Small Forest Management
5

ESTABLISHING

A SMALL FOREST

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This publication has been jointly prepared by
the Ministry of Forestry and the
New Zealand Forest Research Institute Ltd

Establishing a Small Forest is part of the *Small Forest Management* series, which is intended as a guide for owners and managers of small forests. The *Small Forest Management* series includes:

1. Special Purpose Timber Species
2. Forestry Joint Ventures
3. The Resource Management Act
4. Planning a Small Forest
5. Establishing a Small Forest
6. Managing a Small Forest for Timber
7. Harvesting a Small Forest
8. Marketing a Small Forest

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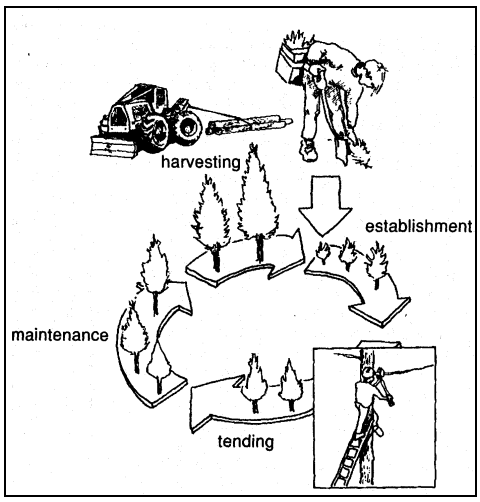
Introduction

"Establishing" a forest is the first part in the forest management cycle (see *figure* 1). Establishment generally starts with confirming site preparation requirements, and finishes when the trees need no more assistance to grow, that is they are free from weed competition, are standing upright and are growing healthily. For example, the end of the establishment phase for radiata pine in New Zealand is usually when the trees are about two years old. The success or otherwise of establishment will impact on the way the forest is subsequently managed, which will, in turn, affect the type and quality of the end product.



1: The forest management cycle

This publication provides information to enable forest owners to successfully establish an area of forest and protect it from weed competition and animal damage until it reaches a "free to grow" state. It assumes the site, species and (in general terms) the end-product have been decided. Subjects such as choosing species or matching species to site are described in *Planning a Small Forest*, and *Special Purpose Timber Species* (also part of this *Small Forest Management* series). Forest management (after the establishment phase) is described in *Managing a Small Forest for Timber* part of this *Small Forest Management* series.

Identifying the Area to be Established

A critical first step in establishing a small forest is deciding how many hectares are to be planted each year. Factors affecting this decision include budget considerations, forest management practices, environmental planning, and planning the spread of income and costs. Other factors include the potential impacts of tree planting on other work on the property, and the labour requirements if the grower is thinking about a "do it yourself" approach (such as incorporating a small forest into an existing farming operation).

BUDGETING

Successful forest growing should be affordable in the short and long term. Forest areas should be affordable to establish and forest growers should be confident they will be able to sustain future tending costs.

Establishing an area larger or at a faster rate than can be managed financially may cause problems through trying to reduce costs, leading to poor tree survival and growth. On the other hand, if most of the available money is spent on achieving good quality establishment, a lack of finance for future tending operations may

mean silvicultural operations such as pruning and thinning are not done, or are done late, reducing the final return from the stand[1].

The establishment and silvicultural phases should be considered as one unit when calculating a budget. This allows the forest owner to grow the crop without compromising either phase. As a "rule of thumb" for radiata pine, establishment will make up one third and pruning and thinning two thirds of the total cost of growing a pruned stand through to the end of tending.

MINIMUM SIZE

The benefits of economies of scale in forest management are discussed in *Planning a Small Forest*. Some points important in determining the minimum economic size of an area to plant are:

Woodlots of one hectare can provide good returns when sited on rolling or flat areas next to established roads.

On steep or difficult country, larger forest areas (10 hectares or more) are necessary to enable higher fixed harvesting costs (such as expensive roading and machinery) to be spread over the larger volume.

Smaller areas of high value timber crops may yield more income than extensive forests of low value pulpwood or firewood.

The distance to processing plants or export ports may affect the economic woodlot size. This is more significant when growing lower value crops such as pulpwood. Where distances are short, the reduced transport cost means a greater value per hectare, so smaller (more costly) areas can be harvested.

ENVIRONMENTAL PLANNING

The Resource Management Act 1991 (RMA) plays an important role in the sustainable management of commercial forestry and its environmental effects. The RMA concentrates on avoiding, remedying or mitigating the effects of activities, rather than regulating the activity itself.

Small forest owners will mainly deal with regional and district councils, who have specific responsibilities on resource use and potential environmental effects under the RMA. Councils carry out these responsibilities using policy statements and plans, which describe what the councils want to achieve and their methods of achieving it, for example through performance standards.

In some districts and regions, forest projects are subject to controls that may affect commercial tree planting. Varying degrees of controls and prescriptive requirements may restrict the profitability of a project.

A number of major environmental issues are often associated with forestry. *The Resource Management Act,* part of this *Small Forest Management* series gives a brief assessment of the environmental effects of each issue, followed by an outline of some suggested actions that small forest growers can take to address that particular issue.

When planning to plant an area of production forest or to purchase land for that purpose (certainly before any trees are planted), forest owners should contact their local district and regional council planning departments to check the requirements of the district and regional plans. This will identify any effects the councils consider undesirable, outline the steps to take to avoid those effects, and stop the small forest grower from doing anything contrary to the council's plans.

[1] A stand is an area of forest, normally of similar age and the same species that has the same management applied throughout. It can be considered a single management unit in the forest. Small forests of less than 10 hectares are often made up of a single stand. Larger forest areas may be made up of a large number of different stands.

District councils will mainly be interested in the effects of the development and use of the land (such as shading and visual effects), the services that use may require (eg, roading) and if there are any subdivision activities. *Regional* councils will be interested in issues relating to the quality of water and air, soil conservation, cover issues relating to the quality of water and air, soil conservation, natural hazards (eg, floods), and the sea coast.

PLANNING AN INCOME STREAM

It is possible to plant trees in stages, to spread costs and establish a forest capable of providing regular, ongoing income. Some forest owners may wish to establish a forest with similar areas of each age (or age-class) between planting and the final harvesting age (also called the rotation age). For example, an owner with 50 hectares available for planting may grow radiata pine on a 25 year rotation, planting two hectares every year for 25 years. At the end of the 25 years, two hectares could be harvested every year in perpetuity (providing the harvested area is immediately replanted).

While a forest with one year age classes (as described above) may be the ideal, staggering planting offers similar advantages. For example, an owner may plant five hectares initially, then 10 hectares two years later, then four hectares in another two years time, and so on. Harvesting times can also be staggered to take advantage of short term market fluctuations and/or to "smooth" income. This is discussed in more detail in *Harvesting a Small Forest*, part of this *Small Forest Management* series.

PLANNING FOR HARVESTING

While harvesting techniques may change over the length of the rotation, it is prudent to only plant land that has a reasonable chance of being economically harvested using current methods.

For example, the harvesting equipment will influence the location of roads used during harvesting, and this should be considered when planning access tracks and roads that will be used during tree planting. These tracks, if sited correctly, can be gradually upgraded (eg, for tending) and eventually formed into roads for trucking harvested produce from the site.

Roads or tracks which are built at the time of establishment should be of a minimum standard sufficient to meet the purpose, as the costs will have to be "carried" through to harvest time.

If more than one tree species is being planted, their locations relative to their likely rotation lengths and harvesting methods should be considered. For example, if a slower growing species is planted between a faster growing one and a road, when it is time to harvest the faster growing species, logs will have to be extracted through the slower species. This could damage the slower crop. Alternatively, if the faster crop is between the road and the slower crop, and the faster crop is harvested and restocked, the slower crop would subsequently have to be hauled across the young trees. If this "two crop" scenario cannot be avoided, access corridors should be allowed for when planting.

Site Preparation

Site preparation readies the land for tree planting, to enable successful establishment and the subsequent management of the trees. Some degree of preparation is usually required, whether the land is being planted in trees for the first time (called new planting or afforestation) or a previous tree crop is being replaced after harvesting (usually called restocking[2])

[2] Some people refer to restocking as "replanting". However, replanting usually means replacing an area of young trees that have failed.

Site preparation methods aim to either improve the soil or manage the vegetation, with the objective of improving subsequent tree growth. Appropriate and well-executed site preparation is a very important aspect of forest establishment and can contribute greatly to the success of a forestry project.

Good site preparation will help:

- the planting stock to survive
- reduce planting costs by allowing the planters easier access across the site (by reducing hindrances such as undergrowth)
- reduce the need for weed control after planting
- rapid early tree growth, so that trees will quickly be free from significant weed competition
- reduce pruning, thinning and other management costs by providing easier access
- ensure a more uniform crop (in tree size)
- reduce the risk of fire during, and for some years after, the establishment phase, by reducing the amount of fuel left on the ground.

However, site preparation should not be done as an alternative to species selection. For example, spending large sums of money making a wet site suitable for a species intolerant of poor drainage can be more expensive and less successful than choosing a species more appropriate for a wet site.

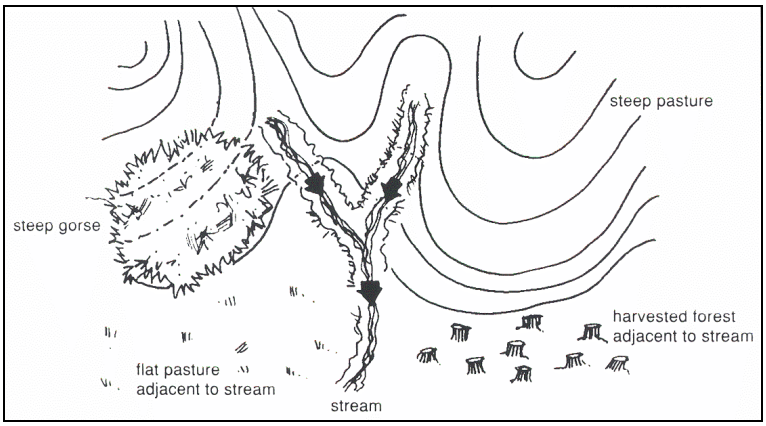
To maximise the potential benefits it is necessary to plan ahead by identifying site preparation requirements, examining available methods, then selecting the most appropriate one(s).

PLANNING

The type of site preparation required will vary for individual forest properties and may also vary within a property. Physical factors such as steep topography and off-site factors such as legislative requirements, may affect site preparation.

Areas that require similar treatment (such as removing scrub weeds) and have similar limitations (such as steep slopes) should be identified. The most appropriate mix of site preparation methods can then be selected and applied to these "site preparation units".

To identify site preparation units, site preparation requirements and restrictions on the property can be mapped. This uses a recent aerial photograph of the property or a map drawn from it, on which, for example, areas of scrub weeds (such as gorse), pasture, steep slopes and flats can be marked, and areas with the same requirements and/or restrictions identified. *Figure 2* shows an example of a map produced under this process.



2: A Map of site preparation units" requiring the same treatment

SITE FACTORS

The following site factors should be considered when planning site preparation requirements.

Vegetation

An important part of site preparation is reducing subsequent competition between weeds and trees, as weeds may completely smother and kill trees. If the trees survive this, two or three years' growth may be lost. It is better to control weeds before tree planting, as there are fewer choices of methods once the trees are planted. Weed control methods (also called "vegetation management") depend on the vegetation - for example, pasture will require little preparation compared with gorse.

Action Classify the vegetation into broad classes that can be treated similarly. For example:

- pasture
- broom/gorse
- bracken/blackberry
- indigenous scrub hardwood
- recently harvested forest.

Soil

Soil features such as hard sub-surface pans[3] can reduce tree growth and increase the risk of trees being blown over (called "wind throw" or "toppling"). Site preparation varies with the particular soil problem. For example, soils with a hard pan below the surface (which impedes root growth and drainage) may need to be ripped (see *Rippers* on page 22) before planting to shatter the pan. Eroding soils may need to be stabilised in some way before planting starts. For example, coastal sand dunes may need to be stabilised by planting marram grass, and then oversowing with a legume. (Lupins were used until the incidence of lupin dieback greatly reduced their viability. Other legumes, such as Maku lotus, are alternatives).

Action Identify any soils that:

- have a hard sub-surface pan (by using a steel probe that can be pushed into the soil to test if there is a hard pan)
- have drainage problems (by observing drainage patterns and surface water flows)
- are currently unstable.

Site preparation techniques that could result in significant soil disturbance may not be appropriate for unstable soils, particularly on steep slopes.

Action Identify areas with erosion-prone soil types.

Frost

Frost can be a problem for young trees on flat areas where cold air settles. Removing surface vegetation (as part of site preparation) can sometimes allow the soil to absorb heat from the sun during the day and release it at night. This may raise the temperature around the planted trees enough to reduce frost damage. Mounding the soil where the tree is to be planted can raise the tree above the coldest air at the soil surface.

Action Identify any "frost flat" areas.

