennell

Koromiko

Erect to spreading, much branched shrub with willow-like foliage, up to 4–5 m. Very similar to *H. stricta.*

Hebe salicifolia is common throughout lowland and montane forests of the South and Stewart Islands, and occurs from sea level to 1100 m. It is commonly cultivated. This shrub is mostly found in open places and forest margins with other shrubby species and young trees. It grows well in moist soils and is not very drought resistant. It has an extensive fibrous root system.

H. salicifolia is suitable for general revegetation of bare and denuded surfaces where moisture is not severely limited. It is potentially suitable for revegetation and stabilisation of saturated slump and slip debris. The species is useful for conservation planting on streamsides and wet gullies. Its fine fibrous root system will help to prevent sheet erosion on old slip faces, roadsides or other disturbed sites.

Propagation is by seed or cuttings.

Hebe stricta (Benth.) L. B. Moore

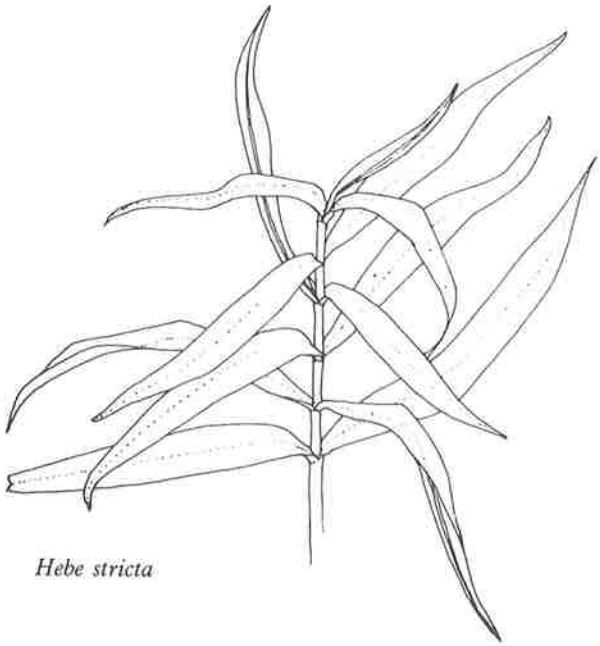
Koromiko

Spreading shrub up to 4 m tall. Less densely foliaged than *H. salicifolia* but otherwise very similar. Some forms and varieties are only small shrubs less than 1 m tall.

Hebe stricta is common throughout the lowland, hill country and montane forest of the North Island. There are five named varieties, var. *stricta* being the most common and widespread. It is commonly cultivated in many parts of the country but not in great numbers. *H. stricta* mostly grows in open places along streamsides, roadsides and stable slip faces. It prefers well drained soils with good moisture but will establish on moderately heavy clays. It has a shallow, very fibrous root system.

This shrub is very suitable for planting on earthworks and slip faces. It is not as suitable for unstable sites as *H. salicifolia* but along with *Cortaderia* spp. it can be used to provide early cover for subsequent establishment of forest species.

Propagation is easily done by cuttings. It has been suggested that hardwood wands of 2 cm or more in diameter can be planted like willow wands. Seed is easily germinated in any moist but free-draining germination mix. Collection of seed from



Hebe stricta

the wild is best accomplished by setting seed trays under healthy plants. There is a very short period between seed becoming ripe and the capsules dehiscing to drop seed. Time of seed ripening varies but a good crop is usually present in late May and early June.

When planting on fertile subsoils 20–50 g of slow-release NPK fertilisers in each planting hole will be beneficial.

Hoheria populnea A. Cunn.

Houhere, Lacebark

Medium-sized, much branched, erect tree up to 10 m. Some forms have less branching and form a strong trunk but more often the species is represented by plants with several branches arising from near ground level. Semi-deciduous, sometimes bare in late winter. There is some hybridisation with *H. sexstylosa* which often causes confusion in identification.

Hoheria populnea is abundant in coastal and lowland forests of the North Island from North Cape to the Waikato but it is cultivated throughout lowland districts of the North and South Islands. Its altitudinal range is sea level to 450 m. It is most common in forest margins, streamsides and riverbanks. It tolerates moderate frost but will not tolerate prolonged drought, infertile soil or excessive waterlogging. It is moderately palatable to domestic stock, goats, hares, deer and possums.

The species is very suitable for planting in shelter with taller trees. It is good for medium height shelter on its own but is not tolerant of persistent strong winds. It is possibly useful in forest restoration within its natural range. It is very nutrient demanding and thus impoverishes the soil within its rooting zone.

Propagation is mostly by seed, which ripens in late autumn and germinates readily. Insects often destroy much of the seed as it ripens on the tree. Desirable forms need to be propagated from semi-hardwood cuttings. These should be taken from young plants; or from older plants early in the summer before flower buds develop. Seedling-grown trees will be variable in form but careful selection of seed trees can largely overcome this problem. Selected forms raised from cuttings should be used for shelter. It is worth selecting for eriophyd mite (gall) resistance and rust resistance because there is some variation between populations and seedlings.

Other species of *Hoheria* could be useful in shelter and revegetation. *H. angustifolia* is more slender than *H. populnea* and is common along streamsides and forest margins from New Plymouth and Hawkes Bay to Southland. Its altitudinal range is sea level to 800 m. It does not grow well in heavy or infertile soils but is otherwise very hardy. The species is not as good for shelter as *H. populnea* and not as quick to establish because it passes through a juvenile stage. It is possibly useful in gully control in non-drought areas. *H. glabrata* and *H. lyallii* are found in the wetter and drier montane forests of the South Island respectively. These species are suitable for revegetation within their natural ranges but are slower growing than *H. populnea*. *H. sexstylosa* is a bushier, narrower-leaved, small tree up to 8 m with pendent branches and is found in lowland forests of the North and South Islands, but not in the extreme north or extreme south. The most suitable use is revegetation and low-tier shelter. It is commonly grown from seed but will require several years before being ready for planting. It can become badly affected by gall formation.

Knightia excelsa R. Br.

Rewarewa, NZ Honeysuckle

Tall, almost fastigiate tree up to 30 m. Has elongated, stiff leathery leaves up to 15 cm long, dark green above and pale beneath.

Knightia excelsa occurs in lowland and montane forest throughout the North Island and in the Marlborough Sounds. It is a common emergent tree of scrubland or cutover forest, and occurs from sea level to 900 m. Specimens are often cultivated in gardens throughout the lowland regions. It is a true pioneer species yet has a considerable life span. It prefers a well-drained friable soil and will tolerate seasonal drought and moderate frost once established. Rewarewa has a very deep tap-root which can penetrate some subsoil pans. It is unpalatable to browsing animals, except occasionally possums, and vulnerable to fire.

It is suitable for shelter but is not fast growing on poorer sites. Under good conditions it will grow about half a metre and more per year which is comparable with some exotic conifers (e.g., *Thuja plicata*). Selection of the most suitable forms for shelter is advisable. Rewarewa may have some potential to control or prevent slip erosion but this has not been evaluated. In the forest situation it provides a very good environment for future forest species and could be used more in vegetation restoration work in forest regions.

Propagation is usually by seed. Seed, which is set in spring, takes six months to a year to mature and is collected in the following late autumn, winter or early spring. Seed is best collected by placing trays under selected trees. Seedlings will require two growing seasons before planting on the site. It transplants readily but care should be taken to preserve the tap-root. The effect of undercutting and wrenching in the nursery on the trees' subsequent stability and ability to grow deep roots is not known.

Leptospermum ericoides A. Rich.

syn. ***Kunzia ericoides*** (A. Rich.) J. Thompson

Kanuka, White Tea Tree (often called manuka in Northland).

Shrub of varying form, or medium-sized, and spreading tree, up to 15 m. Clusters of leaves soft to the touch as opposed to the harsher feel of *L. scoparium* (manuka). Capsules stalked, versus sessile in *L. scoparium*.

Leptospermum ericoides is abundant throughout lowland and montane scrub and forest margins of the North and South Islands, and occurs from sea level to 900 m. It often establishes thickly after clearing of forest or on abandoned pasture in some areas. It grows well on all but waterlogged soils. There is some ecotypic variation within the species which allows it to exploit a wide range of habitats from moist

montane forest to the semi-arid montane valleys of Central Otago. Kanuka is very drought and frost tolerant. Seedlings often establish readily on bare subsoils. It has low to moderate palatability but is seldom severely damaged.

Kanuka and manuka are the two most important pioneering native shrubs. Kanuka has a life span of more than 100 years and during this time provides an excellent nurse crop for many native plants and forest trees including timber species. It is very suitable for revegetation of bare or eroded surfaces. Kanuka is also suitable for low- to mid-tier shelter in multi-row shelterbelts. Older plants tend to lose their lower leaves and branches forming gaps in the lower levels of the shelterbelts.

Lowland forms have good potential for use in recreational environments and park-land settings where compaction of the soil in the root zone occurs and sheet erosion is a threat. Prostrate layering forms, such as *L. ericoides* var. *microflorum* (Northland) and others, may have some potential for erosion control on mudflow debris and other wet bare soil.

Propagation is easy using seed. Seed should be collected from local populations but beware of prostrate forms in the vicinity if this form is not desired. Seed is collected in late summer by selecting mature but unopened capsules and drying these to release the seed. Kanuka is also easily propagated from semi-hardwood cuttings. Plants should only be propagated from local material although this is not so critical when used for farm shelter. Lowland forms have slow initial growth but grow rapidly after a few years.

Establishment trials using seed-bearing kanuka slash have been successful on pumice, ash and clay soils. This method consists of laying seed-bearing branches on the ground surface to form a mat 30–40 cm thick and dense enough to provide 80–95% shade. The branches will need to be pegged and tied down to prevent them blowing away. The slash applied this way provides the seed and protects the seedlings from frost heave, desiccation and competing weeds. The cover must not be too sparse or too dense, otherwise seedlings will dry out or will be too heavily shaded. Other seed such as *Hebe* seed may also germinate if sprinkled on to the ground beneath the slash. This method can only be justified for high risk areas such as roadsides or other earthworks where other methods of providing initial cover and a nurse crop are not satisfactory.

Leptospermum scoparium J. R. & G. Forst.

Manuka, Red Tea Tree

Shrub of diverse habit up to 4–5 m. Leaves similar to *L. ericoides* but stiffer and more pungent (needle-like point) giving the branches a rougher feel.

Leptospermum scoparium is common throughout the North, South and Stewart Islands in lowland to low alpine regions, and occurs from sea level to 1400 m. Habitats are diverse and include bogs, wetlands, river gravels and dry hillsides. Individual plants have wide tolerances but ecotypic differentiation also occurs within the species. It is very tolerant of drought, waterlogging and frost. Manuka tends to grow on poorer, colder, wetter or more acidic sites than kanuka but they also frequently occur together.

Manuka is very useful for restoration of native vegetation along roadsides, earthworks and eroded areas. Some cultivars may be used for low shelter (e.g., 'Keatleyi' and 'Album Florepleno'). Other prostrate cultivars, and *L. scoparium* var. *incanum* in Northland, can provide useful ground cover on some bare soils alongside roads and tracks.

The species is easily cultivated from seed and semi-hardwood cuttings. Seed ripens by late autumn but is retained in hard capsules well into the following summer. Selection of propagation material should only be from plants suited to the type of habitat to be revegetated. Laying down seed-bearing slash can also be recommended (as for *L. ericoides*) but often the material is infested with manuka blight which will infect seedlings and reduce their vigour.

Melicytus ramiflorus J. R. & G. Forst.

Mahoe, Whiteywood

Large shrub or spreading tree 7–10 m, or taller in sheltered situations. Distinctive pale grey or whitish bark. Bright green leaves up to 15 cm long and 5 cm wide. Plants are dioecious.