Animals

Domestic stock and feral animal pests such as goats, possums, hares and rabbits can severely damage young trees. Site preparation should include fencing planted areas to exclude domestic stock, and controlling feral animal populations before planting.

[3] A hard pan is an impermeable layer, usually caused by chemical reaction rather than physical compaction, which can be anything from a few centimetres to several metres below the surface. It is often only a few centimetres thick and can be broken with suitable machinery.

Action Identify:
- areas requiring fencing
- areas with populations of pests such as goats, rabbits, hares and possums.

Species Choice
Site preparation should be designed to meet the requirements of the particular tree species. For example, some semi-shade-tolerant species such as Australian blackwood (*Acacia melanoxylon*) grow well when planted in lines or gaps cut through slower growing vegetation such as manuka. Eucalypts and many other hardwood species are sensitive to herbicide sprays, so when planting in pasture a pre-plant spot spray is often better than post-plant releasing[4]. Areas of pasture planted in radiata pine may need no site preparation, with a post-plant release spray providing sufficient weed control.

Action From the planting plan, identify the areas where different species will be planted.

Access
Access is important for planting and later operations such as releasing, pruning, thinning and fire control. Four-wheel-drive access should be available into, and ideally across at least part of, the property.

Action Identify areas requiring tracking to provide a minimum of four-wheel-drive access.

Topography
Topography may restrict the type of site preparation. On steep terrain of more than about 20 degrees, machine access is more difficult, limiting the use of some mechanical techniques (see *Site Preparation Methods* on page 17).

Action Identify areas of the property where slopes are too steep for machine access (usually more than 20 degrees).

Adjacent Land Uses
Potential effects of land preparation operations on adjacent land uses may prescribe the methods that can be used. For example if there are adjacent horticultural properties, aerial spraying of herbicides will require extra planning and supervision. The presence of adjacent forests may limit the use of fire as a land preparation tool. Properties adjacent to urban areas are likely to be restricted in the use of methods such as burning and aerial spraying.

Action Identify the different land uses neighbouring the property, including:
- forestry (including indigenous forests and reserves)
- pastoral farming
- horticulture
- cropping
- urban.

Size
Mechanical site preparation methods will be expensive on small areas (usually less than 10 hectares) owing to the costs of transporting machinery to the site. This may restrict the use of mechanical methods to larger areas.

Action Identify large and small site preparation units.

Resource Management Act
Site preparation operations may be subjected to some controls by a district or regional council. For example, a *district* plan may prescribe how close to a road trees can be planted. The effects of forestry are

[4] Releasing is the term given to freeing ("releasing") young trees from weed competition.

often covered by more than one *regional* plan. *Table 3* is a guide to navigating the (sometimes) complex array of regional council plans that may need to be consulted before carrying out site preparation. For example, if planning a herbicide weeding operation, the table indicates the small forest grower should check the regional plans relative to water and to air

3: Site Preparation and Regional Plans

Operation	Which regional plans to check		
	Soil	Water	Air
ACCESS			
Stream Crossings	X	X	
Access roading and tracking	X	X	
LAND PREPARATION			
Herbicide spraying		X	X
Oversowing	X	X	
Vegetation clearance	X	X	
Tracking	X	X	
Ripping and other mechanical preparation	X	X	
Firebreaking	X	X	
Burning			X
Grazing (before planting)		X	

The Resource Management Act publication lists environmental issues which could be associated with site preparation. It gives a brief assessment of the environmental effects of each issue, and some suggested actions to address that particular issue.

Action

- Use the planning process described in *The Resource Management Act* to identify any resource issues.
- Consult with district and regional councils at an early stage in the site preparation planning process, to discuss requirements and plan for any resource consents which may be required.

New Zealand Forest Code of Practice

The New Zealand forest industry has developed the *New Zealand Forest Code of Practice.* This is used by the forest industry as a guide to forestry planning and practice (including site preparation).

Action

- Identify any values that may be affected by a proposed operation, by following the steps described in the environmental section of the Code.
- With the help of the *Code*, identify operations that may affect those values. Choose the operation technique with the lowest impact (within reasonable costs).
- Check the compliance of the selected operation technique under relevant district or regional plans and obtain resource consents if necessary.

A copy of the Code can be obtained from the Logging Industry Research Organisation (LIRO) (see *Where to Go For Help*).

New Zealand Forest Accord

The *New Zealand Forest Accord* is an agreement signed by environmental groups and some forest owners. One of its main purposes is to limit the clearance of indigenous vegetation when establishing planted production forests. Forest owners who are signatories to the *Accord* undertake to exclude from clearance or disturbance any area of five hectares or greater, or to protect areas of less than five hectares where practical, with a predominance of naturally occurring indigenous tree species. This includes any species which naturally form part of the canopy in the area or attain a diameter at breast height (DBH) of 30 centimetres or greater.

The *Principles For Commercial Plantation Forest Management* is complementary to the Forest Accord and have also been signed by some forest owners and environmental groups. Copies of both documents can be obtained from the New Zealand Forest Owners' Association (see *Where to Go For Help*).

The principles embodied in both of these environmental documents should be followed by all forest owners.

SITE PREPARATION METHODS

The method(s) of site preparation will depend on the above site factors, but will usually involve one or more of the following techniques.

Pre-plant Grazing

Using animals to control unwanted plants by grazing before tree planting can be a very cost-effective method of "biological weed management". For example, cattle can control pampas grass, and goats can control blackberry and gorse. However, good stock management skills are a pre-requisite, with issues of animal welfare as well as weed control. Forest owners will need to plan for expenditure on water supply (if suitable natural sources are not available) and fence maintenance. Fences may be needed within the site preparation area for rotational grazing, and certainly on the perimeter to prevent stock from straying, or re-entering the site after tree planting.

Heavy grazing of pasture should be allowed until the day of planting. This will greatly assist post-plant weed control, which may be reduced to one herbicide release spray a couple of months after planting. However, it should be noted that on very fertile ex-farm sites, grass growth may be vigorous enough to require a second release in late summer or autumn. Also, herbicides for grass control should not be applied immediately after very heavy grazing, as the vegetation needs to be at least 5 to 10 centimetres long to allow good herbicide absorption.

Herbicide

The choice of herbicide (or their use at all), depends on factors such as:

- weed species
- the post-planting risk to the trees if weeds are not controlled
- the tree species to be planted - some are more tolerant of some herbicides than others, so the decision could be made after planting
- timing of spraying - some weeds are managed more easily if sprayed at a certain growth stage. However, if sprayed too early they may regrow, meaning a second spraying could be necessary.

The use of herbicides is described in more detail in the section *Herbicides in Forest Establishment* on page 60.

Preparation by Hand

Using hand equipment such as chainsaws, motorised brushsaws or slashers to cut lines in, or completely clear, areas of vegetation, is slow and labour intensive, and can be the most expensive method of site preparation. However, hand cutting may be suitable for small areas where machines are impractical (owing to cost or where access is difficult), or for particularly sensitive areas where other methods would be inappropriate (such as close to a vineyard, where hand cutting could be more prudent than using herbicides).

Burning

Until the late 1980s, fire was used extensively in New Zealand as a site preparation tool for forestry. However, it is used much less now, mainly because of: improved harvesting techniques, resulting in less debris for burning; public feeling against the smoke levels generated by a fire; RMA issues associated with

air pollution; loss of nutrients from the site (soil nutrients can be volatilised by the heat); and the fact that lighting a forest fire is a risky operation.

Fire has, and will probably continue to have, a place in New Zealand forestry, but it should always be evaluated alongside other methods, be thoroughly planned by a trained and experienced professional, and will generally be limited to harvested sites with a lot of heavy debris.

Where it is used, burning is generally combined with other site preparation methods such as crushing and/or herbicide spraying. While it can be an effective way of controlling weeds and clearing a site, the need to use the other methods in conjunction with burning can make the overall operation expensive. A lot of skill is required in ensuring that a burn is carried out safely and with a good result. It is a job for trained and experienced professionals, and should not be undertaken if there is any risk of damage to surrounding property.

When using fire, the vegetation is usually crushed and/or sprayed with herbicide well in advance to allow time for it to dry. The fire can be lit by hand if the area is small, or by helicopters fitted with special fire lighting equipment on larger areas.

The use of fire as a site preparation tool is governed by the Forest and Rural Fires Act 1977. The Act established rural fire authorities, which are required to have operative fire plans. Rural fire authorities can prohibit lighting fires in the open air during times of extreme fire danger and restrict activities in areas of risk. When these restriction are in place, permits are required from the fire authority for fires in the open air. The rural fire authority can prescribe the equipment required and establish guidelines for protecting forest areas registered with them. Rural fire authorities are usually part of district council functions.

Oversowing

Oversowing with grasses and other herbaceous species can be useful after harvesting a tree crop or clearing of woody weeds. The grass can rapidly establish and prevent other weeds from growing, then be controlled relatively easily by spot spraying.

A common method is to mix the seed (often made up of ryegrass and Maku lotus) with fertiliser and sow it using a helicopter fitted with a seed-sowing bucket. The grasses and herbs need disturbed soil to achieve the best germination, which is why it is more successful on harvested sites. Maku lotus has the added benefit (like clover) of making nitrogen available for tree growth.

Sowing is usually done in the autumn before tree planting. However, because of local variations, advice should be sought from a forestry consultant. If the forest is to be grazed[5] after establishment, oversowing could fill a multi-purpose role by also supplying a source of stock feed.

Oversowing in areas prone to heavy frosts (such as frost flats) prevents soil warming during the day and slows down cold air drainage during the night. This may increase frost damage to trees. In these areas, large (1.5 metre) spots around the trees will need be kept free of grasses after tree planting by spot spraying with herbicides.

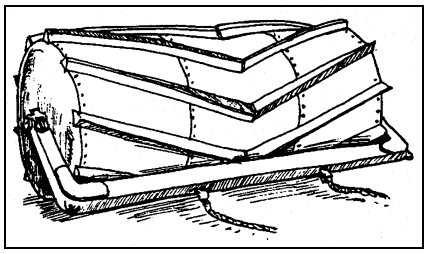
Mechanical Preparation

Mechanical site preparation is usually only cost effective on areas larger than 10 hectares (because of the cost of transporting machinery to the site). It involves either managing vegetation on the site (by crushing it or moving it), or improving soil conditions, or both. Methods of mechanical site preparation follow.

Roller crushing: A large roller weighing several tonnes is released down a slope from a ridge or track, breaking up vegetation in its path. The roller is then winched back up and the process repeated. On flatter

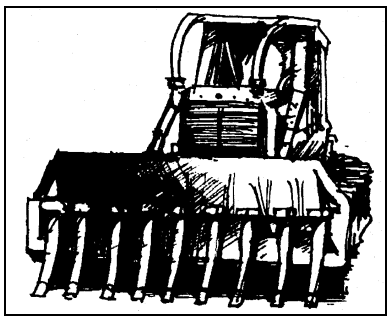
[5] Forest grazing means having farm stock (particularly sheep or cattle) graze among the young trees, particularly in the post-establishment phase (after about age two to three years for radiata pine, depending on the type of animals).

country rollers can be towed by a bulldozer or tractor. Scrub weeds up to 30 centimetres diameter and six metres tall can be chopped to a mulch with this technique and the trees planted through it. Larger scrub may need to be burnt after crushing to remove some of its bulk before tree planting.



4: Larger roller used to chop woody vegetation

Root raking: Root raking can be used to clear planting lines, for example in situations where there are large amounts of debris (called "slash") following harvesting. In its simplest form, a rootrake is a bulldozer blade with the bottom part of the solid blade replaced with teeth or prongs. Instead of topsoil being removed when the machine pushes vegetation, stumps and roots aside (as with a solid blade), the "rake" leaves the soil behind. Root rakes mounted on excavators can also be used, with the "teeth" being on the excavator bucket. Their long reach reduces machine movement, which helps to reduce the amount of soil compaction caused by the machine.



5: Root Rake

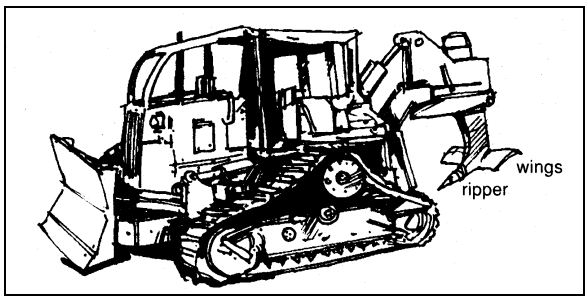
V-Blading: This refers to using a bulldozer and blade to push cleared lines through standing vegetation or harvest debris. The blade, in the shape of a "V", pushes the vegetation to either side of the "V" (a straight blade is inefficient because the bulldozer has to keep backing up to clear accumulated rubbish). V-Blading must be done carefully to minimise removal of topsoil and in most cases, a root rake is preferable. Care should be taken with V-blading to ensure that the bladed path will not channel surface water down a slope, causing topsoil erosion.

Rotary Slash: Rotary slashers used in forestry site preparation are generally heavy duty versions of those used in agriculture, and are used to cut lines in standing vegetation. Trees can then be planted in the cut lines. This is not a widely used option because of slope limitations and the fact that vegetation usually regrows after slashing, requiring further treatment.

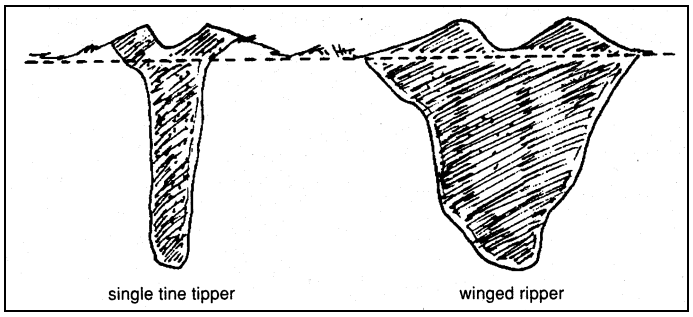
Discs and rotary hoes: These can be used to cultivate surface soil on areas with easy terrain such as frost flats (see *Frost Reduction* on page 13). Discs are heavy duty versions of agricultural discs, while rotary hoes are several cutting knives bolted on a rotating horizontal shaft. Their use is limited by topography and they are not very efficient in dense vegetation.

Rippers: Rippers can be used to shatter heavy soils and/or break sub-surface pans to improve drainage and tree root penetration. A winged ripper (a long steel shank with wings attached to the base - see *figure 6*) provides a much greater shatter zone than single tine rock rippers (see *figure 7*). A winged ripper is mounted on the tool bar of a crawler tractor and pulled through the ground at a depth of 60 centimetres or

more (so the tractor needs sufficient horsepower to achieve this). Heavy clay soils should be dry when cultivated to get the full shattering effect.



6: Winged ripper



7: Comparison of shatter zones

Ripper mounder: This is a winged ripper followed by two offset disc gangs, all mounted on the tool bar of the same crawler tractor. The offset discs pull the soil up into a mound over the ripped line, which provides a planting site for the trees. On some sites such as podsilised clays, this method can result in better tree growth than ripping alone, or discing alone. It has advantages on frost flats or wet areas as the mound raises the trees above the coldest temperatures at the soil surface, or out of the waterlogged soil.

Spot ripper mounders fitted onto excavators can rip, cultivate and mound a small area of soil sufficient to plant a tree in (a "spot") in a single action. They are useful on slopes too steep for tractors (excavators can work more safely on these slopes), can be more economical and cause less unnecessary soil disturbance or compaction.

SELECTING APPROPRIATE METHODS

Given the property's site preparation units and a knowledge of the available site preparation methods, the most appropriate site preparation method(s) can be selected for each unit. The checklist below, and *tables 8* and *9* may help this process.

1. Is any site preparation required? If, for example, the site preparation unit comprises pasture with no major soil problems, has relatively good access, is effectively fenced, and is to be planted in radiata pine, site preparation may not be needed. In this case weed control by a release spray after planting will often be adequate.

2. What are the objectives of carrying out site preparation? These could include, for example, providing a reasonably clear site with adequate access to assist tree planting operations and subsequent vegetation management, or to carry out drainage work. Defining objectives helps concentrate the planning process on work that needs doing.

3. What is the best site preparation? Using the requirements and restrictions affecting the site preparation unit (see *Planning* on page 11), refer to *tables 8* and *9* to select the best combination of site preparation methods which will achieve the best result in relation to the objectives.

4. Is the cost of site preparation justified? Once the best site preparation methods have been selected, consider if it is worth preparing the particular unit or if it is better left unplanted. Site preparation can be an expensive operation particularly if there is established woody vegetation such as gorse present. A high cost early in the rotation can reduce the economic return of the project. High cost site preparation operations should be considered carefully, it may be possible to buy good clear land for less than the cost of preparing difficult land.

5. Check the chosen method for its off-site effects by referring to *table 9* and the *Forest Code of Practice* process, described on page 16.

6. Check for any regional and district council requirements under their policies and plans (see *Resource Management Act* on page 15).

7. Be prepared to review the selection of site preparation method(s) if any of points three to six above indicate that the chosen method should not proceed.

8: Requirements Met by Different Site Preparation Methods

Site Preparation Method		Veg Size Class	Rel-ative Cost	Vegetation Management								Soil Problem				Frost
Type	Method			Pasture	Bracken	Gorse	Broom	Native Hardwood	Buddleia	Pampas	Harvested Forest	Hard Pan	Compacted Surface	Poor Drainage	Unstable Soil	
Mechanical	Roller Crush (RC)	(i) (ii)	H			** AS	** AS	** RR			** RR					
		(iii)	H			*** B, RR	*** B, RR	*** B, RR			***					
	Root Rake (RR)	(i) (ii)	M			*	*				**					
	V Blade (VB)	(i) (ii)	M								*			*		*
	Line Doze (LD)	(i) (ii)	M					*			*					
	Rotary Slash (RS)	(i)	M					*								
	Disc & Rotary Hoe (D)	(i)	M										**			**
	Ripper (R)	(i)	M									*** 1	*** 1	*** 1, 2		
	Ripper Mounder (RM)	(i)	M									*** 1	*** 1	*** 1, 2		***
Chemical	Aerial Spray (AS)	(i) (ii)	L-M		** RC,RR	** RC	** RC	** RC	**	**						**
	Spot Spray (SS)	(i) (ii)	L	*** 3	* 4	* 4										
	Target Spray (TS)	(i) (ii) (iii)	L		** 5	*** 5	*** 5		*** 5	*** 5						

Hand	Line Cut (LC)	(i) (ii) (iii)	H			*	*	**	*							
	Clear fell (C)	(i) (ii) (iii)	H			* B	* B	* B								
Burn	Burn (B)		L			** AS,RC	** AS,RC	** AS,RC			*					
Biological	Oversow (O)		L-M			*** AS, RC +B	** AS, RC+B	** AS, RC+B	*** AS	*** AS	***				***	
	Graze (G)		L	**		* 6				**						


est-veg.xls

LEGEND FOR TABLE 8

Vegetation Size Classes:

(i) Light: <= 10 cm diameter
(ii) Medium: <= 100 stems per hectare of 25 centimetres or over
(iii) Heavy: >100 stems per hectare over 25 centimetres diameter

Relative Cost:

L under $150 per hectare
M $150-$500 per hectare
H $500-$1000 per hectare

Notes:

1. On harvested forest or other areas with heavy slash a light rake may be necessary first.
2. Can improve drainage if there is an impervious pan that can be shattered by the ripper.
3. Generally only used for tree species sensitive to herbicides. A post-plant release spray is preferable for resistant species such as radiata pine.
4. Only useful where there are small seedling weeds, such as after an aerial spray and burn
5. Can be used where there are scattered weed plants. May be undertaken from the ground or helicopter if the area is large.
6. Only suitable on low gorse up to about one metre in height.

*** or ** or ***** Site preparation methods are rated in terms of their suitability and effectiveness in meeting a particular requirement. One star implies low suitability, three stars implies high suitability.

Combinations of Different Site Preparation Methods: The initial letters of another method required in conjunction with a particular site preparation method are given with the suitability rating. Where there is more than one other method shown and they are separated by a comma, either method can be used. Where there is more than one other method shown and the second is preceded by a + it must be used in addition to the first. For example AS, RC + B means the method requires aerial spraying or roller crushing and burning.

9: Relative Impacts of Different Site Preparation Methods on Adjacent Land Uses

Site Preparation Method	Slope (degrees)	Soils prone to erosion	Adjacent Land Uses				
			Forestry	Pastoral Farming	Horticulture	Cropping	Urban
		Impact Rating (1 = little; 5 = great) *					
Roller Crush (RC)	>=15	3	1	1	1	1	3
Root Rake (RR)	<=20	3	1	1	1	1	3
V Blade (VB)	<=20	5	1	1	1	1	3
Line Doze (LD)	<=20	5	1	1	1	1	3
Rotary Slash (RS)	<=20	3	1	1	1	1	2
Disc & Rotary Hoe (D)	<=15	5	1	1	1	1	2
Ripper (R)	<=20	3	1	1	1	1	1
Ripper Mounder (RM)	<=20	4	1	1	1	1	1
Spot Ripper Mounder	<=20	2	1	1	1	1	1
Aerial Spray (AS)		2	3	2	5	5	5
Spot Spray (SS)		1	1	1	3	3	3
Target Spray (TS)		1	1	1	3	3	3
Line Cut (LC)		2	1	1	1	1	1
Clear fell (C)		3	1	1	1	1	3
Burn (B)		3	4	2	4	3	5
Oversow (O)		1	1	1	1	1	1
Graze (G)		1	1	1	1	1	1

* Note: These are subjective ratings based on potential negative impact. A rating of 1 implies there is little adverse impact while a rating of 5 implies a potentially devastating impact that will exclude or require very careful use of the method.

DIFFICULT WEEDS

Weeds such as gorse, broom, bracken, blackberry, barberry, pampas, buddleia, and Himalayan honeysuckle must be thoroughly controlled before planting. Even if they cannot be eliminated, they must be knocked back at least sufficiently to allow trees to be planted and dominate the regrowth. These weeds often grow after harvesting and if left untreated can cause problems for the next crop.

Gorse and broom can be treated before planting with brush-weed herbicides such as Escort and Trounce[6] herbicides. Other weed species can also be treated before planting with a number of specialist brush-weed herbicides. Forest growers should seek specialist advice from the New Zealand Forest Research Institute Ltd (NZFRI), forestry consultants or herbicide manufacturers' representatives.

Selecting the Planting Stock

Choosing the correct tree species to match property conditions is described in *Planning a Small Forest* and *Special Purpose Timber Species*. Once the species has been chosen, the next task is to obtain the best young trees or "planting stock". This involves choosing the seed source as well as the type of planting stock.

Planting stock has two basic types; "seedlings", which are grown from seed; and "cuttings", which includes true cuttings and stock reproduced by other vegetative methods. Planting stock is the collective name for seedlings and cuttings. Seedlings are grown in a nursery and planted in a forest after one or two years. Cuttings are small pieces taken from a parent tree (often young shoots), put into a nursery bed to develop roots, and then planted in a forest.

[6] Throughout this publication, where common brand names are used, it is for ease of identification. This does not imply a recommendation.

SEED SOURCE

Small forest growers are generally more likely to buy "ready-to-plant" planting stock from a tree nursery. However, some may wish to grow their own seedlings from seed.

The seed source of a tree seedling determines its potential to develop basic features such as rapid growth, large size and a straight stem. The tree is then shaped by the environment in which it is planted to give its final adult character. For example, planting stock from a seed source with excellent stem straightness is unlikely to end up as a straight tree at harvest if it is planted on a wind-exposed ridge.

Seed may be collected from natural stands in the country of origin, from unimproved planted stands, from plantations that have resulted from some degree of genetic improvement or from carefully managed seed orchards. Seed orchards are based on selected parents from tree breeding programmes which results in improved tree crop characteristics.

Seed bought from a reputable seed merchant will usually produce better results than "collect-your-own" seed, as merchants know how to correctly collect and store the seed.

Natural Seed Sources

Some tree species occur naturally over a large geographic area with a wide range of climatic and other environmental conditions. This often results in different provenances[7], in different parts of the natural range. These provenances may have different growth characteristics, tree shape, wood properties and environmental tolerances. For example, a eucalypt from a natural stand at high altitude is likely to have greater frost tolerance than one from a stand of the same species at lower altitude. A grower considering planting eucalypt on a frost prone site should ask the tree nursery manager about the seed source and provenance of the planting stock.

The number of available seed sources and information on their performance will vary between species. The NZFRI maintains a register of seed sources for different species, and provides up-to-date recommendations on the best sources. Seed supplied by reputable seed merchants in New Zealand is usually obtained from registered seed sources.

Information on seed sources and planting stock for the five main groups of special purpose timber trees in New Zealand (cypress, acacia, eucalyptus, poplar, other deciduous hardwoods) can be found in *Special Purpose Timber Species*.

GENETICALLY IMPROVED RADIATA PINE

Tree breeding programmes have been carried out on some species to select desirable characteristics. The most advanced and important programme in New Zealand involves radiata pine.

Radiata pine improved seedlots are currently classified into three major breeds:

Growth and Form (GF): This breed has been specifically developed to give fast growth, staight stems, reduced forking, improved resistance to some diseases and thus a greater volume. It is recommended for use throughout New Zealand and is the most frequently planted breed.

Long Internode (LI): This breed was developed to provide long clear lengths between branch whorls. Trees from this breed allow lengths of knot free timber to be cut between whorls for use in remanufacturing processes (eg, finger jointing). The breed can be grown on medium-fertility sites but should be used with caution on high fertility sites as it may result in poor tree form (note: further developments with tree breeding are overcoming this). It does not grow quite as fast as the Growth and Form breed

[7] Provenance is used to describe a seed source or seed origin which has evolved under certain environmental conditions in its country of origin through the process of natural selection.