Melicytus ramiflorus is common and often abundant in open areas, forest margins, gullies and streamsides in lowland and montane forests throughout the North, South and Stewart Islands. It also occurs on the Kermadec Islands. Its altitudinal range is sea level to 1000 m. It is mostly adapted to well drained and reasonably fertile soils. Leaves are only moderately frost hardy but plants can recover from frost damage fairly readily because the stems and buds are not so easily damaged. Mahoe prefers moist climates and, although it tolerates exposed sites, it can become very mis-shapened by persistent and strong winds. It is palatable to deer and stock, and slightly palatable to possums.

The species is useful for both revegetation and restoration of indigenous vegetation in wetter climates on uneroded soils, but not on infertile soils or exposed subsoils. It is best used in combination with other species. Plants are long-lived (80 years and more).

Propagation is by seed or cuttings. Its ripe berries are deep purple and appear in late summer. Young plants are sensitive to direct sunlight therefore transplants should be planted in the shade of a nurse crop.

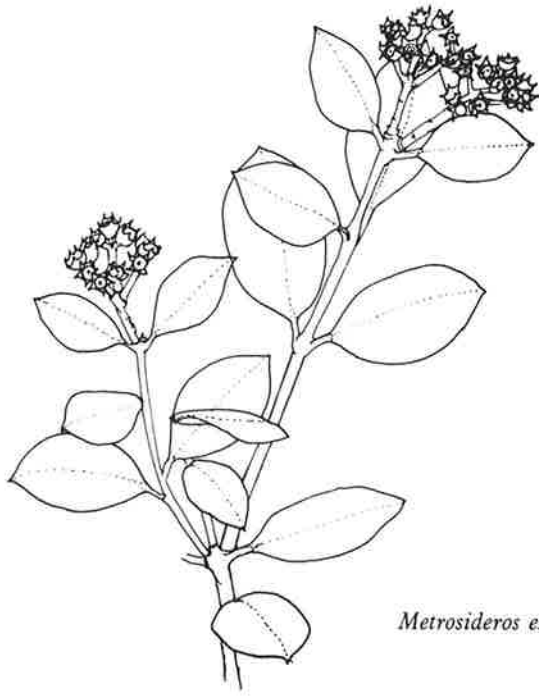
A similar but smaller and narrower-leaved species, *M. lanceolatus* (mahoe wao), is not uncommon in the wetter regions and can be useful in revegetation and restoration of indigenous vegetation because it has fast early growth and sets fruit in 3–4 years.

Metrosideros excelsa Sol. ex Gaertn.

Pohutukawa

Much branched, spreading tree, 10–20 m tall. Well known by its robust appearance, and seasonal display of red flowers in December and January.

Metrosideros excelsa is abundant in coastal forest and along coastlines of the northern half of the North Island. This seems to have been its natural range before Maori



Metrosideros excelsa

and European settlement. Now, it is often planted in most lowland districts in moderately frost-free sites and many more plants adorn the more southerly coastal areas of the North Island where they have grown from self-sown seed. The species grows well in most well-drained soils but very young plants will tolerate only 1 or 2°C of frost without protection. It is very wind resistant and, although generally regarded as being very tolerant of salt spray, its foliage can be damaged by a combination of salt spray followed by dry weather.

Pohutukawa can provide excellent shelter in coastal areas. It is a long-lived tree (perhaps 300 to 800 years) but has rapid early growth which makes it very suitable for permanent shelter. It tolerates trimming very well, and this will be required occasionally if a narrow shelterbelt is to be maintained.

The species is possibly useful for planting behind dunes to prevent their inward encroachment. Leaves are palatable to opossums and trees are subject to damage though not usually severe.

Propagation is normally by seed but semi-hardwood cuttings can also be used. Seed is ripe during late summer.

Metrosideros umbellata Cav.

Southern Rata, Ironwood

Much branched, erect tree 10–15 m tall. Well known for its brilliant but intermittent summer displays of red flowers, especially where plants of this species are dominant as in the mountain forests of Westland.

Metrosideros umbellata occurs in the lowland, montane and, occasionally, subalpine forests and scrublands from Whangarei southwards in the North Island and throughout the South, Stewart, Auckland, Campbell and Snares Islands. Its altitudinal range is sea level to 1200 m. In wetter montane forests of the South Island and on Stewart and Auckland Islands it is often the dominant or subdominant tree but is also a principle pioneering species particularly on rocky sites. Trees have a life span of 200 years or more but in their older stages can be severely damaged by opossums. Seedlings and young plants are often damaged by deer. It requires a moderately wet climate and well-drained soil for good growth and does not tolerate droughty climates; otherwise it is quite hardy.

It could possibly be used for shelter in wetter regions but its greatest use is for revegetating bare soils in wetter climates (i.e., within its natural range and habitats). Infertile or heavy, poorly drained soils should be avoided or, if possible, fertilised or drained accordingly. For restoration of indigenous vegetation it is best planted under the canopy of a nurse crop, e.g., *Coprosma*, *Coriaria*, *Hebe*, *Olearia* species.

It is easily propagated from semi-hardwood cuttings or by seed which ripens during late summer and autumn. Percentage of viable seed is often low but in favourable years there is still abundant viable seed. The seed is best sown fresh.

Other *Metrosideros* spp.

Other species of *Metrosideros* that may have some use for long-term shelter include *M. robusta* which occurs in lowland forests from Northland to Westland and Canterbury, and *M. kermadecensis* which is common on Raoul Island. *M. robusta* can form a large spreading tree of 15–25 m (up to 15 m in the open); *M. kermadecensis* is slightly smaller. Both are wind hardy but are tolerant of only light frosts, especially at the seedling stage. They are best suited to high rainfall areas. *M. robusta* hybridizes with *M. excelsa* where the two species occur in close proximity.

Myoporum laetum Forst. f.

Ngaio

Shrub or spreading tree up to 10 m tall. Usually densely foliated with lanceolate, gland-speckled, bright green leaves up to 10 cm long.

Myoporum laetum occurs in coastal and lowland forest of the North Island and of the South Island as far south as Otago but is rare at the southern extent of its range. Its main habitat is coastal where it sometimes forms the dominant vegetation; occasionally it is seen as isolated plants on very exposed coastal hillsides. It occurs mainly in the margins of inland lowland forest. Plants grow rapidly on fertile, well drained soils but tolerate poor and occasionally dry soils very well. Young plants are frost tender but older plants can tolerate moderate frosts of perhaps 5 or 6°C. Although seedlings require some protection if they are to develop rapidly, they are very tolerant of salt spray and strong coastal winds. Ngaio leaves are unpalatable, but toxic if eaten.

It is best suited to low-tier or front-line coastal shelter. It is possibly suitable for planting in low areas between stabilised dunes to give long-term protection from blowouts. (The introduced *M. insulare* has often been planted on dunes and is now naturalised in many North Island areas.) Ngaio is useful in revegetation and restoration but, because it is not a colonising species, it should be planted after an initial ground cover or nurse crop has been established.

Propagation is by seed or cuttings. Cuttings root very readily. Its berries turn dark reddish purple as they ripen during autumn. Seed will germinate more readily if soaked beforehand or stratified for a short period. Ngaio is very quick to establish after being planted out and grows rapidly under favourable conditions.

Myrsine australis (A. Rich.) Allan

Mapou, Matipo, Red Matipo

Much-branched, densely-foliated shrub or small tree up to 6 m. Distinctive grey bark on older branches and trunk, but reddish bark on young branches, twigs and petioles. Leaves leathery, often with undulate margins.

Myrsine australis is often local in distribution but is found throughout the North, South and Stewart Islands along forest margins and in scrubland, from sea level to 900 m. It will not tolerate waterlogged soil for long periods nor severe drought conditions; otherwise it is very hardy and grows rapidly in infertile soil with ample moisture.

The species is well suited for use in low shelter because it has a moderately narrow crown and is very wind-tolerant. It can be pruned or trimmed as necessary. It is also useful in intermediate stages of revegetation and restoration of indigenous vegetation.

It is mostly propagated from seed but semi-hardwood cuttings can be used. The drupes turn black as they ripen during the autumn. The fruits should be sun-dried and the seeds broken out and these then sown soon afterwards without further treatment.

Nothofagus spp.

Southern Beeches

There are four species (one of which includes two varieties) native to New Zealand. They are *N. fusca* (Hook. f.) Oerst. (red beech, tawhairaunui), *N. truncata* (Col.) Ckn. (hard beech, tawhairaunui), *N. menziesii* (Hook. f.) Oerst. (silver beech, tawhai), *N. solandri* var. *cliffortioides* (Hook. f.) Poole (mountain beech, tawhairauriki), and *N. solandri* var. *solandri* (Hook. f.) Oerst. (black beech, tawhairauriki). All species except silver beech readily hybridize wherever they occur in close proximity. Studies

by the Forest Research Institute, New Zealand Forest Service, have demonstrated marked provenance variation in seedling growth rates and form. Beeches are absent from Stewart and Chatham Islands.

Nothofagus fusca is a tall tree up to 30 m, distinguished by relatively large but thin leaves with deep, sharp-toothed margins and 1–3 domatia (pits) on the underside near the base of the midrib. Red beech is common, and often dominant, in lowland and low montane forests from Rotorua and Urewera southwards. Its distribution is not continuous; it is absent from Taranaki, and central and eastern South Island areas except Banks Peninsula. Its altitudinal range is sea level to 1200 m. Neither red nor hard beech tolerate persistent strong winds or drought; otherwise they are hardy. Soil temperatures greater than 40°C can severely damage the roots, and hence, lead to plant death.

Nothofagus truncata has slightly smaller and thicker leaves than red beech with blunt-toothed margins and no domatia. It is similar in size, habit and habitat to red beech but only occurs in the northern half of the North Island, and the Nelson and northern Westland regions of the South Island.

Nothofagus menziesii is perhaps the most distinct species. Its leaves are smaller than red or hard beech, thick, dull green when mature and bluntly double-toothed. Domatia are usually present on the undersides of the leaves at the base of the midrib. Silver beech is usually a smaller tree (less than 20 m tall) but can be as much as 39 m. It occurs in mountain forests from the volcanic plateau and East Cape southwards but is absent from Taranaki and drier areas of eastern South Island. It is found from sea level to 900 m. As with red beech, it is a good species for timber production. It is generally very hardy but does not grow in exposed, droughty sites.

Nothofagus solandri var. *solandri* and *N. solandri* var. *cliffortioides* have entire leaves and are often hard to distinguish from each other especially where their ranges overlap. Leaves of black beech are often slightly larger and oblong to roundish in outline whereas mountain beech leaves are slightly thicker and more ovate with an acute tip, and often have more recurved margins. Black beech grows to 25 m in height and mountain beech to 15 m. Their altitudinal range is sea level to 750 m and 1200 m respectively. Black beech is common and often dominant in the drier forests east of the Main Divide from East Cape to South Canterbury but it also occurs in wetter forests of the western North Island from Waikato southwards. Mountain beech is restricted to the higher elevations in the North Island and is widespread in all but the driest eastern areas of the South Island. Both species are very hardy but, although they are the most drought tolerant of the beeches, they cannot be regarded as highly drought tolerant.

Silver and mountain beech and to a lesser extent the other beeches are important pioneering species in secondary successions because they rapidly establish on soil and subsoils exposed by fires, fallen trees, road cuts and slips if seed sources are nearby. On favourable sites, such as rich alluvial deposits, red beech is a very good coloniser. Beeches require mycorrhizal fungi for vigorous growth. These fungi are invariably present in soils under beech forests but for plants grown in nurseries artificial inoculation may be required.

In soil conservation the beeches can be used in shelterbelts and revegetation. Red and silver beech are probably the best for shelter although silver beech tends to develop a very wide crown and red beech tends to become flagged by persistent, strong winds.

All beeches are very well suited for revegetating bare soil and open areas within forests. Small areas of disturbance within a beech forest usually revegetate naturally but larger areas will need assistance. Young beech seedlings do poorly in fully exposed positions or in drought-prone soils, but are otherwise hardy.

Propagation is by seed, which ripens in autumn and needs to be collected fresh as it falls from the trees. The seed trees should be carefully selected to avoid hybrid seed and to meet the requirements of the planting programme. Seed supply in the wild is not consistent; good seed years (mast years) occur only once in 2–4 years.

Seed can be stored dry (6% moisture content) in airtight containers at temperatures of 4–10°C for up to 8 years with little loss in viability, or it can be sown immediately either into trays or directly into the nursery. Moist-chilling or stratification before sowing improves germination. Young seedlings up to 10 cm high can often be collected readily from the forest and easily transplanted to nursery beds provided care is taken to prevent dessication and/or root damage. Seedlings require 2 years to reach a plantable size and should be undercut in the autumn of the second year then wrenched at monthly intervals until planting out in the winter. Sowing seed in straight lines will facilitate lateral root-pruning.

Forest-grown seedlings, 40–80 cm tall, can be used for transplanting directly to nearby planting sites. These seedlings are often present in large numbers on previously disturbed areas or beneath canopy gaps in the forest. Seedlings on sites with low natural fertility can be lightly fertilised in the spring prior to lifting the following winter to improve their vigour. Roots need to be undercut and side pruned in the autumn before lifting and transplanting in the winter. This is accomplished by a 45°angle spade cut on one side of the stem, starting about 15 cm from the base of the stem, and a vertical spade cut on the opposite side of the stem. The remaining two sides should be pruned a month later. Lifting and transplanting should be carried out with a minimum of delay between these two operations. It will be necessary to moisten and cover lifted seedlings if they are being transplanted on a sunny day.

Direct sowing of beech seed on disturbed sites can also be recommended but some preliminary trials are usually necessary to ascertain the suitability of the site for direct sowing.

For rapid establishment, transplanted seedlings should be given protection from prevailing winds for at least a couple of years. On exposed sites it is beneficial to establish nurse crops of *Coprosma*, *Olearia*, *Hebe* or *Pittosporum* species. Plantations of alders and pines established on screes on the Craigieburn Ranges by the Forest Protection Division of the Forest Research Institute appear to provide very favourable environments for the establishment and growth of mountain beech seedlings if the canopy is open to some degree. Once these seedlings are established they can be released by opening up the canopy of the nurse crop.

When planting beeches in shelterbelts, they can be planted next to fast-growing but short-lived species such as willows. By the time the fast-growing species have started to decline the beech trees should be 10–15 m tall and providing good shelter.

Olearia spp.

This genus has 32 species in New Zealand, all endemic, with at least one or more species occurring in each main and many minor vegetation types from coastal to low alpine regions. A few species have very wide distribution and about a dozen have very limited distributions. Hybridization occurs between some species and is quite common in cultivation. A few species which are recognised for their shelter value, as well as some species which show potential for revegetation, are described below. For some species, their potential for revegetation and erosion control resides in their extreme hardiness, tolerance of dry or exposed conditions and ease of propagation (mostly from hardwood or semi-hardwood cuttings). Seed availability is often poor for some species.

Other species of *Olearia* which will be suitable for revegetation and restoration of disturbed sites include a few common and easily propagated species, namely *O. rani*, *O. lacunosa*, *O. nummularifolia*, *O. arborescens*, *O. furfuracea* and *O. coriacea*, wherever the site is close to a population of one or more of these. More attempts should be made to evaluate the suitability of these and other species, especially the drought-hardy ones, for erosion control.

Olearia albida (Hook. f.)

Tanguru

Erect shrub or small tree up to 5 m. Generally robust in appearance with stout branchlets and coriaceous leaves.

Olearia albida occurs in coastal forests and scrublands from North Cape to East Cape but its distribution is rather local. It is cultivated in most lowland districts. (*O. albida* var. *angulata* is probably more common in cultivation and has very wavy leaf margins and is generally more hardy.) It does not tolerate poorly drained soil. It is very wind hardy and drought tolerant but new growth which sometimes appears in autumn may be frost damaged. It is very browse resistant. It is very good for low shelter and has often been used for hedges.

Propagation is by hardwood or semi-hardwood cuttings. Open-grown material with a wrenched and properly conditioned root system is very easy to establish. (*O. albida* var. *angulata* is slower in early growth but otherwise equal.)

If necessary it can be clipped or trimmed regularly.

Olearia avicenniaefolia (Raoul) Hook. f.

Akeake

Broad-crowned, much branched shrub or small tree up to 6 m.

Olearia avicenniaefolia is found in lowland to subalpine scrubland of the South and Stewart Islands and occurs from sea level to 900 m. It is cultivated in many areas, including North Island gardens. Although common in many areas of scrubland it is not always present. It is very hardy and tolerates dry conditions very well but not extreme drought. In Westland it is a colonizer of stable gravels and talus slopes.

Its main use is for restoration of indigenous vegetation and revegetation of earthworks and perhaps for gully erosion control especially on gravelly, free-draining substrates.

It is easily propagated from hardwood or semi-hardwood cuttings.

Olearia paniculata (J. R. & G. Forst.) Druce

Akiraho

Much branched shrub or small tree up to 7 m.

Olearia paniculata is found from East Cape and Raglan Harbour to Greymouth and Oamaru. Its altitudinal range is sea level to 500 m. It is mostly found in coastal and lowland scrubland and forest margins and is very common in hedgerows throughout New Zealand. It withstands wind and dry conditions very well but requires good drainage in wetter climates and is not suited to heavy soils. It is frost tolerant.

It is excellent for low shelter, and tolerates trimming and clipping very well. The species is subject to gall infestation but this is seldom a problem with healthy plants.

Propagation is frequently from cuttings, but fresh seed germinates readily. Plants are frequently grown in containers but open-grown, well-conditioned plants should be used more because they will establish more quickly when transplanted.

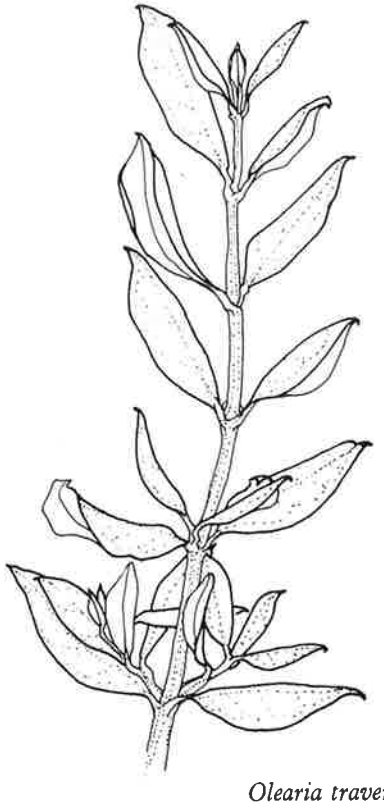
Olearia traversii (F. Muell.) Hook. f.

Chatham Island Akeake

Erect shrub or small tree up to 10 m with a short, stout trunk.

Olearia traversii is found in the forests and scrub near sand dunes and rocky places of the Chatham Islands (now much depleted in the Chathams). It is commonly cultivated in most lowland districts of mainland New Zealand. It grows well in most soils other than poorly drained or waterlogged soils. It is very wind hardy and tolerant of coastal conditions, being similar in ecology to the mainland pohutukawa.

The species is commonly used in hedges and is recommended for low- to mid-tier shelter and for filling in gaps under established shelter. Heavy branches arising from ground level are prone to breakage but removing the lower branches of young plants will lessen this problem.



Olearia traversii

Propagation is by cuttings. Open-grown plants can be ready for planting after a full growing season. Ground-level branches often originate when the upper shoots of non-hardened or severely stressed transplants die, thus promoting the growth of shoots from lower on the stem. Proper conditioning and handling of planting stock will lessen this problem. Plants respond well to trimming and clipping.

Olearia virgata var. ***lineata*** Kirk

Twiggy Tree Daisy

Shrub or tree up to 5 m. Small leaved but leaf shape highly variable. The only variety considered here is *lineata* although others may have limited applications.

O. virgata var. *lineata* is found on river flats and in scrublands, grasslands and forest margins from Greymouth to Stewart Island but does not occur near the east coast. Its altitudinal range is sea level to 1000 m. It is cultivated in many parts of the country. The variety grows well in a wide range of soils and does very well in dry climates. It is very wind and frost tolerant.

It is suitable for low shelter and revegetation of bare surfaces within its natural range. The cultivar 'Dartonii', often marketed as *Olearia* Dartonii, is excellent for low shelter because of its rapid early growth.

Propagation is by cuttings. Fresh seed can also be used but viability may sometimes be very low.

Pittosporum colensoi Hook. f.

Rautawhiri

Small tree up to 10 m with erect to spreading branches. Similar to *P. tenuifolium* but has stouter branches and usually large leaves with whitish midrib. Hybrids are very common, in fact so common that some workers refer to *P. colensoi* as a subspecies or variety of *P. tenuifolium*. In horticultural practice they are not always differentiated.

Pittosporum colensoi is common in lowland to montane forest from Bay of Plenty southwards to Stewart Island. In the South Island it occurs mainly west of the Main Divide. Its altitudinal range is sea level to 900 m. It is commonly cultivated but not in great numbers. It prefers moist and well-drained soils. The species tolerates frost and wind but not dry climates. It is readily browsed by rabbits, hares and deer but less by possums.

It is suitable for low shelter when planted with taller species or on its own where it is not exposed to persistent strong winds. Within its range, local populations are useful for revegetation of roadworks or other earthworks and for planting as a nurse crop for forest regeneration.

It is easily grown from seed, which is often produced abundantly by late summer to autumn. Seed can be sown directly into nursery beds. Plants can be ready for planting out after one year in the nursery but for more open sites older, larger and well-conditioned stock should be used. On suitable sites growth is rapid; up to 1 m per year.

Pittosporum crassifolium Banks & Sol. *ex.* A. Cunn.

Karo

Shrub or small tree with ascending branches, up to 9 m tall. The crown is often wide and on some plants in poor conditions is open with no strong leading shoots.

Pittosporum crassifolium

Pittosorum crassifolium occurs along forest margins and steamsides in coastal localities mostly from North Cape to East Cape but plants have also become established as far south as Wellington. It is often grown in most coastal and moderately frost-free lowland areas throughout New Zealand. Its best growth is on moist soils but once established it will tolerate seasonal dry periods, salt spray and strong winds. It is not easy to establish on heavy, wet soils.

It is very good for shelter, especially near the coast where salt spray may occur. Selection of robust and erect forms will add to the effectiveness of the shelter. It is possibly useful for soil and earthworks stabilisation in coastal regions.