Dothistroma Resistant (DR): This breed was developed for resistance to *Dothistroma* needle blight (*Dothistroma pini*). Its basic characteristics are similar to those of the GF breed and it is suitable for planting in areas where *Dothistroma* is a problem.

Other breeds are available (and are being further developed) that provide special characteristics, such as high wood density.

Improvement Rating

Planting stock is rated within each breed according to its level of genetic improvement. For example, a seedlot could be classified as GF14, which is from the Growth and Form breed with an improvement rating of 14. This means it will produce a greater volume of wood in a shorter time than a tree from a GF8 seedlot, but not as much as a tree from a GF25 seedlot. An example of a seedlot description is DR21(23)*, a Dothistroma resistant breed with a disease resistance rating of 21. The figure in brackets is the GF rating and the asterisk warns that the seedlot is made up of only a few parents.

The effect of genetic improvement is usually visible in radiata pine five years after planting and becomes more marked as the stand matures. Field trials by NZFRI have evaluated the performance of different seedlots compared to "bulk", unimproved seed. The results of these trials are shown in *table 10*.

10: Comparison of the Performance of Typical Radiata Pine Seedlots with that of "Bulk" seed.

GF Rating	% Volume Gain	% of Acceptable Stems in a forest situation
1	0	45
7	5-10	50
14	13-18	65
16	15-20	70
19	19-23	70
23	27-32	80
9 (Long Internode)	8-13	55
14 (Dothistroma Resistant)	13-18	65

Source: NZFRI

Selecting the Appropriate Seedlot

Unless there is a specific requirement to produce factory grade clears[8] from long internode, unpruned trees or to plant radiata pine on a site with a high incidence of *Dothistroma* needle blight, the GF breed is generally the best breed for most forestry situations in New Zealand.

Planting stock from the most recently developed seedlots with the highest improvement rating will be more expensive owing to scarcity of supply. The seedlot improvement rating should meet the grower's requirements, without paying for a higher rating than is needed. For example, lower GF ratings could be more suitable for unpruned regimes on exposed or low fertility sites, while sheltered and fertile sites and intensive pruning regimes will optimise the advantages of high genetic improvement ratings.

One of the main advantages of using planting stock with a high GF rating is that the number planted per hectare can be reduced. However, a low stocking is a disadvantage on weedy sites, where canopy closure needs to be reached as early as possible to suppress weed growth, a low stocking is a disadvantage. In such cases a grower is better advised to plant higher numbers of lower GF stock.

[8] Factory clears are lengths of defect-free timber which can be used as components for items such as furniture or interior joinery.

Cuttings

Radiata pine tree stocks are normally produced from seedlings or cuttings.

Cuttings are used to reproduce the most recently developed, genetically improved trees, as seed from these trees is usually in limited supply and is often very expensive. The cost of producing cuttings is generally greater than that for seedlings.

Cuttings taken from one- or two-year old trees will be similar in appearance and performance to seedlings, and are called “juvenile cuttings”. Cuttings taken from three- or four-year old trees are said to "physiologically aged" and have more desirable properties, yet may grow a little slower in diameter.

Tree form, and in particular stem straightness, of aged cuttings is generally superior to that of seedlings or juvenile cuttings. Root systems of aged cuttings also tend to be thicker and become less distorted during planting. Field observations of young trees grown from aged cuttings also suggest they have a lighter crown than seedlings, which means they are less affected by wind storms and less prone to toppling over.

These features of aged cuttings are valuable if low initial stockings are to be used on fertile farm sites. Under these situations, aged cuttings are likely to provide a better crop than higher rated GF seedlings or juvenile cuttings. The use of aged cuttings instead of seedlings or juvenile cuttings should be discussed further with the nursery manager and forestry consultant in relation to specific sites and management objectives.

TYPES OF PLANTING STOCK

The seed or other genetic material selected can often be grown in different ways in the nursery to produce different types of planting stock.

Open rooted seedlings: Seed is sown in a nursery bed and the seedling roots are pruned mechanically (while still growing in the bed) to form a good, fibrous root system. Seedlings should be lifted from the nursery a day or so before planting.

Open rooted seedlings are often classified by the number of years spent in a nursery seed bed and the number of years after transfer to a second bed in the nursery (usually called a “lining out” bed) at wider spacing. The lining out bed is required by some species to produce a strong and fibrous root system. For example, *Pinus nigra* is sometimes sold as 1/1 seedlings (one year in a seed bed and one year in a lining out bed). Radiata pine seedlings are usually 1/0 (grown for one year just in the seed bed).

Container grown seedlings: These are grown and supplied in a small plastic, cardboard or (sometimes) peat container, complete with its own soil. The best containers are called "rootrainers" as they generally prevent too much distortion of the root system. Polythene “planter bags” are sometimes used, but are usually limited to very particular special purpose trees or specimen trees.

Open rooted cuttings: These are produced in the same way as open rooted seedlings, except the material put into the nursery bed is a cutting rather than seed.

Unrooted Cuttings: With some tree species such as poplars and willows, cuttings are produced in the nursery for direct planting on the forest site, without going through a stage in a nursery bed to produce roots (the roots develop in the ground after “planting”). Unrooted cuttings have different sizes, from small "wands" of a few centimetres to large "poles" of two to three metres long.

Selecting The Type of Planting Stock

The choice of planting stock depends on the species, scale and accessibility of the planting project, and cost considerations. There are also advantages and disadvantages associated with the different types of stock.

Species: The initial choice will be based on the particular species, as a given species will often be most effectively reproduced in only one form. For example, poplars and willows are generally planted as unrooted cuttings and conifers as open rooted stock.

Scale and accessibility: The choice of stock type will be affected by the scale and accessibility of the planting job. Container grown stock is heavier and more difficult for planters to carry, so good vehicle access is required.

Cost considerations: Open rooted seedlings will usually be the cheapest, particularly for species produced in large quantities, such as radiata pine. Container grown stock will generally be the most expensive, but may be the only way of obtaining some special purpose species that are only produced in small numbers.

Table 11 summarises some of the features to be considered in choosing between different types of planting stock.

11. Choosing the type of planting stock

Planting Stock	Suitable Species	Suitable Scale	Cost	Advantages	Disadvantages
Open rooted seedlings	Most conifers and a wide variety of hardwoods.	Suitable for large scale plantings owing to ease of handling large numbers of plants	Low	• Suitably large and well-conditioned stock can be produced that is suitable for most sites • Ease of handling • Quality of the root system is easily assessed • Well hardened stock may be less susceptible to frost and animal damage.	• Care must be taken in handling to ensure stock is not damaged and roots do not dry out. • Should not be used if major planting delays are likely. • A short "shelf life" between lifting from the nursery and planting (2)
Container grown seedlings	Particularly suitable for fast growing hardwoods. Can be used for most species.	Not always popular for large plantings with difficult access owing to weight of soil and containers (1)	High	• Stock can be stored if planting is delayed (2). • Planting can sometimes be delayed until after the worst winter frosts when soil temperatures begin to increase. This reduces the risk of damage and allows immediate growth. • Good in drought-prone soils	• Quality of root system is difficult to assess. It may be root-bound or not sufficiently developed.
Open rooted cuttings.	Most species can be grown from cuttings. Radiata pine cuttings are common.	As for open-rooted seedlings	Moderate	• Improved tree form and growth if physiologically aged material used. • Exact copy of parent • Other advantages as for open rooted seedlings	• Aged cuttings of radiata pine are more palatable to stock and pests than seedlings • Other disadvantages as for open rooted seedlings.
Non rooted cuttings	Poplars, willows and some other hardwood species.	Suitable for large- and small-scale planting.	Moderate	• Easy planting, cuttings can be rammed directly into the ground. • Exact copy of parent	• Cuttings must be stored in a cool store and kept moist if planting is delayed.

Notes: (1) In some areas, notably Southland and Otago, large numbers of Douglas fir stock are produced in containers
(2) Open rooted stock can be stored after lifting, but only in a cool store

Ordering Tree Stock

Most faster growing conifers and hardwoods, such as radiata pine and eucalypts, are sown in a nursery in the spring before the winter in which they are intended for planting. To guarantee supply, planting stock should be ordered from the nursery before the seed is sown.

Where the seed is likely to be more difficult to obtain, such as less common special purpose species or radiata pine with a high GF rating (greater than GF28 at the time of publication), orders may need to be placed two years ahead. Slower growing species such as Douglas fir, which normally require two years' growth in the nursery before planting out, should also be ordered two years ahead, particularly for large projects.

Many nurseries require a deposit, paid at the time of ordering. The Ministry of Forestry has contact details for nurseries specialising in producing planting stock for planted production forestry projects.

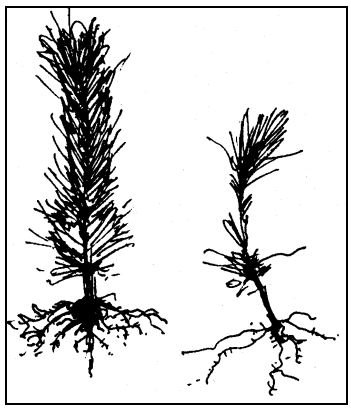
Checking Planting Stock Quality

The quality of the planting stock ordered should be checked at regular intervals with the nursery manager and inspected carefully a month or so before it is lifted from the nursery bed.

Container grown stock should have a well developed root system but not be root-bound. Some types of containers, particularly the polythene planter bags, are more susceptible to root-binding.

Open rooted stock should:

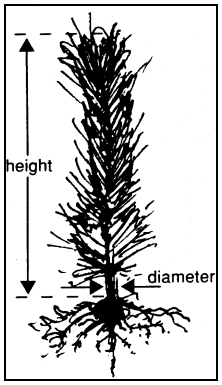
- be "hardened off", that is not be soft, green and actively growing (soft stock has no resistance to the adverse effects of planting) and with a dormant terminal bud
- have a good root system. The tap root should be callused or cleanly cut and there should be an abundance of fibrous roots. For one year old radiata pine stock (1/0) the taproot should be cut 7-10 centimetres below ground level and there should be abundant fibrous roots (see *figure 12*).



12: The good quality seedling on the left has a callused tap root and abundant fibrous lateral roots that have been properly trimmed. The seedling on the right has a bent, damaged taproot with only a few weak lateral roots

- have a uniform size. Planting a mixture of stock sizes can result in uneven growth.
- be the right size. Under ideal conditions, small seedlings transplant better than big ones. However, a minimum size is required in order for the planting stock to: have sufficient food reserves for initial growth; survive handling; avoid being buried in uneven ground; and survive weed growth. Size is measured in terms of stem diameter at ground level (sometimes called root collar diameter) and height (see *figure 13*). Stem diameter is an indicator of seedling food

reserves, which dictates the seedling's ability to grow a new root system. *Table 14* shows recommended sizes for some common species.



13: Seedling stem diameter and height are used in assessing quality

14: Recommended Sizes for Open-Rooted Stock

Species	Minimum Stem Diameter (mm)*	Desirable Height (cm)
Radiata pine	6	25 - 35
Douglas fir	10	40 - 50
Macrocarpa	6	25 - 35
Leyland Cypress	6	25 - 35
Eucalypt species	8	50
Acacia melanoxylon	10	60 - 80

*Note: Diameter is taken at the root collar (where the root joins the stem)

STOCKING QUANTITY

The initial spacing between trees at planting and the resulting number of trees per hectare are determined by the species planted, the site on which they are planted, and the way they are to be managed. These issues are examined in more detail in *Managing a Small Forest for Timber*. A brief discussion of the issues and broad recommendations for initial spacing are set out below, while *table 15* includes a spacing guide for all species.

Species and Seedlot: Factors such as shade tolerance, crown size and tree form affect the initial stocking suitable for different species. Improved genetic material (eg, high GF-rated radiata pine) can be planted at low initial stockings owing to the higher proportion of acceptable stems (see *table 10*). This reduces the need for a higher selection ratio when thinning.

Some species, such as eucalypts, should be planted at a square spacing (such as three metres between rows and three metres between trees in the row) to obtain balanced canopies. This is because eucalypts are "crown shy", which means neighbouring trees that are too close together will bend away from each other, which causes internal stresses in the timber (lowering its value).

15 Spacing guide for all species

Distance between rows (m)	Distance between trees within the row (m)											
	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
2.0	2500											
2.5	2000	1600										
3.0	1667	1333	1111									
3.5	1426	1143	952	816								
4.0	1250	1000	833	714	625							
4.5	1111	889	741	635	556	494						
5.0	1000	800	667	571	500	444	400					
5.5	909	727	606	519	455	404	364	331				
6.0	833	667	556	476	417	370	333	303	278			
6.5	769	615	513	440	385	342	308	280	256	237		
7.0	714	571	476	408	357	317	286	260	238	220	204	
7.5	667	533	444	381	333	296	267	242	222	205	190	178
8.0	625	500	417	357	313	278	250	227	208	192	179	167
8.5	588	471	392	336	294	261	235	214	196	181	168	157
9.0	555	444	370	317	278	247	222	202	185	171	159	148
9.5	526	421	351	301	263	234	211	191	175	162	150	140
10.0	500	400	333	286	250	222	200	182	167	154	143	133

Site

Site can affect initial stocking requirements in a number of ways. Exposed sites should have a higher stocking, as stem malformation is likely to be higher and a greater number of stems will be needed for later selection in thinning. Where scrub weeds such as gorse are a problem, high stocking can result in rapid canopy closure and weed suppression.

Row Spacing

The space between tree rows is influenced by forest management requirements. For example, on a grassy site (and if topography will allow) it may be possible to mow the pasture between the rows for hay, so the space will have to be sufficient for machinery access. Where a production thinning is planned, wider spacing between rows will help in removing the thinnings from within the stand.

STOCKING FOR DIFFERENT SPECIES AND REGIMES

The species and regimes appropriate for particular growing conditions can be different for distinct areas of New Zealand. More detail on regimes can be found in the Ministry of Forestry's *Managing a Small Forest for Timber, Special Purpose Timber Species* and *Zone Study* publications.

Following are some examples of stockings for different species and regimes. These are only indicative and will vary depending on particular situations. When it comes to choosing a specific regime, small forest growers should seek advice from forestry consultants with local knowledge.

Radiata Pine

Pruned Sawlog Regime: This focuses on producing high quality, knot-free wood in the pruned butt log. Plant 500 to 1000 stems per hectare, depending on site, the type of tree stocks used (seedlings or cuttings) and GF rating. Usually, a high GF rating will mean fewer trees per hectare. An average (and possibly conservative) stocking using GF19 planting stock is 800 trees per hectare.

Unpruned Sawlog Regime: This regime (sometimes called a minimum tending regime) aims to produce unpruned sawlogs with relatively small branches. A stocking higher than the pruned regime is used to encourage smaller branches. Plant 900 to 1000 trees per hectare with GF17 or GF19 stock.

Pulplog Regime: This regime concentrates on producing large volumes of wood in a relatively short time (12 to 15 years), to be turned into pulp. Plant 1500 to 2000 stems per hectare. The GF rating is less important with short rotations and the choice of GF rating will depend more on the price of the available planting stock.

Douglas Fir

Production Thinning Regime: This regime is appropriate on flat to rolling terrain, with easy machine access for production thinning. Plant 1370 stems per hectare (2.7 metres x 2.7 metres).

Thin to Waste Regime: This regime is more appropriate for steep sites with difficult access. Also plant at 1370 stems per hectare (2.7 metres x 2.7 metres).

Eucalypt Species

Pruned Sawlog Regime: This is an intensive management, 30-year regime which focuses on producing high quality, knot-free wood in the pruned butt log. Plant 1100 stems per hectare at a three metre by three metre square spacing.

Pulplog Regime: This is a short rotation (10 to 20 years) regime for pulp production. The main species are *Eucalyptus nitens*, *E. fastigata* and *E. regnans.* Plant 1000 to 1200 stems per hectare.

Cypress

Pruned Sawlog Regime: This regime aims to produce high quality, pruned butt logs and small branched top logs, plant 1200-1600 stems per hectare at a square spacing.

Australian Blackwood

Australian blackwood *(Acacia melanoxylon)* needs shelter, especially side shelter, to achieve maximum growth rates and good tree form. It grows best in situations where side shade is provided by indigenous vegetation or a nurse crop such as a eucalypt species.

Pruned Sawlog Regime: Fertile, clean farm sites require an intensive management, clearwood regime using a nurse species to assist form development. Plant alternate rows 3.2 metres apart of blackwood and nurse species (eucalypts, poplars or willows) with seedlings spaced 3 metres apart in the rows and staggered in relation to those in the adjoining rows. In this way a blackwood is opposite a nurse (525 trees per hectare of each of blackwood and nurse species).

Planting

The benefits of a well prepared site and good planting stock can be lost if planting is not carried out correctly. Care must be taken to ensure trees are planted at the right time and are handled carefully. They must be planted at a suitable spacing, using a good planting technique. The planting operation should be efficiently supervised.

WHEN TO PLANT

The planting time is mainly determined by the type of stock being planted.

Open rooted stock

This should be planted during winter while it is dormant, which usually means planting between late May and the end of August.

In areas where spring drought is common and frosts and waterlogging are not a problem, early planting ensures the stock has the maximum time to establish before spring drought strikes. In the Central North Island and South Island, where frosts can be severe, planting should be delayed until the worst frosts are past. Where both drought and frost are a problem, planting time may vary in relation to the tolerance of the species. Frost tolerant species may be planted earlier and drought tolerant species later.

Container grown stock

Planting container grown stock involves little disturbance to the tree as the roots are maintained in the same growing medium. This allows greater choice of planting time. In the North Island, eucalypts grown in containers can be planted between April and November. If summer droughts are not a problem, evergreen species grown in containers can be planted in late spring when the danger of frosts is past and the stock can start growing immediately. Deciduous tree species grown in containers should be planted out while in winter dormancy, before bud break.

Drought

Planting of any type of stock of any species should not take place during periods of drought, when there is little or no soil moisture.

HANDLING TREE STOCK

All handling and transport between lifting at the nursery and planting out on the forest site should be carefully controlled to minimise stress and damage to the planting stock.

Lifting

Open-rooted stock should be lifted carefully out of the nursery beds to minimise damage. Some soil and mycorrhiza[9] should be left on roots. In many nurseries, lifting is done by hand to minimise damage to the planting stock.

Root trimming

When lifting, the roots of open-rooted stock should be trimmed with sharp shears. Correctly undercut[10] one-year-old radiata pine stock will have a tap root about 10 centimetres long when lifted. The fibrous side roots should be trimmed to the same length.

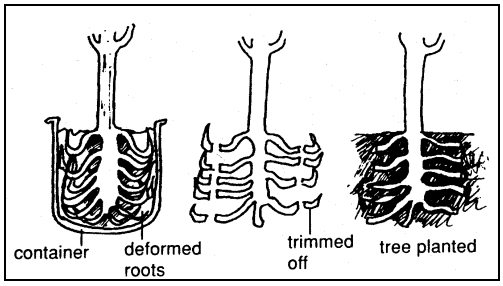
Stock with long roots are difficult to plant and the roots can be bent during planting, resulting in lasting deformity. Bent roots do not anchor the trees firmly, making them more prone to topple over in high winds. If trees are to be planted in heavy clay soils (eg. parts of Northland) the tap roots and fibrous side roots should be trimmed to about five centimetres. This will involve some extra cost, but is necessary as it is not possible to open up a planting hole in heavy clay sufficiently large to take longer roots (the alternative is to dig a large planting hole, which is more expensive than paying for extra root trimming in the nursery).

The roots of container grown stock will twist if they hit the sides or bottom of the container. These distorted roots should be cut off at planting, using a sharp knife or shears to shave off deformed lateral

[9] Mycorrhiza fungi are essential for good growth of many young trees. They form a symbiotic association with the roots, which helps in the uptake of nutrients and moisture.

[10] Undercutting is the name for a nursery operation where a cutting bar is pulled along the bed at a depth of about 10 centimetres. This cuts off the tap roots of the young trees which promotes regrowth of fiborous lateral roots, important for rapid establishment.

roots and slice off the bottom 2 centimetres of soil to remove any restricted tap root growth (see *figure 16*).



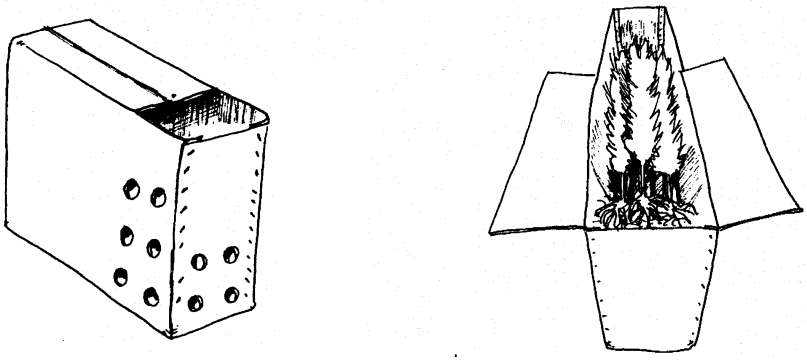
16: Trim deformed lateral roots and tap root on container stock before planting

Packing

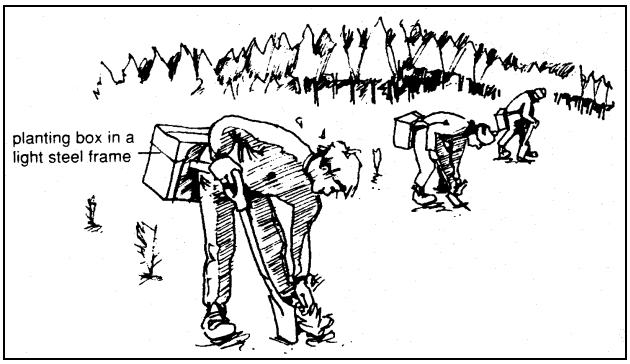
Open-rooted stock should be packed carefully into containers that will protect it during transport. Stock should be packed horizontally to reduce bruising and root breakage during transport. The best system is to pack trees at the nursery bed (immediately after lifting and root trimming) into special waxed cardboard or plastic planting boxes (see *figure 17*), which protect the stock from physical damage, sunlight and moisture loss. They may be placed into larger crates (sometimes called "pods") for transport to the planting site. At the planting site, planting boxes are carried in light metal frames and the trees are planted directly from the boxes (see *figure 18*).

Polythene bags or other flexible packaging increase the risk of handling and exposure damage. Some common problems include thumping the bag down on the truck bed (which severely damages the roots) and leaving the bags exposed, which (with polythene bags) can lead to the trees being "cooked" in their own little "greenhouse". A lot of extra care is needed with this type of packaging, which usually means more supervision.

The roots of planting stock must never be allowed to dry out and should always be covered and moist. The shoots (tops) should also be kept covered to minimise transpiration and hence drying out.



17: Standard planting box



18: The best method of transporting open root stock is to use planting boxes in which trees remain from the time they are lifted in the nursery to the time they are planted

Transport

Tree stocks should be protected from exposure to the sun or wind during transport to help keep roots and shoots moist. Transport in planting boxes inside a covered vehicle is best. Planting stock should never be transported any distance on the back of an open truck as it will dry out rapidly and become stressed.

Storage: Open-rooted tree stocks should spend the shortest possible time out of the ground and ideally should be planted within 24 hours of lifting. Because of this, especially for larger planting jobs which will continue over several days or weeks, the supply of stock from the nursery should be carefully planned so that only enough for one or two days planting are delivered at a time. If open rooted stock has to kept for a few days, it should be delivered in planting boxes, stored in a ventilated shed, watered every second day, prevented from drying out (eg by covering with straw) and protected from wind and frost.

Tree stocks can be kept in cool stores, at $-1^{o}C$ to $-2^{o}C$, for three to four weeks before planting. This has added advantages of hardening the stock off more (which can improve survival after planting) and providing flexible planting timing.

PLANTING TOOLS

All planters should use a good spade, with a blade length of at least 30 centimetres. It is not possible to cultivate a suitable planting spot, or open up a sufficient hole for the tree, with a worn blade. Spades specially designed for tree planting in different soil types are available from forestry equipment suppliers (contact details are available from the Ministry of Forestry). For safety reasons, planters should wear strong boots.

PLANTING OPERATION

Once stock is at the planting site, a number of steps should be taken to ensure it is correctly planted to get the best possible start in life.

Check Stock Quality

The stock should be checked at planting to ensure that it:

- is hardened off
- has a good root system
- is uniform in size
- is of the right size

- has healthy shoots
- has roots and shoots that are moist and supple.

Poor stock should be rejected and not planted, as it may die (requiring replanting) or have reduced tree growth and consequently reduced economic returns. Any faults should be reported immediately to the supplying nursery and samples of the defective stock returned to the nursery manager so that faults can be rectified.

Use Skilled Planters

One of the best ways for small forest growers to ensure successful tree planting is to employ skilled and experienced planters. Some people think that tree planting is an unskilled job, but professional tree planters are a very important part of the forestry workforce. Reputable contractors who specialise in tree planting have extensive experience in supervising their crews and training workers to *Forest Industry Record of Skills* standards (see page 77). It is recommended that small forest growers use these contractors for their tree planting.

Where growers are doing their own planting (either directly, or by hiring their own workers), it is essential that correct planting methods are studied and used. Learning correct planting methods will also give owners confidence when they visit a contract planting job.

Planting Method

A video, *Quality Tree Planting* (available from the Ministry of Forestry), illustrates a proven and recommended method of tree planting. It is highly recommended for all involved in planting - owners, supervisors and workers.

Planting spot: Plant the stock in a spot free from obstructions such as rocks and roots which may cause root distortion and retard growth.

Planting technique: This involves cultivating the soil as much as possible with the spade and opening up a hole large enough to contain the roots without distortion. A suitable method for planting open rooted stock is as follows[11].