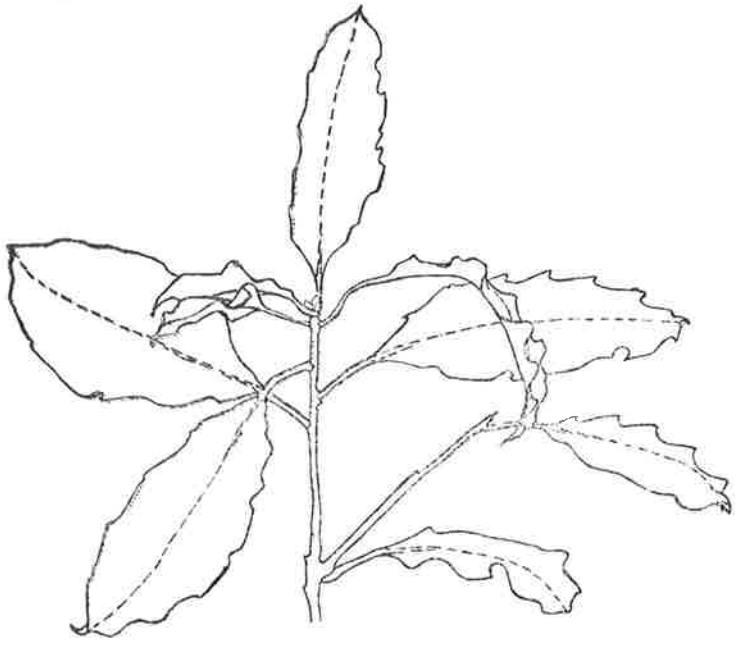
Propagation is by seed but cuttings can be used also. Seed should be selected from trees of the best form and health. Seed is ripe from mid to late summer. It is often retained on the trees until the following spring but by then viability may be poor (M. Nichols, Department of Lands and Survey, Taupo, pers. comm.). Stratification will promote more even germination. Seed can be sown in open ground. Under ideal conditions early spring-sown seed can produce plantable-sized seedlings by the following winter. Undercutting and side pruning in autumn will help to condition open-grown plants. Plants are susceptible to attacks by a sucking insect (pittosporum chermid) which causes disfiguration of leaves and loss of vitality. It is therefore important to select only nursey stock which is free of the disease.

Pittosporum eugenioides A. Cunn.

Tarata, Lemonwood

Erect, sometimes spreading, small tree up to 12 m. Distinctive light green foliage which is lemon scented when crushed.

Pittosporum eugenioides occurs throughout the lowland and lower montane regions of the North and South Islands, mostly along streamsides, in forest clearings, along forest margins and in second-growth forest. Its altitudinal range is sea level to 600 m. It grows well in most well-drained soils but is not hardy in droughty climates. It does not naturally establish on low fertility, eroded soils but responds well to fertilizer applications. It is frost tolerant but will not tolerate waterlogging even for short periods. Although it is quite wind tolerant, persistent winds in spring will cause damage to young leaves and shoots. Tolerances vary somewhat between provenances; some are more wind tolerant and others, especially at the seedling stage, do not do well in full sunlight.



Pittosporum eugenioides

Being widespread, lemonwood is a good species for revegetation of disturbed but not exposed sites. It is not a primary coloniser but once established it is a good nurse plant for other forest species. Its growth is 0.5–1 m per year. It is good for shelter but not as a first line of defence. It tolerates trimming very well and can be kept to a very narrow width. The cultivar 'Zita Robinson' has a very upright growth habit and should be suitable for shelter. Young plants are not wind stable in seasonally wet and poorly coherent soils.

Propagation is by seed but semi-hardwood cuttings can be used. Seed becomes ripe during the mid-summer period. This is the previous season's seed (the current year's seed crop has been formed but the fruits are still green). Seed should be sown in spring to obtain good sized plants of 30–50 cm by the following winter. Winter-sown seedlings can be ready for lining out in nursery beds in the spring. A programme of wrenching in summer and autumn will be required to give well conditioned plants ready for lifting and transplanting in July or early August. Poorly conditioned stock will result in many failures as will poor handling which allows leaves or roots to dry out at any stage. Planting on exposed sites will result in poor survival and growth.

Pittosporum ralphii Kirk

Karo

Spreading shrub or small tree 4–6 m tall. Similar to *P. crassifolium* but leaves more oblong (as opposed to spathulate) and longer.

Pittosporum ralphii occurs along forest margins and streamsides mostly from Hokianga to Thames, Taupo and southern Hawke's Bay. It is grown in gardens in most lowland districts and it appears to have become naturalised around coastal Wellington. Its altitudinal range is sea level to 500 m. It tolerates dry conditions, moderate frost and salt-laden winds. Young plants are not wind stable in wet and poorly coherent soil.

The species is suitable for shelter and once established is very hardy. It is fairly quick growing and puts on 0.5–1 m of stout growth per year. It is suitable for revegetation of disturbed sites within its natural range.

Propagation is mostly by seed but semi-hardwood cuttings can be used. Spring-sown seeds should give plantable seedlings in one season. Plants will establish well on subsoils and heavy infertile clays if some slow-release fertilizer is applied at the time of planting. Compacted soils or heavy, poorly drained soils will need to be ripped or drained.

Pittosporum tenuifolium Sol. ex. Gaertn.

Kohuhu

A variable species with a wide range of forms but generally small tree up to 10 m with densely foliaged crown. It often hybridizes with *P. colensoi* and *P. crassifolium.*

Pittosporum tenuifolium is common from North Cape to Southland but does not occur west of the Main Divide in the South Island. It is found mostly along forest margins, streamsides and in regenerating forest or scrubland, and occurs from sea level to 920 m. Various wild forms and cultivars are commonly cultivated in all lowland districts. It is a very hardy species and tolerates most soil conditions except waterlogging and extreme drought. It is frost tolerant and reasonably wind tolerant. Persistent strong winds will damage the new growth. Young plants are not stable in wet and poorly coherent soil.

It is good for shelter, and its habit of producing foliage down to near ground level makes it most suitable for filling in gaps under taller shelter trees. Its most practical use, however, is as a nurse crop and as early vegetative cover on earthworks and deforested areas.

Revegetation at Aratiatia after hydro dam construction. Predominant species in this area are *Pittosporum eugenioides* and *P. tenuifolium.*

Well established roadside revegetation planting at Aratiatia. Species include *Pittosporum tenuifolium, P. eugenioides, Coprosma robusta, Hebe stricta, Pseudopanax crassifolium, Coriaria arborea, Olearia* species.

Riparian planting along trout spawning stream, Kinloch, Taupo. Major species are *Hebe stricta, Cortaderia toetoe, Phormium tenax* and *Cordyline australis.*

Riparian planting in the same area, with *Pittosporum colensoi* in the middle distance.

Pomaderris apetala. This species is useful for medium-height windbreaks in areas exposed to salt-laden winds.

Pittosporum tenuifolium used as a horticultural shelterbelt, Te Puke. Age is seven years.

Pittosporum crassifolium and *P. ralphii* alternating in a low windbreak. These species are well suited to underplanting tall windbreaks in coastal areas.

Pittosporum eugenioides and *Plagianthus betulinus*, Aokautere, age seven years.

Propagation is by seed and sometimes by cuttings. Seed should be collected from populations of uniform form and habit; otherwise extremely variable seedlings will result. Although seed ripens in late summer to autumn it remains on the tree most of the winter and into the spring. Like the other *Pittosporum* spp. listed above, growth is fairly rapid but if open-grown plants are used they will require careful conditioning and transplanting to avoid growth cessation at the time of planting. Container-grown plants can easily become root bound if they are held over for more than the first growing season and are not repotted.

Plagianthus betulinus A. Cunn.

Ribbonwood, Manatu

Medium-sized deciduous tree, 10–15 m tall. Adult plant has round-headed to rather flat and spreading open crown. The divaricating small-leaved juvenile stage persists for a number of years but has prominent upright habit. Some provenance variation in the number of years that the juvenile stage persists. Dioecious, and the male plant is regarded as having the better form.

Plagianthus betulinus is local in occurrence from Mangonui in the North Island to Stewart Island. It is found on riverbanks and alluvial terraces, and in coastal and lowland forest margins, from sea level to 450 m. It is most common on fertile alluvial soils and in moist climates (> 1000 mm annual rainfall). It is hardy throughout the lowland districts but not tolerant of hard frosts or severe drought. The extremely wind-tolerant, supple-branched, divaricated juvenile stage allows the main trunk to grow vertical even in strong prevailing winds.

It is suitable for mid-tier shelter. The juvenile stage does not have much spread and will tolerate light side-trimming. Its deciduous habit makes it useful where winter shade is not desirable. It should be planted alternately with a lower growing species because the adult plants will open out underneath.

Propagation is by seed which ripens from early summer to early autumn. Seed should be selected from populations having good branching habit and good vigour. (Some plants suffer from shoot dieback that is caused by a stem borer, and rust.) Plants on infertile sites will require additional fertiliser.

Plagianthus divaricatus J. R. & G. Forst.

Makaka, Shore Ribbonwood

Erect but densely divaricating small shrub 1–2.5 m in height. Leaves small and slender. Branches are reddish brown, tough and slender.

Plagianthus divaricatus grows around edges of coastal salt-water marshes and shores of estuaries just above the normal high tide limit throughout the North, South, Stewart and Chatham Islands. It tolerates soil that is more or less continually wet with salt water but can survive in less brackish conditions if competition from other plants is not too severe. It withstands light frost, driving salt spray and occasional flooding by salt water. It does not establish on rocky substrate, or shifting gravel or sand.

It is excellent for estuarine and other coastal planting just above and beyond the normal high tide level. It requires at least two growing seasons after planting before it provides any shelter. If more erosion control is needed other species can be established behind the makaka. For early and adequate shelter, and protection, plants will need to be planted at a spacing of 0.5 m. Wider spacing can be used for general revegetation.

Propagation is by seed or cuttings. Seedlings will require two growing seasons before reaching 30–40 cm at which stage they are ready for planting. Seed is ripe in mid to late summer and should be collected in the vicinity of the area to be revegetated. Hardwood cuttings also root readily when planted in the open but experimentation is required before direct planting of cuttings on-site can be advised.

Podocarpus totara G. Benn. ex D. Don and ***P. hallii***, Kirk

Totara and Hall's Totara

Mature trees of *P. totara* reach up to 30 m but require a century or more to reach this height. The juvenile stage of some provenances has long lax branches and widely spaced leaves which may persist for several decades during which time a height of 5–10 m is reached. There is also some provenance variation in the adult form and height. *P. hallii* is a smaller species but has larger leaves and thinner, more flaky bark. Hybridization occurs.

Podocarpus totara is common in lowland and montane forests of the North, South and Stewart Islands. It occurs from sea level to 500 m (occasionally up to 700 m) in the north but only up to 300 m in the far south of New Zealand. At higher elevations it is replaced by the smaller *P. hallii* which grows up to 1000 m elevation in the north and 700 m in the south. *P. totara* is a forest tree but it is well suited to growing in the open. It is wind, frost and drought tolerant but new growth, especially on young seedlings, can be damaged by late frosts or hot dry winds. Provenance variation can be expected in the degree of tolerance. Plants will stagnate with competition or shade but if well established they respond quickly when released. *P. hallii* is more shade tolerant, more frost tolerant, more drought tolerant and less subject to insect damage. *P. totara* is occasionally damaged by defoliating insects and egg-laying cicadas, the latter causing stem damage. *P. totara* is well adapted to immature but not necessarily fertile soils.

P. totara is very suitable for use in low, medium and high shelter depending on how long one is prepared to wait. Because of its longevity but relatively slow growth (0.5 m per year), it is best used for permanent shelter along permanent boundary fences, or along state highways and secondary roads. Its relatively slow growth and ability to tolerate trimming and drought make it suitable for low-maintenance shelter hedges. Where taller yet early shelter is desired totara should be planted alongside faster growing but shorter-lived shelter species.

Propagation is usually by seed but hardwood cuttings from adult trees have been used for propagating shelter and specimen plants to avoid the less aesthetic juvenile stage. Seed should be collected from trees of desired form. Seed of unknown origin should not be used. For seed collection the New Zealand Forest Service recommends placing hessian or "Sarlon" sheets under selected seed trees in late summer and autumn. These sheets should be of manageable size, preferably in wooden frames supported above ground level, and the seed cleared at regular intervals. Forest humus can be raked up after seed fall to yield a supply of seed. Most seed germinates after 6–12 months but some can remain dormant for up to 2 years. Preparation of a seedbed and lining out, and planting out procedures are described in the New Zealand Forest Service publications *What's New in Forest Research: No. 85, Raising Native Trees,* and *No. 86, Establishing Nursery Raised Native Trees.*

Totara seedlings will require at least 2 years in the nursery before planting out. Larger plants will require less maintenance after planting out and suffer less from weed and grass competition.

Container-grown plants can be recommended for small planting jobs but care must be taken to ensure the roots do not become pot-bound. Bare-rooted stock has been difficult to establish on poor sites. Use of fertiliser is unnecessary on forest sites with volcanic ash soils where topsoil is present because any improvement in the fertility benefits the weeds much more than the totara seedlings. There could be a need for fertiliser on more difficult sites.

Pomaderris apetala Labill.

Tainui

Erect shrub or small tree up to 5 m. It has dark green leaves with wrinkled upper surfaces and more or less tomentose undersides.

Pomaderris apetala only occurs naturally in New Zealand in a few coastal localities of the North Island from Kawhia Harbour to the Mokau River, and on the Chatham Islands. However, it is widely grown as an ornamental and shelter species throughout most lowland districts. Much of the material propagated in New Zealand is probably from an Australian population of the species but in horticultural practice is not often differentiated. Also some forms which are sold as *P. apetala* differ from the main species and are probably a separate species (see Allan 1961, p. 421). It grows best on moderately good soils and is moderately frost and wind hardy. It does not tolerate waterlogging or extreme drought.

Pomaderris apetala

The species is best suited for low shelter and for filling gaps under taller, open shelter. It will grow quickly and reach its maximum height in 6 or 7 years after which it opens out and becomes less densely foliaged.

Propagation is normally by cuttings.

Pomaderris phylicaefolia (tauhinu) is a smaller plant with narrower leaves. It is sparsely distributed throughout the North Island and northern South Island. There are several recognised variations. Tolerances vary according to locality but most plants tolerate moderate drought and frosts. *P. phylicaefolia* has a dense root system which is good for soil stabilisation on drought-prone, rocky coastal sites. Propagation is by seed or cuttings. These should be collected close to the locality to be planted.

Pseudopanax arboreus (Murr.) Philipson

Five-finger, Puahou

Small, round-headed tree up to 8 m tall. Branches numerous, stout and fairly brittle. The distinctive compound leaves of 5–7 petiolate leaflets radiating from a central petiole give rise to its common English name.

Pseudopanax arboreus is abundant in lowland forests and scrub from North Cape to Southland and occurs from sea level to 760 m. It is not frequently cultivated but

this is mostly because it is abundant in the wild. It is not a pioneer or colonising species but is very abundant in the early to middle stages of secondary successions. The seedlings are occasionally epiphytic but mostly they establish in the litter under the canopy. Plants require fertile and humus-rich soil and do not readily establish on bare soils or topsoils. It tolerates coastal conditions and moderate frosts but young growth can be desiccated by hot, dry winds. Despite the brittle branchlets it stands up to strong winds very well.

It is suitable for low-tier shelter and general revegetation of disturbed sites where topsoil remains. Where topsoil has been removed slow-release fertiliser will greatly aid establishment. The species cannot be recommended for planting on very exposed sites or as front shelter against persistent, strong winds. It is very suitable for planting on road embankments, particularly in moist climates.

Propagation is usually by seed which is usually abundant and which ripens in mid summer. Seed must be sown while fresh, or immediately stratified and then sown. Seed can be stored in moist, cool conditions for at least 6 months. Semi-hardwood cuttings root readily under mist. Seedlings in milder climates can be ready for planting out 7–8 months after sowing but in cool climates plants should be lined out in nursery beds for a full season before lifting and planting.

A closely related species, *P. colensoi* is slightly smaller and is of common occurrence up to altitudes of 1200 m throughout the North, South and Stewart Islands. It is only in Fiordland and on Stewart Island that it commonly grows at sea level. This species is very hardy and is recommended for use on disturbed sites at higher elevations than those for which *P. arboreus* is suited.

Schefflera digitata J. R. & G. Forst.

Pate

A small spreading shrub or tree up to 8 m tall. It has digitately formed compound leaves consisting of 3 to 9 (most commonly 6 to 8) short-petiolated leaflets. Superficially similar to five-finger but leaflets are thinner and more finely serrated. More or less deciduous in the colder, higher altitude areas.

Schefflera digitata grows throughout the North, South and Stewart Islands in damp openings and edges of forests and along streambanks and shady roadsides, from sea level to 1200 m. It requires moist, partially shady conditions for rapid growth. It is commonly a species of early secondary successions but will persist in open habitats not otherwise occupied by taller species. The species is generally quite hardy but not very wind tolerant. It is highly palatable to most browsing animals commonly present in New Zealand bush.

It is very suitable for revegetation in forest regions, especially in damp shady areas, in that it will rapidly cover and protect the soil and provide good growing conditions for other forest species.

Propagation is from seed, which ripens in the autumn, or from cuttings. The dark, single-seeded fleshy fruits are borne on racemes hanging in loosely arranged panicles.

Senecio spp.

There are about 40 species in New Zealand of which about 23 are shrubs or small trees. (Several shrubby members of this genus are probably better assigned to the genus *Brachyglottis* but here the old name is retained and the new name is appended as a synonym.) Many of these are very hardy and easy to propagate. The few species listed here may be of general use in soil conservation but many of the other species will have local use, especially in revegetation in or near botanically sensitive areas (e.g., scenic reserves, national parks).

Senecio bidwillii Hook. f.
syn ***Brachyglottis bidwillii*** (Hook.f.) Nordenstam

Compactly branched shrub up to 1 m high.

Senecio bidwillii is common in subalpine and low alpine scrub and fellfield in the North Island from East Cape to Mt Egmont south to Cook Strait. *S. bidwillii* var. *viridis* is slightly larger and occupies similar habitats about and west of the Main Divide from Nelson to southern Westland. It occurs from 800 to 1600 m. Metcalf (1972) also refers to another form found in the drier eastern ranges near the Main Divide. The species is not drought hardy but does withstand heavy frost and encrustations of icy rime. It grows well in thin and poorly developed alpine soils.

The species is useful for limited revegetation of roading and other earthworks in the subalpine and lower alpine zones but does not provide rapid ground cover.

Propagation is easily done from cuttings and these should be collected from near the site which is to be revegetated. Care must be taken to ensure that plants raised in lowland nurseries are adequately hardened when transplanted to colder sites. This may require that containerized stock is moved to higher altitudes in August so that the plants will maintain hardiness until planting commences as the sites become free of snow and the soil thaws.

Senecio elaeagnifolius Hook. f.
syn **Brachyglottis elaeagnifolia** (Hook. f.) Nordenstam
and ***S. bennettii*** Simpson & Thompson
syn ***B. buchananii*** (J. B. Armst.) Nordenstam

Senecio elaeagnifolius is a very stout spreading shrub up to 3 m. Mainly found in upper montane and subalpine forest and scrub areas of the North Island south of East Cape at 800–1200 m. The closely related *S. bennettii* is a compactly branched shrub up to 3 m high; common in lowland to subalpine scrub of the South Island mountains but occurs more frequently west of the Main Divide.

These species are very frost hardy, and tolerate poor soil and very windy environments. They do not grow well in dry conditions.

Both species are suitable for revegetation of roadsides and other disturbed sites within their natural ranges, especially at higher elevations where few other species are suitable.

Propagation is by cuttings. Plants will require a full growing season in a lowland nursery before being ready for planting. As with *S. bidwillii* plants will need to be adequately hardened if planting is at a higher elevation and cooler site than the nursery.

Senecio huntii F. Muell.
syn ***Brachyglottis huntii*** (F. Muell.) Nordenstam

Rautini

Shrub or small round-headed tree up to 6 m. Its large lanceolate leaves, clustered near the branch ends, are distinctive as are the numerous yellow flowers when in full bloom.

Senecio huntii is only found naturally in the Chatham Islands; there it grows mainly around the margins of bogs. It is cultivated in many mainland areas as a hardy ornamental shrub. Although normally growing in deep peaty soils it will grow in sandy soils and tolerates prolonged dry conditions. It does not tolerate more than light frosts and will not tolerate shade.

Its main use in soil conservation would appear to be for windbreaks on peaty soils in milder lowland climates.

Propagation is by cuttings.

Senecio reinoldii Endl.
syn ***Brachyglottis rotundifolia*** J. R. & G. Forst.

Muttonbird Scrub, Puheretaiko

Stout branched shrub or small tree up to 6 m. Its rounded, thick leaves are similar to *S. elaeagnifolius* or *S. bennettii.*

Senecio reinoldii is common in the coastal scrub of the South Island from Jacksons Bay to the Southland coast and Stewart Island. It is cultivated in a few North and South Island gardens in areas with moist climates. Its natural habitat is mainly exposed cliffs and rocky beaches where it withstands the most violent storms and gales which are mostly accompanied by salt spray. It can also tolerate fairly dry, wind-swept hillsides but prefers a steady moisture supply. Probably intolerant of hard frosts.

The species is ideal for planting within its natural range as a first line of shelter against the westerly and southerly gales. It may have some use as low-tier shelter several kilometres inland although many other species will be equally or more suitable. It is suitable for general revegetation of exposed disturbed sites, including road batters in the southern coastal regions.

Propagation is by cuttings.

S. greyi similarly is a hardy coastal species occurring on coastal rocks and nearby ravines of the southern and south-eastern Wairarapa coast. It is variable in form but, although it is widely cultivated throughout New Zealand for its foliage and flowers, little selection has been done to find plants that are suitable for shelter and soil conservation in coastal areas.

Sophora microphylla Ait.

Kowhai

Small tree up to 10 m. Spreading, sometimes drooping, light-foliaged branches. Passes through a juvenile stage with densely divaricating branches. Deciduous. Distinctive yellow flowers appear in early spring before new leaves are produced.

Sophora microphylla is variable in form with at least two varieties being recognised. Slow growing juvenile forms are most common but *S. microphylla* var. *fulvida* and *S. microphylla* var. *longicarinata* reach adult form quickly, although they do not grow to a large size.

Kowhai is widespread throughout the lowland and lower montane regions of the North, South and Chatham Islands in open forest, and along rivers and forest margins. In some pastures isolated trees or groves have been allowed to remain. It is commonly cultivated for its beautiful yellow flowers. Its altitudinal range is sea level to 800 m. It grows well on a wide range of soils but does not establish readily on subsoils. It withstands moderate exposure to wind and is frost hardy. The level of hardiness varies between populations from diverse habitats.

Kowhai is a good species for planting on moderately fertile roadsides, streambanks and most disturbed but stable surfaces where long-term protection is required. It is also suitable for planting as secondary shelter, but, because of its long-persisting juvenile stage, it will be necessary to plant faster-growing but shorter-lived shelter species alongside. Its deciduous habit will be of benefit where winter shading is not desirable.

Propagation is generally by seed. Very fresh seed, collected in early summer before it becomes hard, can be sown immediately without any pre-treatment. Otherwise older hard seed, which maintains viability for many years, will need to either have the hard coating softened by immersion in boiling water or be scarified. Cuttings taken from adult plants can be used to avoid the juvenile stage. Seedlings or cuttings will require 2 years in containers or nursery beds before reaching a planting out size of 40 cm or more. On the site, grass competition must be prevented for several years.

Sophora tetraptera is a similar species but grows up to 12 m high and has larger leaflets. It occurs naturally in lowland districts from North Cape to Manawatu but is commonly cultivated throughout New Zealand. It is not as hardy as *S. microphylla* and does not have a juvenile stage. It may be better for revegetation in areas close to natural populations but would not be suitable for shelter or planting in exposed situations.