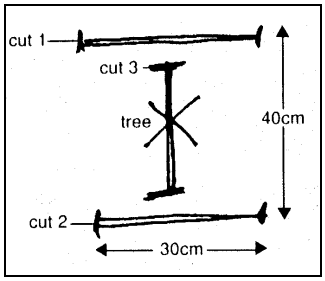
Spade cultivation: The correct cultivation method is to dig the spade into the soil to its full depth (30 centimetres), using the boot to push the spade down. Lever the handle back for maximum break-up of soil (cut number one in *figure 19*), remove the spade and, reversing the blade, dig the spade to full depth 40 centimetres (a bit more than a good boot length) away from the first cut (cut number two in *figure 19*). By pushing the handle away, an area the width of the spade (30 centimetres) and 40 centimetres long is well cultivated (*figure 20*). In heavy or hard soil, enough effort must be used to achieve the same level of cultivation, even if it takes more time and requires extra spade cuts.

Planting method: After finishing the second cut, with the spade blade reversed (blade facing the planter), lift the spade from the cultivated ground and sink it vertically into the centre of the cultivated planting spot (cut number three). Push the handle away to an angle of 45 degrees, so that the spade levers the soil up creating a hole at the bottom. Then push the spade down to anchor the blade tip in the uncultivated soil at the bottom of the hole and pull the handle back to open up a good planting slot.

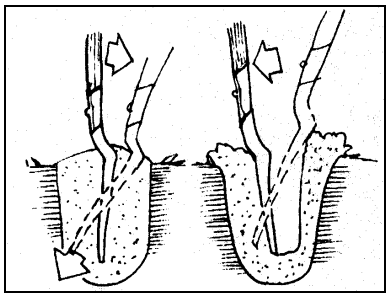
If the soil is loose and falls back into the hole, repeat the hole opening technique. With a little practice, this hole opening method can be completed in less than two seconds. The hole can be held

[11] This description of correct planting is reproduced by courtesy of Robin Trewin of Forest Establishment (a consulting company specialising in establishment techniques).

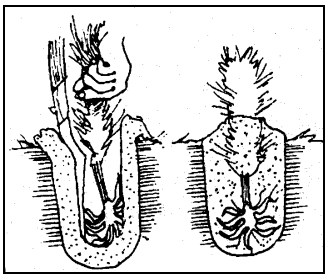
open with the spade, the tree placed into the hole and tree roots placed at the bottom of the hole (*figure 21*). The spade is pulled away and, after pushing/filling soil back in the hole, the tree is given a positive pull-up to straighten and point lateral roots down slightly (*figure 22*). This encourages vertical root growth for good anchorage and wind-firmness. Planting is completed by firming-in soil with the soles of the boot, either side of the stem (*figure 22*).



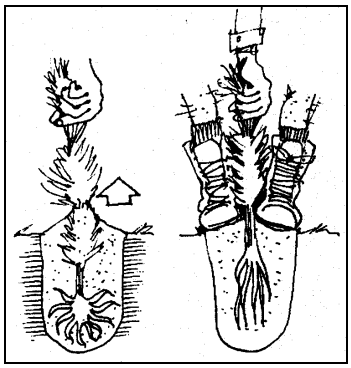
19: Orientation of the three spade cuts and final location of the tree



20: Use the first two cuts to cultivate



21: Place the tree in the third cut, and fill with soil



22: Pull up and firm

Planting sequence:

1. Cultivate a good planting spot 30 centimetres x 40 centimetres to a minimum depth of 30 centimetres.

2. Open a good planting slot, more than 25 centimetres x 10 centimetres at the bottom of the cultivated spot.

3. If the depth is less than 25 centimetres, the hole opening operation must be repeated to increase hole depth.

4. Place the tree roots at the bottom of the hole. Some roots may be slightly twisted but they will be straightened later.

5. Fill the hole, burying the roots deep in loose soil.

6. Give the tree stem a positive pull-up (10 centimetres, a hand width) to straighten any roots that may have been twisted up and to point lateral roots down slightly.

7. Still holding the stem, firm soil around tree roots by pressing down firmly with the soles of the boot (one either side). Never stomp down with the heel as this crushes and damages roots.

On light sandy or pumice soils the amount of cultivation can be reduced and a single cut may be sufficient.

Container stock: Container grown stock can be planted using the same method but excluding the pull up. Larger container stock in planter bags will require a hole to be dug out that is large enough to take the root mass. Trees should be removed from plastic containers before planting, although those in peat containers can be planted while still in the container.

QUALITY CONTROL

Tree planting operations should be thoroughly supervised to ensure that the prescribed standards are met. However, regardless of the level of supervision, quality control (QC) is recommended to check that the work has achieved the prescribed standards. As with all QC systems, the actual QC assessments should be carried out by the person responsible for the job (supervisor, consultant or contractor), and should be done *immediately* after the actual job.

Small forest owners may also wish to carry out some quality control, even if they are not directly involved in the operation. The owner should ensure that the planting contractor has been given a planting prescription that sets out the spacing to be used and the planting quality that must be achieved. Appendix 2 contains an example of a planting prescription. Once the planters know what they are supposed to be doing, a quality control process can check that it is being done.

The two levels of quality control can be roughly classified as “formal” and “informal”.

Formal

Formal QC procedures are more often used where the forest owner wants to quantify and record the results, for example to calculate payment for work done (possibly to pay a bonus for good work), or to have poor work rectified. It involves marking out randomly located plots in the area that has just been planted, and making (and recording) assessments of the quality of tree planting. Appendix 2 details one system owners could use to carry out their own QC, or as an example to check if contractors or

consultants are using a similar system. In this way, the owner can be satisfied that the operation is being thoroughly supervised and checked.

Informal

Checking individual planters' work daily can help maintain standards. A description of an informal QC system follows.

- Quality checks are discussed with the planting contractor before planting starts, and standards agreed. If one planting technique is used by all planters, the standard will be uniform and easy to check.
- A one per cent sample (one tree in every hundred) is checked in the presence of the contractor, and preferably immediately behind the workers. For example, the check may take place within the same work period (morning or afternoon) that the trees being planted.
- Firmness in the ground is checked by gripping the stem firmly between index and second fingers and lifting. If the tree moves up, it is not tight enough in the soil. Cultivation depth (a minimum of 30 centimetres) is checked by pushing a steel probe down either side of the tree (10 centimetres from stem) to locate the harder, uncultivated bottom of the planting hole.
- Planting depth and root placement are checked by cutting the ground to full spade's depth on all four sides of the tree and removing the tree and root system in-situ on the blade of the spade. The soil is carefully broken away from the bottom to reveal root positioning. If planted correctly, most roots should be orientated slightly down, but not twisted or thrust up. Planting depth (the depth of the tree in the soil, as opposed to cultivation depth) is checked at the same time. Maximum depths should be half of the green stem in light soils, two thirds in sandy soils and one third in other soils. These planting depths will place the roots deep enough for good moisture uptake and tree stability. Planting depth is important in heavy soils as planting too deep can cause stems to rot and buried lower branches tend to grow causing double leaders.
- If several consecutive trees are found with planting faults, the sample could be increased to one tree in every 50, or less. It the owner is not satisfied with the results, the contractor may be asked to replant the trees planted in that work period. Once trees are badly planted, it is difficult to re-plant them without damaging the roots. It is better to obtain fresh tree stock and have contractors replace and discard the badly planted trees at their own expense. This would need to be written into the planting contract.

FERTILISER REQUIREMENTS

Soil nutrient levels on recently farmed sites are likely to be relatively good by forestry standards and fertiliser should not be necessary for radiata pine. However, sites which are likely to suffer from a deficiency in an important nutrient such as nitrogen (N) or phosphorous (P) should have artificial fertilisers applied during establishment. Eucalypts generally need fertiliser (especially nitrogen), except on very fertile sites.

Soil testing can be used to check if fertiliser will be needed during the establishment phase. This can be arranged through NZFRI or other analytical laboratories that provide a similar service.

If radiata pine needs any fertiliser during the establishment phase, it will usually be from the following:

- Phosphorous – especially in Northland and Auckland, and on some soils such as the Westland pakihis, Moutere gravels and Nelson granites.
- Nitrogen - in any areas where soils are sandy or podsolised and on pakihi soils; also the Canterbury Plains, Westland and Nelson.
- Boron an important micro nutrient (trace element) deficiency in a wide range of soils in Nelson, Marlborough, inland Canterbury and Otago, and some coarse pumice soils in the Taupo region.

However there is a fine line between deficiency and toxicity with this element, so it must be carefully applied.

The Ministry of Forestry's *Zone Study* series contains information about nutrient deficiencies in specific parts of the country. Two other useful publications for a small forest owner planting radiata pine are *An Atlas of Radiata Pine Nutrition in New Zealand* (Hunter et al, 1991) and *Nutrient Deficiencies and Fertiliser Use in New Zealand's Exotic Forests* (Will, 1985), (see *References)*. Advice on possible local nutrient deficiencies and rates of fertiliser application can also be obtained from forestry consultants.

Information about fertiliser requirements for tree species other than radiata pine is less well documented. Growers are advised to check with local forestry consultants or NZFRI. Fertiliser requirements for eucalypts are described in *Appendix 3*.

Application Methods

By Hand: Fertiliser can be applied at or immediately after tree planting, but is better done two months later when roots have had time to develop and are better able to use the nutrients. Operators usually carry the fertiliser in canvas bags slung around their waist and use a calibrated cup or tin to scoop it into spade slits 15 centimetres to the side of each tree. If fertiliser is placed uphill of the tree, or too close, it may burn the roots and possibly kill the tree. Placing the fertiliser in a spade slit prevents it getting washed away.

Aerial: Hand application can be expensive and slow, because it is very labour intensive. Helicopters or fixed-wing aircraft are alternatives for applying slow release rock phosphate. This may be done as part of a pre-plant oversowing programme (see page 20), or as a specific operation soon after planting. This method is being increasingly used over restocking sites in areas of low phosphate availability, such as on clay country in Northland and Auckland.

Ground Spreading: It is possible to include a fertiliser application into mechanical site preparation, such as ripping and mounding (page 23). Agricultural ground spreading machinery can also be used where topography is suitable.

Post-Plant Protection

From the time the trees are planted a programme of protection from weeds and animals should be put in place.

RELEASING FROM WEED COMPETITION.

Good weed control is essential to guarantee high survival and subsequent growth, and young trees should be kept free from competing weeds until they are well established above the weed species. For example, trees with grass control can have 50 percent more volume at age 11 than those without grass control. Other advantages of weed control, depending on the type of weed, include reduced fire hazard, elimination of a source of weeds that would otherwise affect neighbouring properties, and improved access for later operations such as pruning and thinning. A further advantage on particularly cold sites is that good herbicide weed control can result in bare ground, which can lower frost levels (see *Frost* on page 13).

It is not always necessary to eliminate all the weeds from the site, even if this is possible. Ideally, weed control should aim to maintain a weed-free area around each tree with a diameter twice the height of the surrounding vegetation.

The length of time over which weed control is required will vary depending on the growth of the tree species and the height and vigour of the surrounding vegetation. Radiata pine planted into slow growing pasture may only require one release spray a couple of months after planting. However, fertile pasture sites or sites with vigorous grass such as kikuyu may need a second releasing. Slower growing tree species, or tall weed species such as broom, may mean several releasing operations are necessary before the weeds no longer compete with the trees.

Releasing can be done using herbicides or by hand.

Herbicide releasing

There are two main ways of applying herbicides for releasing; by hand or by air. Hand equipment includes "spotguns" (which are modified agricultural drench guns), knapsacks and "Weed-a-Metres"[12] (granule herbicide applicators). Aerial release spraying is usually carried out by helicopter.

Radiata pine is resistant to many herbicides, so can be effectively sprayed in a releasing operation after planting. Most other species are more sensitive to herbicides and are more suited to pre-plant spraying.

On easy country, with agricultural tractor access, it may be possible to spray strips along planting rows using agricultural-style spray booms.

The use of herbicides is discussed in more detail on page 60.

Hand releasing

Competing vegetation can be physically cut back from the tree using slashers, or motorised scrub bars. It may be required a number of times during a season, owing to regrowth of weeds after cutting. Hand-releasing is labour-intensive, often ineffective (because the cut weeds regrow), an expensive alternative to herbicide releasing, and difficult to economically justify in large-scale plantings. It also has the major disadvantage of failing to remove below-ground competition, which can be more severe than the more obvious above-ground competition (especially in the case of grasses).

This type of releasing may be adequate for small areas (eg, less than two hectares) and for some types of specialised planting, such as a special purpose timber species planted in lightwells. It is also useful for particularly sensitive areas where other methods would be inappropriate (such as close to a neighbouring vineyard, where hand releasing could be more prudent than using herbicides).

PROTECTION FROM ANIMALS

The best way to protect a stand of newly planted trees from damage by animals is to either separate the animals from the trees or remove the animals.

Domestic Stock

Where trees are planted as part of a livestock farming situation, adequate fencing must be allowed for as part of the site preparation planning. The type of fence will depend largely on the type of stock - for example, a two-wire electric fence could be enough for dairy cattle, but would be inadequate for sheep or goats. Advice on fencing for stock can be obtained from local farm consultants or farming neighbours.