Weinmannia racemosa Linn. f.

Kamahi

Spreading forest tree up to 25 m. Has a juvenile trifoliate-leaved stage which may persist for many years. Adult plants have simple, oppositely arranged leaves. Long-lived (up to 400 years).

Weinmannia racemosa is abundant in lowland and montane forests from Auckland to Stewart Island. It occurs from sea level to 1000 m in the North Island, to 900 m in the South Island and to 650 m on Stewart Island. Its distribution mostly corresponds to forested areas that have an annual rainfall greater than 1000 mm. In places it forms the forest canopy, especially where beech is absent (as in parts of Westland), and is often prominent in second growth. Kamahi is an important nurse species although its own seedlings often establish on other live and dead vegetation. It has a wide habitat range varying from sheltered lowland streamsides to exposed mountain ridges and slopes. Seedlings are not very frost tolerant. Kamahi is also intolerant of extensive waterlogging or drought although well established trees can tolerate brief periods of drought. It grows well on a wide range of soils and, because of its ability to spread by root suckering and to coppice from smashed stems, it can survive very severe and damaging storms. It is palatable to possums; they are capable of defoliating and eventually killing mature trees but there are many regions where little or no damage occurs.

Kamahi is a very good species for use in revegetation of roadworks and other disturbed soil in forested areas. It is not a good coloniser so will benefit from a nurse crop of *Coprosma, Coriaria, Olearia* or *Hebe* species.

Propagation is by seed, which ripens in March. Seed can be sown directly on patches of bare moist clay soil or subsoil at the planting site. Old moist logs can also provide a good seed nursery. For direct sowing the site's suitability should be carefully assessed by sowing trials before large-scale seedings; otherwise, it is best to establish nursery-grown stock. Browsing and grazing animals must be excluded from the planting area.

Grasses and Herbs

Acaena spp.

Bidibid, Piripiri

These are creeping herbs or semi-woody, procumbent plants with ascending short branches, pinnate leaves and coarsely serrated leaflets. Seed heads of most species protrude above the leaves, and are often the most obvious feature of the plants. Seeds of all but two species contain spines tipped with barbs which cling to clothing and animals. For this reason bidibids are often cursed and generally looked upon unfavourably.

There are about 14 species and several varieties of bidibid recognised in New Zealand. A number of species hybridize wherever they occur together and this can make identification difficult. The introduced Australian *A. ovina* also hydridizes with the New Zealand *A. anserinifolia.* Plants used for soil conservation should therefore only be propagated from plants present near or at the planting site.

Two species do not occur on the mainland but all others or their varieties are found in the South Island, and of these, five also occur in the North Island. Bidibids

occupy a variety of habitats from coastal sand dunes to lowland, montane and alpine tussock grasslands, and open places within montane forest especially east of the Main Divide in the South Island. Habitats consist of fellfield, rock avalanche debris, moist depressions, damp streambanks, alluvial sands and gravels, slips, and even the moister depressions in semi-arid regions. Individually, few species occur over a diverse range of habitats but with hybridization some populations appear to be quite diverse in their tolerances. *A. anserinifolia* and *A. novae-zelandiae* are the most widespread and are often weeds in rough pasture, and their barbed seeds can cause much damage to wool fleeces. Generally bidibids do not tolerate poor drainage, shade or severe drought. There are only a few species that can take on the role of primary colonisers but, once initial stabilisation has taken place and a few plants have become established, the creeping stems can quickly spread onto adjacent bare ground.

Bidibids, because of their semi-mat-forming habit, are useful for planting on bare ground and earthworks where introduced grass and/or legume swards are not desirable. Their ability to colonise by creeping stems make bidibids useful for covering areas prone to frost heave. As stated above, only local material should be used for propagation and this should be selected from populations already present on sites similar to the site to be planted.

Propagation is by seed or division. Seed should be stratified. Plants are best grown in trays or open beds and then, just prior to planting out, divided into clumps of 5–8 cm across taking care that each plant has sufficient roots. On the site, plants are spaced according to their ability to cover the intervening ground in a few years. Rates of spread are not generally known so some preliminary trial work may be necessary to decide on the best spacing.

Chionochloa spp.

Snowgrass, Snow Tussock, Tall Tussock

Most species are coarse, tussock-forming grasses, 0.7–2.5 m tall, but a few are turf or semi-turf species.

There are twenty species recognised in New Zealand. Some hybridization occurs and there are some populations which are not easily identified to any one species. Species which can be used for a limited number of revegetation situations include *C. conspicua, C. flavescens, C. macra, C. pallens, C. rigida* and *C. rubra.*

C. conspicua is found throughout the lowland to montane forests especially the wetter forests of the North, South and Stewart Islands. The remaining species listed above are found in various situations throughout the alpine regions, often forming the dominant vegetation (i.e., the very extensive snow tussock or tall tussock grasslands). *C. flavescens, C. pallens* and *C. rubra* are found in both the North and South Islands, the latter species dominating in poorly drained grassland and extending down to sea level in the South Island. *C. macra* and *C. rigida* are restricted to the South Island, the distribution of the former being fairly extensive and the latter occupying the driest of the snow tussock grasslands (but not areas prone to severe drought) in Otago and South Canterbury. *C. rigida* also extends down to sea level in eastern Otago. Except for *C. conspicua* which colonises slips, eroded streambanks, alluvial deposits and other open areas of lowland and montane forests, *Chionochloa* species are not primary or early colonisers. *C. pallens* is adapted to young soils which have good available phosphorus levels. The other species are better adapted to more mature soils which are often low in fertility, especially phosphorus. All species are moderately to highly frost tolerant.

Chionochloa species have a limited but valuable use in revegetation; the extensive natural stands play a very important role in water and soil conservation. In areas dominated by snow tussock or tall tussock vegetation, disturbed soils or earthworks can be revegetated by using the local species and taking care to differentiate between species adapted to infertile and mature but relatively undisturbed soils, and those adapted to younger, immature soils or even bare subsoils. However, the high costs

in establishing a reasonable cover with *Chionochloa* species is often a deterrent to their use. *C. conspicua* should be useful for revegetation of slips, earthworks and similar soil disturbances in montane forests. *C. australis* (carpet grass) is an alpine turf-forming species of the Nelson region but, despite its promising growth form, its growth rate is too slow for use in revegetation for soil conservation.

Propagation is by seed or division. Seed supply is irregular because of sporadic flowering, poor seed set or poor filling in some years, and insect predation. Sound seed, when obtainable, should be stratified for at least 3 weeks, and up to 10 weeks for species from the highest elevations. Seeds can be sown direct into nursery beds if the viability is known to be high. Otherwise, seed is best germinated in small trays, and when the seedlings are 1 cm tall they are pricked out and transferred to large trays for eventual lining out in sheltered and shaded nursery beds. Plants require at least 2 years to reach a plantable size of 20 cm or more. Seedlings are best planted in winter or early spring, but if raised in a lowland nursery the seedlings will require some extra hardening off before planting on higher elevation sites. Relatively rapid establishment can be achieved by dividing vigorously growing tussocks into clumps of 10 or more tillers. These can be lined out in a nursery near the planting site for a year before planting. Larger clumps can be transplanted directly to favourable sites in early spring. Seedlings respond well to fertiliser treatment if natural fertility is low.

Cortaderia spp.

Toetoe

Large, coarse tussock-forming grasses up to 5 m in height.

There are 4 endemic species, namely *C. fulvida*, *C. richardii*, *C. splendens* and *C. toetoe*. *C. selloana* (pampas grass) and *C. jubata* are introduced species from South America.

C. fulvida is found throughout the North Island, commonly on streambanks and hillsides cleared of forest, and occurs from sea level to 600 m. *C. richardii* is found throughout the South Island in similar habitats and also on very wet ground in lowland areas. Its altitudinal range is sea level to 600 m. *C. splendens* grows on sand dunes and cliff faces from Kawhia and Bay of Plenty northwards. *C. toetoe* occurs in the North Island from Auckland southwards on wet ground, in forest clearings, along roadsides, and on sand plains and dunes. Its habitat is mostly lowland, up to 600 m. *C. fulvida* and *C. richardii* are well adapted to colonising freshly deposited or exposed river gravels and slip debris. They tolerate low fertility, especially low availability of phosphorus. *C. fulvida* does not tolerate compacted and waterlogged soil. *C. splendens* and *C. toetoe* are less predominantly early colonisers, nevertheless they take on this role where opportunities exist. Toetoes are only slightly drought hardy and grow best where there is an abundant water supply and, except perhaps for *C. splendens*, are moderately frost hardy.

Toetoes are especially useful for early revegetation of slip debris, earthworks and other freshly exposed soils or subsoils in moist habitats throughout their respective ranges. *C. toetoe* and *C. splendens*, and to a lesser extent *C. richardii* and *C. fulvida*, can be used for low shelter, but the larger, introduced pampas grass is most commonly used for this purpose. Toetoes can provide a good nurse crop for other native seedlings but these seedlings will have to be situated to avoid abrasion from the rough-edged toetoe leaves.

Propagation is by seed or division. On suitable sites seed can be sown directly or seed-source plants can be established by transplanting clumps of mature plants from nearby. Care needs to be taken to ensure that a good quantity of healthy roots remain intact. Seed can be sown directly into nursery beds. Depending on site conditions and growth rates, nursery seedlings can be planted out after one or two years. Clumps of tillers can also be lined out in nursery beds for one growing season before being planted out.

Cortaderia toetoe is good coloniser, and is especially useful for early revegetation of freshly exposed subsoils where sufficient moisture is available.

Coriaria arborea is very suitable for revegetation of bare low fertility areas, such as this site in the Waioeka gorge. Photo C. W. S. van Kraayenoord

Coriaria arborea colonising a mudstone road batter, Makarori, Gisborne.

Road batter stabilisaton in central Otago using *Festuca novae-zelandiae.* Photo J. S. Sheppard

Phormium cookianum Le Jolis

Mountain Flax, Whahariki

Large-leaved monocotyledonous herb. Very shrub-like in physical dimensions; up to 2 m tall. Leaves usually lax for the upper third to half of their length but some South Island forms have entirely stiff leaves.

Phormium cookianum is found in shrublands, on hillsides and along streamsides from coastal to subalpine and low alpine regions throughout the North, South and Stewart Islands, but is most common in mountain regions. Its altitudinal range is sea level to 1400 m. It generally grows in wet and occasionally waterlogged ground in montane and subalpine regions but can tolerate seasonally dry conditions very well.

Only local forms should be used in soil conservation and general revegetation. However, a number of forms of diverse origin are cultivated throughout the country.

The species is suitable for revegetation of wetlands, including those at higher altitudes, or for restoration of other wet sites. It is good for secondary planting between coastal dunes once initial stabilisation has been achieved. Mountain flax is useful also for planting on streambanks and alongside drains to stabilise the banks and lessen weed growth. It provides good low shelter but usually the larger and more erect *P. tenax* is used for this purpose. Dense planting of flaxes between rows of shelter trees suppresses weed growth and provides low shelter.

Propagation is by seed or by division into fans. The fans are best lined out for one growing season before transplanting. Plants can be lifted at any time in winter. If necessary, they can be held in moist sawdust for considerable periods but must be transplanted before spring.

Phormium tenax J. R. & G. Forst.

Flax, Harekeke

Large, fairly erect, stiff-leaved herb; some forms having leaves up to 3 m long. There are many forms and varieties which differ in leaf colour, stiffness and length.

Phormium tenax is abundant in coastal and lowland swamps, alluvial ground and montane regions of the North, South and Stewart Islands, and occurs from sea level to 1400 m. Many cultivars and wild forms are in cultivation throughout the country.

This species has a very wide habitat range and climatic tolerance. Most forms are very tolerant of frost, drought, wind and salt spray. Some ecotypic differentiation can be expected. It tolerates very wet and waterlogged soils or dry hillsides. It does not have a deep nor wide-spreading root system but it will grow and maintain roots below the water table.

An excellent species for stabilising the banks of drains and small streams. Its leaves can also shade the water and help to prevent weed growth. The fallen dead leaves which remain attached will partially break the force of water impinging on the banks. It is suitable for planting in gully systems where there is seasonal waterlogging. Some of the taller more erect forms, including the cultivars 'Goliath', 'Purple Giant', 'Variegatum' and 'Williamsii Variegatum', are recommended for low shelter, especially in wet lowland areas, coastal swamps or estuaries, and on seasonally dry, windswept hillsides.

Propagation is by seed and by division into fans. When planting, the roots must not be planted deeper than their original depth. This is especially important in very wet soil.

Other Grasses and Herbs

The following herbaceous species have been used occasionally or may have a limited place in revegetation and soil conservation.

Desmoschoenus spiralis (A. Rich.) Hook. f.

Pingao

An effective sand binder in coastal sand dune country of the North, South, Stewart and Chatham Islands but is prone to being undermined, and, therefore, is not usually as effective as marram grass. Problems with germination of apparently sound seed need to be overcome before propagation from seed can be recommended. Stem tip-cuttings which include the growing point, can be induced to root by inserting their bases into wet sand. However, the stems left on the source plant do not form new shoots so this method is not effective for bulking up planting stock. This species has an important role to play in erosion control of sand dunes wherever exotic plants are undesirable but improved methods of propagation need to be developed. For further comments on this species see Volume 1, Section 3.4, of this Handbook.

Festuca novae-zelandiae Ckn.

(Hard or Fescue Tussock)

Common throughout the North, South and Stewart Islands where it is frequently the physiognomically dominant species of the short tussock grasslands of the lowland montane and subalpine regions. It occurs most extensively in the drought-prone intermontane basins of the eastern and inland South Island regions. It is not a colonizing species and only achieves dominance after long periods of stability. However, it can be planted at close spacing early in revegetation of earthworks in short tussock grasslands to provide a better microclimate for other plants. It is easily propagated from seed. Seedlings are best lined out in the nursery after reaching a height of 10 cm. They will then require a further 2 years before planting out.

Gahnia spp.

Large, forest tussock sedges, mainly found in the North Island and northern South Island. *G. procera* is the most widespread; it extends to Fiordland and also occurs in the subalpine forests in the North Island. *Gahnia* species occur mostly in wetter forests and can establish on very infertile soil and friable subsoil. These species are seldom major constituents of any plant community but they do show some potential to establish early in revegetation and thus provide a nurse crop for other species. Propagation is by seed or division. Some germination problems have been encountered and will need to be overcome.

Rytidosperma setifolium (Hook. f.) Connor & Edgar

Bristle Tussock

Widespread and common in montane to high alpine open habitats, including snow avalanche chutes, in the North, South and Stewart Islands. It is an early species to colonise bare soil in the alpine regions once initial stability has occurred. Its use in soil conservation is mainly limited to revegetation of earthworks in alpine regions where few other species establish readily. Its tussock habit does not provide good ground cover but dense planting improves the microclimate for other species. Propagation is by seed. Seedlings need to be lined out in nurseries for 2 years before planting out.

Poa laevis R. Br.

Silver Tussock

Widespread and common throughout the short tussock grasslands and open places in the North, South and Stewart Islands. It is often co-dominant with hard tussock in lowland grasslands, especially on the more fertile river flats and loess deposits, but is less dominant in the montane and low alpine regions. It often prefers moist places; nevertheless it is very drought tolerant. It has similar usage to hard tussock in that plants, when closely planted, will improve the microclimate for other grassland species. It is best planted on sites with moderate fertility. Propagation is by seed. Seedlings are best lined out in the nursery for several years before planting out.

Pratia angulata (Forst. f.) Hook. f.

A variable species in size, leaf shape and habitat, but generally a creeping herb rooting at the nodes and forming mats or carpets on damp ground and streambanks throughout the North, South and Stewart Islands. It occurs in open forests, grasslands, herbfields and coastal sand dunes. It is browse resistant and often becomes dominant where palatable species have been heavily browsed. It may be useful for revegetation of damp ground and seepages along roadsides or on earthworks within forested regions where other more palatable indigenous species are hard to establish and exotic shrubby species are not desired. Propagation is by seed or division. Little is known about field establishment but small plants or divided clumps are probably best planted at a spacing of 0.5–1 m.

Acknowledgments

The following persons and organisations have contributed by way of discussion and/or valuable information and criticism: H. Scheltus and M. Nichols, Department of Lands and Survey, Taupo; M. J. A. Bulfin and M. Simpson, Botany Division, DSIR, Lincoln; A. Dakin, Water Resources Division, Auckland Regional Authority; E. A. Beveridge, G. Pardy and J. Bathgate, Forest Research Institute, Rotorua; N. Ledgard, Forest Research Institute, Christchurch; J. A. Mitchell and T. Baker, Ministry of Works and Development Power Project Nurseries, Twizel and Cromwell respectively; S. Sahinovich, Ministry of Works and Development, Tongariro Power Project, Turangi; various staff of regional catchment authorities; New Zealand Nurserymen's Association, Lower Hutt; and staff of the Soil Conservation Centre, Aokautere — especially A. Parkinson for advice and comment on propagation methods. Photographs other than those specifically acknowledged were taken by R. L. Hathaway of the Soil Conservation Centre, Aokautere.

References and Selected Bibliography

Allan, H. H. 1961: "Flora of New Zealand" (Vol. 1). Government Printer, Wellington. 1085 p.

Beveridge, A. E. 1977: Native trees on the farm. *Farm Forestry 19*: 58–70.

Beveridge, A. E.; Pardy, G. E.; Bergin, D. O. 1981: The role of planting in re-establishing native forest. *In* "Forest Nursery and Establishment Practice in New Zealand" (Edited by C. G. R. Chavasse). Proceedings Symposium No. 22 Forest Research Institute, New Zealand Forest Service, Rotorua, March 1981.

Bodger, N.; Cath, P. W.; Ledgard, N. 1979: Notes on the propagation of native plants for high country revegetation. New Zealand Forest Service, Forest Research Institute, Production Forestry Report No. 167 (unpublished).

Cath, P. W. 1972: Propagating *Nothofagus solandri* var. *cliffortioides* vegetatively. *NZ Journal of Forestry 17*: 288–292.

Cockayne, L. 1927: "New Zealand Plants and Their Story" (3rd edition). Government Printer, Wellington. 4th edition, 1967 (Edited by E. J. Godley). Government Printer, Wellington. 269 p.

Dakin, A. J. 1974: Vegetative propagation of rimu (*Dacrydium cupressinum*) with cuttings from nursery plants. *NZ Journal of Forestry 19(2)*: 276–285.

Dakin, A. J. 1976a: Growth of indigenous shrub species and response to fertiliser at time of planting: First report on revegetated trial areas at Mangatawhiri Dam, Hunua Ranges. Auckland Regional Authority, Forestry Section, Water Department, Technical Report No. 1.

Dakin, A. J. 1976b: Growth of indigenous shrub species and response to fertiliser at time of planting: Second report on revegetated trial areas at Mangatawhiri Dam, Hunua Ranges. Auckland Regional Authority, Forestry Section, Water Department, Technical Report No. 2.

Dakin, A. J. 1977: Growth of indigenous shrub species and response to fertiliser at time of planting: Third report on revegetated trial areas at Mangatawhiri Dam, Hunua Ranges. Auckland Regional Authority, Forestry Section, Water Department, Technical Report No. 3.

Evans, B. (compiler) 1983: "The Revegetation Manual: A Guide to Revegetation Using New Zealand Native Plants". Queen Elizabeth II National Trust, Wellington.

Given, D. R. 1981: "Rare and Endangered Plants of New Zealand". A. H. & A. W. Reed, Wellington. 154 p.

Godley, E. J. 1979: Leonard Cockayne and evolution. *NZ Journal of Botany 17 (2)*: 197–216.

Hartmann, H. T.; Kester, D. E. 1975: "Plant Propagation: Principles and Practices" (3rd edition). Prentice-Hall, New Jersey. 662 p.

Herbert, J. 1976: Raising seedlings from seed contained in forest duff. New Zealand Forest Service, Forest Research Institute, Production Forestry Division Indigenous Silviculture Report No. 15 (unpublished).

Herbert, J. 1977: Raising native seedlings contained in forest duff. *Forest and Bird 204* (May): 31–34.

Metcalfe, L. J. 1972: "The Cultivation of New Zealand Trees and Shrubs". A. H. & A. W. Reed, Wellington. 292 p.

Moore, L. B.; Edgar, E. 1970: "Flora of New Zealand" (Vol. II). Government Printer, Wellington. 354 p.

New Zealand Forest Service 1980a: Raising Native Trees. *What's New in Forest Research No. 85.* New Zealand Forest Service, Forest Research Institute, Rotorua.

New Zealand Forest Service 1980b: Establishing nursery-raised native trees. *What's New in Forest Research No. 86.* New Zealand Forest Service, Forest Research Institute, Rotorua.

Ogden, J. 1976: Notes on the influence of drought on the bush remnants of the Manawatu lowlands. *Proceedings of the New Zealand Ecological Society 23*: 92–98.

Platt, G. C. 1979: New Zealand native trees, shrubs and plants: Collection and propagation from the wild. *International Plant Propagators Society, Combined Proceedings 29*: 134–139.

Reid, G. M.; Miller, R. C. 1982: Tree and shrub species suitable for erosion control, honey bees and shelter. *The Tree Crops Journal 7 (2)*: 5–8.

Rennison, G.; MacLeod, D. J. 1981: Native trees and shrubs for parks/reserves planting. Some hints on propagation, planting, tending and growth rates. Information Series No. 8, Department of Lands and Survey, Wellington. 35 p.

Sakai, A.; Wardle, P. 1978: Freezing resistance of New Zealand trees and shrubs. *NZ Journal of Ecology 1*: 51–61.

Salmon, J. T. 1980: "The Native Trees of New Zealand". A. H. & A. W. Reed, Wellington. 384 p.

Simpson, M. J. A. 1976: Seeds, seed ripening, germination and viability in some species of *Hebe*. *Proceedings of the New Zealand Ecological Society 23*: 99–108.

Summers, A. E. 1980: Grow your own native seedlings. *New Zealand Tree Grower 1 (3)*: 7.

Wardle, P. 1980: Primary succession in Westland National Park and its vicinity, New Zealand. *NZ Journal of Botany 18*: 221–232.

APPENDIX: NEW ZEALAND NATIVE PLANTS FOR SOIL CONSERVATION.

Many of the species listed are also suitable and recommended for general revegetation and for restoration of disturbed or depleted vegetation before erosion of any type gets a start. The information presented here should be read in conjunction with the information given under "Species Descriptions". A glossary of symbols and abbreviations appears at the end of the table.