[12] "Weed-a-Metre" is an applicator designed for granules, particularly Velpar 20G, and is marketed by NZFRI.

As the trees get older it becomes less important to keep stock from moving into the planted area. With radiata pine, this is likely to be after the final tending operation (the trees will have started to develop fissured bark, which is better able to withstand animal damage). This means fences could be removed and used elsewhere.

Livestock behaviour should also be taken into account. For example, areas where stock are likely to congregate, such as gateways, stock-camps and water troughs, could be left unplanted if forest grazing is planned as part of the management regime (see *Grazing* on page 70). Young trees on clay soils are particularly susceptible to mortality during wet weather as congregating stock can compact the soil during wet conditions (called "pugging" the soil) and crush tree roots, killing the trees.

Animal Pests

A number of animal pests throughout New Zealand can damage newly planted tree crops. Possums, rabbits, hares and goats can be particularly destructive of young trees. District and regional councils generally co-ordinate wild animal control programmes and small forest growers can assist by belonging to local pest control organisations run by councils. Local Landcare Groups (which can usually be contacted through regional councils and Federated Farmers) often work in the area of pest control; forest owners may find it useful to join such groups.

Forest owners should check for any signs of animal damage. An organised shooting and/or poisoning programme may be needed when populations of wild animals such as rabbits or possums build up and damage the trees.

Animal Repellents

Applying animal repellents when planting should be considered for browse-prone species such as eucalypts or *Acacia melanoxylon*. The most effective and easy to use repellent follows:

Ingredients

- 80g of egg powder and 800 ml of water; or 5 fresh eggs and 600 ml of water.
- 150 ml of acrylic resin; or 150 ml of acrylic paint.

If egg powder is used, mix the powder into a paste; if fresh eggs are used, beat them well. Add the other ingredients. Spray 20 ml per tree immediately after planting (eg, with a spotgun). A further application may be required in spring.

Fence Maintenance

Fences and gates should be regularly checked to ensure they remain capable of excluding domestic stock and wild animals. Gates may need to be locked to ensure they are not accidentally opened and left open.

PROTECTION FROM FIRE

Although fire is often believed to be major threat to forests, it is a relatively minor threat in many areas of New Zealand. Dry eastern areas of the country, prone to drought, are most at risk from fire. Forests are at risk during establishment because there is often a build up of fuel (dried vegetation or harvesting debris) among the young trees.

The risk can be reduced by:

- creating firebreaks (strips of land at least four metres wide that are not planted with trees) to either stop a fire getting into the forest or slowing its progress through a forest
- keeping fire breaks maintained by physically removing vegetation (eg, blading it off with a light bulldozer or using disks or a plough to bury the turf), or by keeping vegetation very short through mowing or grazing

- managing human activities in the forest and limiting access during high fire risk periods to reduce the likelihood of a fire being started
- ensuring equipment used in the forest (eg, chainsaws, motorbikes, etc) is in good order, with spark arresters if needed
- co-ordinating fire control with neighbours and other local forest owners.

Forest owners are advised to have a fire plan that sets out the procedures for rapidly controlling any fire that does occur. These should include providing fire ponds if there are no water supplies close to the forest. Forest owners should also be involved with local rural fire committees, who can be contacted through district councils and who could also provide help with developing a fire plan.

Small forest owners should liaise with district councils on monitoring rural fire risk. Machinery operations (such as land clearing) should be suspended when fire risk is extreme, as there may be risk from sparks or hot engines. Forest grazing is a way of controlling undergrowth that will reduce fuel availability and hence fire risk.

Forest owners should consider fire insurance cover; during establishment this can cover fire fighting and re-establishment costs. Some insurance companies and brokers have forestry schemes available, so small forest owners should shop around. Information on insurance schemes is also available from the New Zealand Forest Owners' Association (see *Where To Go For Help*).

PROTECTION FROM WIND

Wind is generally considered the greatest risk to forestry in New Zealand. Damage can vary from the effects of major storms uprooting trees, to less obvious wood defects that reduce value. Correct choice of species, site and regimes are the best management remedies for windy sites.

The main effects of wind can be reduced by encouraging root development through using good quality planting stock that is well planted.

Sites with a likelihood of wind damage could have a higher number of trees planted per hectare than those less at risk. This provides the crop with some mutual protection benefits and, if storm damage does occur, there is a greater chance of salvaging a crop.

Crown lightening (also called "sail pruning") on exposed sites can reduce the sail effect of the tree crown and maintain stability in younger trees (aged two to three years). On fertile sites, crown development may outstrip root growth and lead to the tree toppling over in windy conditions. Crown lightening involves removing a few (two or three) branches. The choice of branches will depend on the weight of the crown and its overall sail effect to the prevailing wind.

If trees are blown over during establishment, they can be "rescued" by being pulled upright and held by stakes to keep them in place until they are stable again. Staking can be a very expensive operation, and another option is to cut the blown-over tree back to the last branch, which will rapidly take over as the new leader. This will probably result in a kink in the first metre or so of the tree, but it can be cut off at harvest.

Herbicides in Forest Establishment

Herbicides are a type of chemical used to control vegetation growth (insecticides and fungicides are two other common chemical types). Herbicides, insecticides and fungicides are also known collectively as "pesticides".

Using herbicides is one option when considering methods for weed control. However, herbicides are often expensive and may pose some degree of hazard to non-target vegetation and/or to the user. Their use should not be assumed as the first option, each situation should always be examined and other options considered.

The use of chemicals (including herbicides) is regulated by district and regional councils and the Resource Management Act. For example, some regional councils have published "discharge to air" plans that set out the circumstances in which resource consents will be needed for spraying chemicals.

In all situations where herbicides are used, it is essential that the user

- seeks expert advice
- always follows the manufacturer's instructions
- uses any safety equipment recommended by the manufacturer
- avoids damaging any non-target vegetation
- undertakes a training programme.

Small forest growers intending to use herbicides are recommended to complete a "Growsafe " training programme. They should also specify that any operators working with herbicides in their forests have completed the same programme. "Growsafe" user courses are based on the *Agrichemical Users' Code of Practice*.

The *New Zealand Agrichemical and Plant Protection Manual* is a good reference for small forest growers wanting further general information on pesticides and their use.

HERBICIDE TYPES

The main categories of herbicides are:

Contact Herbicides

Fast acting and effective only at or near the point of contact. Complete coverage is necessary to kill a plant and frequently the lower stems and roots are not affected. For example: paraquat (Gramoxone), diquat (Reglone).

Translocated or Systemic Herbicides

Readily absorbed by the plant foliage and translocated to roots and buds. It is unwise to apply these materials during droughts or mid-winter periods when weeds are not actively growing. Examples: glyphosate (Roundup), amitrole (Amitrole 400).

Root-Absorbed Herbicides

Aided by light rainfall or adequate soil moisture, these herbicides move through the soil and are absorbed into the plant system via the roots. They may remain active in the ground for a long time. Examples: hexazinone (Velpar), triazine (Gardoprim 500 FW).

Germination Inhibitors

Residual herbicides that kill seedlings as they germinate and usually remain active for three to six months. Examples: hexazinone, simazine (Gesatop 500 FW), atrazine (Atradex 900 WG).

SELECTING THE HERBICIDE

Weed Species

Herbicides should be capable of controlling the particular weed problem on the site. *Table 23* describes a range of herbicides which could be used in radiata pine pre- or post-plant situations for a

range of weed species. Readers wanting further information about specific herbicides for particular weed problems in radiata pine forests are advised to refer to NZFRI Bulletin 180 *Forest Weed Control Manual*, available from NZFRI. Information about herbicides that are suitable for weed control among other tree species other than radiata pine is less well documented. In these situations, growers are advised to consult representatives of herbicide manufactures, local forestry consultants, or NZFRI.

23: Common herbicides for use with radiata pine

Weed Problem	Pre-plant	Post-plant
Blackberry	Roundup Trounce + Escort + Pulse Escort Tordon Brushkiller	Velpar
Bracken	Roundup + Pulse Trounce + Escort + Pulse Escort + Pulse	Beacon Velpar
Broom	Roundup + Pulse Tordon Brushkiller Escort + Pulse	Velpar (seedlings only) Versatill (seedlings only) Radiate
Buddleia	Escort + Pulse Tordon Brushkiller Velpar Roundup	Tordon Brushkiller (seedlings) Velpar
Gorse	Roundup + Pulse Tordon Brushkiller Grazon Escort + Pulse Trounce + Escort + Pulse	Tordon Brushkiller Radiate
Grasses	Roundup Touchdown Gardoprim	Velpar Gallant Targa Gardoprim Atradex
Herbaceous broadleaves	Gardoprim Atradex Roundup Simazine SDA Herbicide Velpar Touchdown	Gardoprim Atradex Prefix D Versatill
Pampas	Roundup Velpar	Velpar Gallant Targa

Source: NZFRI

Notes: For the rate (amount) of herbicide to use in particular situations, users should refer to the label on the herbicide container, or should consult a local representative of the manufacturer, or refer to NZFRI Bulletin 180. The Ministry of Forestry strongly advises that all herbicide users obtain expert advice before embarking on a spraying programme. The herbicide names in the table are well-known trade names used for ease of reference, and do not represent a recommendation. For example, "Roundup" is a trade name for the chemical called glyphosate, which is also available under other trade names.

Tree tolerance

When planting herbicide-sensitive species such as eucalypts, herbicides must be carefully chosen to avoid damage to crop trees. When using non-selective herbicides such as Roundup the application method and timing must be chosen to avoid damage. Residual herbicides (such as simazine or hexazinone) should be avoided in light soils (eg pumice or sand), as they may leach down into the root zones of young trees, causing death or reduced vigour.

Application issues:

When selecting which herbicide to use, application issues should also be considered. For example, in hand application operations, if water availability is a problem or access is difficult for workers carrying full knapsacks, a granular herbicide that is lighter to carry, and will have a similar result may be a better choice than one which has to be applied with water.

WHEN SHOULD THE CHEMICAL BE APPLIED?

The herbicide required to control a weed problem and the herbicide tolerance of the tree crop will determine whether the herbicide is applied before (pre-plant) or after planting (post-plant).

Pre-plant

This is best done in mid-autumn while weeds are still actively growing. This gives sufficient time for the herbicide to work before tree planting starts. Pre-plant spraying allows the use of non-selective[13] herbicides, which control a wide range of weeds but would damage most tree species, eg, Roundup. This method is widely used for sensitive tree species, eg. cypresses, eucalypts, acacias, or where difficult weeds are a problem. It also has the advantage that the bare earth left after the vegetation dies down makes planting easier and reduces the severity of frosts on cold sites.

The longevity of the herbicide effect must be considered when planning a pre-plant spray. For example, Roundup (used by itself) has only a short-term effect and the bare earth that results after spraying is soon re-invaded with weeds. In such cases, a longer-acting herbicide should be used. Because there are so many herbicides for different situations, expert advice should be sought.

Post-plant

This is carried out after planting, by spraying the herbicide either

- around individual trees, usually by the careful use of a knapsack or spotgun (tree shields - protective covers placed over the tree - may also be used as an added precaution to prevent damage to the tree), or
- over the top of trees, using selective herbicides, either by spot spraying individual trees, or broadcast spraying, for example by helicopter.

Post-plant spraying over the top of trees should be carried out when soil moisture is high and soil temperatures are starting to rise in early spring, as this will assist the weeds to absorb the herbicide. However, it should not generally be undertaken if the young trees are actively growing (eg, during a full spring flush) or are under stress, (eg, during a drought), as in such conditions a normally "safe" herbicide may damage the trees.

Post-plant spraying has the advantage that seedling weeds can be controlled right to the base of the tree where soil has been disturbed during planting (soil disturbance often encourages weed seeds to germinate).

APPLICATION METHODS

Herbicides can be applied by hand-held applicators, by motorised backpack, from the air, or from ground vehicles. It is vital to distribute the herbicide uniformly, as local variations in concentration may damage trees where the deposit is high and leave the weeds unharmed where it is low. Growers should seek advice from local experts, including representatives of chemical companies, to determine the most cost-effective methods for specific situations.

[13] A non-selective herbicide will affect all plants it is used on, whereas a selective herbicide is one which is only affective ("selects") on certain plants.

Hand

Hand applicators can be used for some types of pre-planting site preparation, such as spraying small clumps of weeds or spraying herbicide where the trees will be planted.

Post-planting, spraying around individual trees is commonly used and can be very convenient. Spot spraying can cut chemical costs substantially compared to aerial applications. For example, it will require only 6 percent as much herbicide to spot-spray 600 trees per hectare, as to aerial spray the whole hectare. There is also less risk of drift off-target. As a general rule, the diameter of the area sprayed should be twice the anticipated height of the surrounding vegetation.

Hand applicators take the form of spotguns, knapsack sprayers, or granule applicators.