Species	Erosion Type to be Controlled or Prevented	Successional Status	Growth Form and Height		Environmental Tolerances				
					Salt Spray	Wind	Drought	Frost	Waterlogging
TREES AND SHRUBS									
Aristotelia serrata	ShR (Sc) G	S_1	ST	9m	low	mod.	low	high	mod.
Brachyglottis repanda	ShR W (Sb)	S_1 S_2	sST	7m	mod.	mod.	mod.	mod.	low
Carmichaelia spp.	ShR	P S_1	S	2m	low	low-high	mod.-high	(high)	low
Cassinia fulvida	Shr W_c (G) sand dunes	P S_1	S	2m	mod.	mod.	(high)	high	low
C. leptophylla	ShR (G)	(P) S_1	S	5m	mod.	mod.	(high)	mod.	low
C. vauvilliersii	ShR (G)	S_1 S_2	S	2m	mod.	mod.	mod.	high	low
Coprosma acerosa	ShR W sand dunes	S_1	(p)S	2m	mod.	mod.	mod.	mod.	high
C. lucida	ShR	S_2 L	ST	6m	mod.	mod.	low	mod.	mod.
C. parviflora	ShR	S_1 S_2	ST	5m	low	mod.	mod.	high	low
C. propinqua	ShR	S_1 S_2	ST	7m	low	mod.	mod.	high	mod.
C. repens	W_c ShR	S_1 S_2	ST	8m	high	high	mod.	mod.	low
C. robusta	ShR (W)	S_1 S_2	ST	6m	mod.	mod.	mod.	mod.	mod.
Cordyline australis	W (M) (G)	S_2 L	T	5-13m	mod.	high	mod.	high	high
Coriaria arborea	ShR G	P S_1	S	6m	low	mod.	mod.	mod.	low
C. plumosa	ShR	S_1	pS	0.5m	low	mod.	low	mod.	low
C. sarmentosa	ShR	S_1	S	1m	low	mod.	low	mod.	low
Corokia buddleioides	ShR W (G)	S_1 S_2	sS	4m	mod.	high	mod.	mod.	low
C. cotoneaster	W (ShR) (G)	S_1 S_2	dS	3m	mod.	high	mod.	high	low
C. x *virgata*	W ShR (G)	S_1 S_2	S	2-4m	mod.	high	mod.	(high)	low
Corynocarpus laevigatus	W_c	S_2 L	T	16m	high	high	mod.	low	low
Dacrycarpus dacrydioides	(W) (M)	(S_1) S_2	T	25-50m	low	mod.	mod.	mod.	high
Dodonaea viscosa	W_c ShR G sand dunes	S_1 S_2 L	sST	7m	high	high	high	mod.	low
Fuchsia excorticata	ShR W Sc	S_1 S_2	sT	12m	low	mod.	low	mod.	mod.
Griselinia littoralis	W_c ShR	S_1 S_2	sT	10-15m	high	high	low	high	mod.
Hebe elliptica	W_c (ShR)	S_1 S_2	sS	5m	high	high	low	mod.	low
H. odora	ShR	S_1 S_2	sS	1-2m	low	high	low	high	mod.
H. salicifolia	ShR	(P) S_1 S_2	sS	5m	low	mod.	mod.	high	low
H. stricta	ShR	(P) S_1 S_2	sS	4m	mod.	mod.	mod.	mod.	low
Hoheria angustifolia	W (ShR)	S_2 L	T	10m	low	mod.	low	mod.	mod.
H. glabrata	ShR (W)	(S_1) S_2	T	10m	low	mod.	low	high	mod.
H. lyallii	ShR (W)	(S_1) S_2	ST	6m	low	mod.	mod.	high	low
H. populnea	W (ShR)	(S_1) S_2	T	10m	low	mod.	mod.	mod.	mod.
H. sexstylosa	W (ShR)	S_2	ST	8m	low	mod.	mod.	mod.	mod.
Knightia excelsa	W	S_2 L	T	20-30m	low	mod.	mod.	mod.	low
Leptospermum ericoides	ShR G W	P S_1 S_2	ST	15m	low	mod.	high	high	mod.
L. scoparium	ShR G (W)	P S_1 S_2	S	5m	mod.	mod.	(high)	high	(high)
Melicytus ramiflorus	ShR G	S_2	sT	10m	low	mod.	mod.	mod.	mod.
Metrosideros excelsa	W_c ShR G	S_1 S_2	sT	10-20m	high	high	mod.	low	low
M. robusta	W_c (ShR)	S_2 L	sT	15-25m	low	mod.	mod.	mod.	low

M. umbellata	ShR	S_2 L	sT	15m	high	high	low	mod.	low
Myoporum laetum	W_c ShR	S_2 L	ST	10m	high	high	mod.	mod.	low
Nothofagus fusca	W ShR	S_2 L	T	25–30m	low	mod.	mod.	high	mod.
N. menziesii	ShR	S_2 L	(s) T	20–30m	low	mod.	mod.	high	mod.
N. solandri var. *solandri*	ShR	S_2 L	T	25m	low	high	(high)	high	mod.
N. solandri var. *cliffortioides*	ShR	S_2 L	(s) T	15m	low	mod.	(high)	high	mod.
N. truncata	ShR	S_2 L	T	25–30m	low	mod.	mod.	high	mod.
Olearia albida	W	S_1 S_2	ST	5m	mod.	high	high	mod.	low
O. avicenniaefolia	ShR (G)	S_1 S_2	sST	6m	low	high	mod.	high	low
O. paniculata	W_c	S_1 S_2	ST	7m	high	mod.	mod.	high	low
O. traversii	W_c	S_1 S_2	ST	10m	high	high	mod.	mod.	low
O. virgata var. *lineata*	ShR (W)	S_1 S_2	ST	5m	low	mod.	high	high	low
Pittosporum colensoi	ShR (W)	S_1 S_2	ST	10m	low	mod.	mod.	high	mod.
P. crassifolium	W_c ShR	S_1 S_2	ST	9m	high	high	mod.	mod.	low
P. eugenioides	W ShR	S_1 S_2	ST	12m	low	mod.	low	mod.	mod.
P. ralphii	W_c ShR	S_1 S_2	ST	6m	high	high	mod.	mod.	low
P. tenuifolium	ShR	S_1 S_2	ST	10m	low	mod.	mod.	high	low
Plagianthus betulinus	W	S_2 L	(s) T	10–15m	low	mod.	mod.	mod.	mod.
P. divaricatus	W_c estuarine	S_1 S_2	S	2m	high	high	mod.	(mod.)	high (saline)
Podocarpus totara	W ShR	(S_1) S_2 L	T	10–30m	low	mod.	mod.	high	mod.
P. hallii	W ShR	S_2 L	T	10–20m	low	mod.	(high)	high	mod.
Pomaderris apetala	W	S_1 S_2	ST	5m	mod.	mod.	mod.	mod.	low
Pseudopanax arboreus	ShR (W)	(S_1) S_2	ST	8m	low	mod.	mod.	mod.	low
Schefflera digitata	ShR	S_1 S_2 L	S	8m	low	low	low	mod.	mod.
Senecio bidwillii	ShR	S_1 S_2	S	1m	low	high	low	high	mod.
S. elaeagnifolius	ShR	S_1 S_2	sS	3m	low	mod.	mod.	high	mod.
S. huntii	W	S_1 S_2	sST	6m	mod.	mod.	low	low	mod.
S. reinoldii	W_c	S_1	ST	6m	high	high	low	mod.	low
Sophora microphylla	ShR (Sb) (W)	S_2 L	dT	10m	low	mod.	mod.	high	mod.
S. tetraptera	ShR (Sb) (W)	S_2 L	T	12m	low	mod.	mod.	high	low
Weinmannia racemosa	ShR W_c	S_1 S_2 L	sT	25m	low	mod.	mod.	mod.	mod.
GRASSES AND HERBS									
Acaena spp.	ShR	S_1	Hc	0.2m	low (some mod.)	mod.	low (some mod.)	mod. (some high)	low–mod.
Chionochloa spp.	ShR W	S_2 L	Gt	0.2–2m	low	high	low–mod.	high	low–mod. (C. rubra high)
Cortaderia spp.	ShR W_c Sb G	(P) S_1 S_2	Gt	2.5m	mod. (some high)	high	mod.	mod.	mod. (C. toetoe high)
Gahnia spp.	ShR	S_1 S_2	Gt	1–1.5m	low	mod.	low	mod. (G. procera high	mod.
Festuca novae-zelandiae	(ShR) W	S_2 L	Gt	0.5m	low	high	high	high	low
Rytidosperma setifolium	(ShR) W	S_1 S_2 L	Gt	0.4m	low	high	mod.	high	low
Phormium cookianum	ShR G Sb	S_1 S_2 L	Ht	1–2m	high	high	mod.	high	high
P. tenax	W_c ShR G Sb	S_1 S_2 L	Ht	2–3m	high	high	mod.	high	high
Poa laevis	ShR W	S_2 L	Gt	0.4m	low	high	high	high	mod.
Pratia angulata	ShR	S_1 S_2	Hc	0.1m	mod.	low	low	mod.	high

GLOSSARY OF SYMBOLS

EROSION TYPE

ShR	sheet and rill erosion; see also M (mass movement)
W	wind erosion, subscript 'c' indicates the species is especially suited to coastal situations
Sc	scree creep, mostly in mountain lands
M	mass movement including slips, slumps and flows; most species listed under ShR can help to prevent mass movement but few can be used to check active mass movements or highly unstable surfaces
G	gully erosion
Sb	streambank erosion

SUCCESSIONAL STATUS

P	pioneer or colonizing species, good for planting on bare and often infertile soils or subsoils
S_1	a colonizing species suited to stabilized surfaces and often requiring extra fertilizer on infertile soil. Often suited to planting on slip faces or earthworks and useful as a nurse crop
S_2	successional species requiring a better soil and often some shelter but will provide shelter for other species once established
L	later successional species, often used to complete the landscape effect and, being long-lived, to provide long-term shelter and stability

GROWTH FORM

S	shrub
T	tree, forms a distinct trunk although sometimes short
ST	shrub or small tree
G	grass or sedge
H	herbaceous plant
p	prostrate or low-growing
s	spreading or forming wide canopy
d	divaricating, often only in juvenile stage
t	tussock forming
c	mat or creeping

ENVIRONMENTAL TOLERANCES*

1. Salt spray (wind-borne salt)

low	little or no capacity to withstand salt deposits on leaves
moderate	tolerates some salt on the leaves but will lose vigour rapidly with continual, heavy or frequent deposits of salt
high	tolerates salt laden winds and salt-spray and to some extent salt build-up in the ground water

2. Wind

low	will be damaged by strong winds either by severe desiccation or mechanical damage to leaves and branches
moderate	will tolerate strong winds, even occasional gale force winds, with only minor damage but will not grow well in persistent prevailing winds; species which are not drought hardy will suffer windburn from hot dry winds
high	will tolerate strong to gale force winds with little or no damage and will generally tolerate persistent winds but drought susceptible species will do poorly in hot dry winds

3. Drought

low	may withstands short periods (e.g., a day or two) of mild moisture stress but will rapidly lose vigour or suffer permanent damage under longer periods of moisture stress
moderate	can withstand seasonal droughts providing the soil moisture does not drop below the 'wilting point' for extended periods (e.g., several weeks or more)
high	can withstand prolonged seasonal drought and in some cases semi-arid conditions

4. Frost (winter maximum)

low	generally tender and will be damaged by cold winds or frost of −2 or −3°C
moderate	will tolerate frosts of −3 to −6°C
high	generally considered as frost hardy in most lowland and lower montane districts and will tolerate frost temperature of −7°C or lower

5. Waterlogging

low	will not tolerate roots being in waterlogged soil for more than several days in succession
moderate	will withstand frequent waterlogging but not continual waterlogging for long periods (e.g., more than several weeks)
high	can withstand roots continually in wet or waterlogged soil; growth may be slower but otherwise plants are not affected

( ) Brackets indicate uncertainty or can be read as meaning occasionally.

*Environmental tolerances often vary within a species and with time of year. Tolerances also depend on the growth stage and adaptation or acclimation to a particular environment.

V. R. WARD, GOVERNMENT PRINTER, WELLINGTON, NEW ZEALAND—1986

35521E—86PT