Spotgun: The spotgun is a modified animal drench gun which can be set to give the right quantity of solution per squirt, for a given herbicide concentration. The nozzle should be held 50 centimetres above the vegetation (not at knee height, which is 50 centimetres above the ground).

Knapsack sprayers: These have a back-pack container that holds the herbicide and water mixture which is pressurised by a hand operated pump. The spray is applied through a nozzle on the end of a wand, operated by a trigger, and attached to the back-pack by a flexible hose. It is possible to buy a handpiece for knapsack sprayers (the Targetmaster) that will, like the spotgun, administer a fixed dose. This has all the attributes of the spotgun with the extra advantage of being less tiring to use, compared to the possible hand fatigue from squirting a spotgun a few thousand times a day. If a knapsack does not have a "dose measure", correct dosage rates are controlled by spraying for a set time (in seconds), using a constant pressure (which means a pressure gauge should be fitted between the trigger and the lance. A method of calibrating a knapsack sprayer is given below.

Granule applicators: Granule applicators are made up of a plastic container (which holds the granules), a trigger (which measures the dose) and a spreader (which looks like a plastic funnel). An example is the Weed-a-Metre. The applicator is held at a fixed height (either 1.3 or 0.9 meters directly above the tree, depending on the model - a weighted string of the correct length can be tied to the spreader to measure the correct height) and, when a dose is released, the spreader spreads the granules over a one metre diameter circle. Granule applicators often more convenient to use than the other two methods but are limited by the types of herbicide they can use. Suitable granules are currently available only as Velpar 20G and Prefix D. Advantages include a significant reduction in the weight a worker has to carry and elimination of the need for a water supply to the herbicide mixing site.

Tree shields: Shields can be used to protect trees that may be sensitive to herbicides while still allowing the herbicide to be applied. A useful and inexpensive shield can be made by removing the bottom of a 10 litre plastic container and attaching a handle to the side, long enough for the operator the put it over the tree without having to bend over. Operators using tree shields still need to be careful not to allow spray to drift onto unprotected trees, or to let herbicide drip from the shield onto the tree when removing the shield.

Aerial

The usual method of applying herbicides from the air on forestry pre- or post-plant operations is by helicopter fitted with a spray boom. Helicopters can be more manoeuvrable, fly more slowly and follow the contour better than fixed wing aircraft. In most instances where a small forest grower needs to use aerial herbicide spraying, a helicopter will be the preferred machine.

Situations where a helicopter would be chosen in preference to other spraying methods include:

- large areas, where it is critical to spray all the vegetation in as short a time as possible, to maximise the opportunities of good weather and/or correct stage of vegetation growth.
- steep terrain and/or sites containing heavy harvesting debris, where it would be difficult to carry herbicide in a knapsack
- where all the vegetation has to be covered, such as a pre-burn desiccation spray.

Owing to their very high operating costs, helicopter operations must be well organised and executed. Issues associated with risk of off-target damage must be addressed through good operational planning. Small forest growers should make full use of forestry and aerial work professionals when thinking about a helicopter spraying job.

CORRECTING THE APPLICATION RATE

Too high herbicide rates are a waste of money, can cause tree damage when releasing and are environmentally undesirable, whereas too low a rate may result in little or no weed control. Assuming that the spray mixture is correct (ie, the correct amount of herbicide is correctly mixed in the right volume of water, as per the instructions on the herbicide label), the two main causes of incorrect application rates are not allowing for slope and incorrect calibration of equipment.

Slope Allowances

Allowing for slope on hill country means the extra land on steeper slopes will be treated; otherwise the result could be an under-dose of herbicide and a poor kill of vegetation. Herbicide rates are usually quoted per hectare and, when the number of hectares are measured from a map, the result is horizontal distance, without any allowance for slope. *Table 24* gives the appropriate percentage increases for various degrees of slope. For example, a block of land on a 30 degree slope is measured on a map as being 10 hectares, but actually it is 11.5 hectares.

24: Adjustment for slope

Slope(º)	Approximate increase required (%)	Multiply area (ha) by
10	2	1.02
20	6	1.06
30	15	1.15
40	30	1.30
45	41	1.41

Slope allowance is particularly important in aerial spraying, but the same principle is true for hand spraying.

Knapsack Calibration

If a knapsack sprayer is not fitted with a "dose measure", correct dosage rates are controlled by the time (in seconds) that herbicide mixture is sprayed. Calibration is the procedure used to determine how long an operator must spray with a given nozzle at a constant pressure to ensure that the correct dosage is applied to each spot. It is important that the constant pressure is maintained, so the knapsack should be fitted with a pressure gauge at the trigger.

As the area sprayed around each tree is normally about one square metre, the following procedure can be used:

1. Mark out several test squares, 1 metre x 1 metre, on an area typical of the weeds to be sprayed.

2. Maintaining a constant pressure, record the time taken to adequately spray each square, and then calculate the average time, eg, 4 seconds.

3. Keeping the same pressure, spray into a measuring container for 30 seconds and then use the formula: Volume sprayed divided by Number of seconds. For example, if 200 ml of spray is discharged in 30 seconds, the amount sprayed per second =200 ml / 30 seconds = 6.7 ml/second.

4. The volume applied per one square metre spot = time spent to spray a spot x volume discharged per second: eg, 4 seconds x 6.7 ml/second = 26.6 ml/ m^2 spot or 266 litres/ha.

Example: If 15 litres/ha Gardoprim is required to release radiata pine, how much Gardoprim is needed for one 12 litre knapsack? Following the above example, the answer would be:-

(Knapsack capacity (12 litres) x 15 (l/ha) x 1000 (ml/l)) divided by 266 = 676 ml

Which means the 676 ml of Gardoprim is needed at each knapsack filling, and that each spot needs spraying for 4 seconds at a constant pressure (using the pressure gauge).

Nozzles

The nozzle is the most important part of any sprayer. Uneven application as a result of faulty nozzles may cause big variations in the rate of herbicide applied. Too high a rate can cause tree damage when releasing, whereas too low a rate may result in little or no weed control.

Nozzles deteriorate and need to be checked periodically for signs of wear. To avoid damaging the nozzle, blockages should never be cleared with a pin, knife, or other hard object; soft fine fuse wire is ideal for the purpose and will not cause damage. It is a good idea to keep a length attached to the sprayer for immediate maintenance. Using a strainer on the end of the pipe in the tank will help to prevent blocking by grit or undissolved chemical. *Never* attempt to clear a blocked nozzle by placing it to the mouth and blowing through it.

Grazing

Releasing from weed competition is usually regarded as an operation required during the first 12 to 18 months (or two years, in the case of some species that are slower to establish, like Douglas fir). However, on some very weedy sites it may be necessary to consider longer vegetation management. Restocking situations can be particularly weedy; after removing the tree crop and soil disturbance during harvesting, conditions are ideal for an explosion of dormant seed (eg, gorse), or germination of seed blown in from neighbouring sources (eg, pampas grass), or vigorous growth of a previously suppressed weed.

In these situations, grazing with domestic stock is one method of longer term vegetation management, which could start during establishment.

GRAZING OPPORTUNITIES

If grass has been growing on the site before trees are planted, it may be feasible to graze stock after planting. However, the grazing potential will reduce as the grass is shaded by the trees and as debris from pruning and thinning builds up. Grazing offers many benefits to both stock and forest. For example, stock can benefit from the shelter while the forest can gain from a reduced fire risk, lower silvicultural costs (with workers able to move more easily through the forest) and the turnover of nutrients from the grazed weeds. However, the possibility of the stock damaging the trees must

always be considered and the need for careful and continuous stock management has to be emphasised (see *Grazing Damage* in the next section).

Agroforestry regimes (where stock graze under trees spaced wider than normal to encourage pasture development) were popular during the 1970s and 1980s. However, they are now not generally recommended, especially for radiata pine. This is mainly because the heavy branching of such widely spaced trees on fertile farm sites produces a very low value product above the pruned log, which reduces the overall value of the stand. Current recommendations for forests on farms is to have the same number of trees per hectare as a similar (but usually less fertile) forest site.

"Forest grazing" refers to the situation where farm stock (particularly sheep and/or cattle) are grazed within a forest, either among the trees or along the margins of stands. This may require some extra expense beyond normal forest management, such as fencing, water supply, and possibly oversowing with pasture species including legumes.

The main choices of stock are:

Lambs (weaned) are the best choice when trees are 9 to 12 months old, but considerable care is still needed to avoid browsing damage to trees.

Ewes can be grazed from tree age two years onward, as long as they are carefully managed. Trees over three years old are usually relatively safe from sheep.

Cattle can be grazed among young trees, but considerable care is needed until heavy bark appears on the stem (at about age eight). Cattle unused to forest grazing are more likely to damage trees than xperienced beasts, and dairy breeds are reputedly much worse than beef breeds. Generally, cattle should not be grazed among trees during the establishment phase.

Deer or goats should not be grazed among young trees at all.

When moving stock, it is most important that animals are "drifted" in and out of a stand of trees to prevent them trampling the trees. This requires experienced stock handlers and dogs.

Many forest managers are not prepared to accept the risk of tree damage associated with any early grazing and do not introduce stock until the tops of the trees are beyond browse height. They believe that the financial returns from an extra two to three years of grazing are not sufficient to jeopardise a very valuable forestry operation. For those who are prepared to take the risk, it is *essential* to ensure good livestock management and to have a system of frequent checks.

GRAZING DAMAGE

Domestic stock can damage trees in the establishment phase by grazing the foliage, stripping off the bark, pushing smaller trees over, or by causing root damage by trampling.

Stock being grazed in a forest need very careful management, with tree damage levels being closely monitored (at least daily), and stock removed immediately damage is seen (note: stock mustering under trees can take a lot longer than on open pasture, and it is easy to miss some animals). Careful timing of stock introduction into young trees is important; if the trees are too small, the risk of stock damage increases.

Stock welfare is equally as important when they are under trees as when they are in a paddock. If natural water supplies are inadequate or hard to access, a water supply should be piped in. Generally, grazing under trees is "rough grazing" so stock condition can soon be lost if they are left there too

long. Animals under stress are more likely to damage trees. Tree damage can be high in areas where stock congregate (around gates and troughs, or on "camp sites"), and a compromise may be needed if the owner is to continue with forest grazing, such as accepting that these areas are unlikely to produce good trees and leave them unplanted.

TIMING OF GRAZING

Generally, trees should be three years old before stock can be grazed among them. However, local conditions may permit some earlier grazing, so advice from a local forestry consultant is recommended.

Grazing stock among young trees many provide some benefits, but exposing young trees to the possibility of grazing damage may result in long term financial loss if damage is not prevented or minimised. The possibility of the stock damaging the trees must always be considered and the need for careful and continuous stock management has to be emphasised.

Arranging the Work

After choosing what, where and when to plant, the next decisions in planning forest establishment work should be the level of personal involvement from the forest owner. The choices include:

- "doing it yourself" - becoming a forest worker
- using the assistance of a professional consultant, but still doing the physical work
- using professional consultants and experienced contractors, but overseeing the operation
- leaving the management completely to professional consultants and contractors.

Most site preparation work that involves machinery will generally be done by contractors who hire out the specialised equipment (with operators).

Tree planting work is generally best done by specialist forestry contractors, except for small areas less than five hectares. This ensures the work is done quickly, efficiently and safely. If a small forest grower has any doubt about their own ability to carry out a particular operation, hiring experienced contractors is the best alternative.

Similarly, small areas of post-plant releasing could be done by the forest owner, but using a contractor (often the same one as for the tree planting) for larger areas is often a better choice.

The requirements of the Health and Safety in Employment Act (HSE) 1992 must be considered when planning any work on a forestry property. These are covered in some detail on page 75.

PRICING

Competitive tendering is often a good way of obtaining the best price for a job. This is particularly the case when a small forest owner has not had any previous experience with forestry contracts. Forest owners can advertise the work in the local press and/or contact a number of contractors and invite them to tender for the work. Before accepting a tender, the forest owner (or the owner's agent) and contractor(s) should inspect the area to discuss the job. For tree planting work, the quality standards, methods of measuring quality, and who will do the quality control should also be discussed. It is very useful for the owner to ask the contractor to demonstrate the planting method the contractor will be using, to avoid any later misunderstanding. The owner's satisfaction with the discussions and demonstration can be taken into account when awarding the contract.

When choosing between tenders, it is important to avoid accepting very low tenders which may result in the contractor losing money or the job not being done properly in an attempt to make a profit. Low tenderers may also disrupt the operation by pulling out before it is completed, if they start to lose money on the operation.

CONTRACTS

Once a tender has been accepted a contract should be signed between the forest owner (or the owners agent) and the successful contractor. This contract should contain a work description and set out the period for completing the work and details of payment. Any work carried out for a small forest grower by someone else, such as a forestry contractor, whether it costs $1,000 or $10,000, should be done under a written contract, to give both parties some security.

As planting work is seasonal, it is possible that some of the workers in a contract crew are new recruits. It is a good idea to build into the contract a clause allowing an initial training period on an hourly rate payment, which removes production/performance pressures from the crew and allows time to be spent on training. The contractor and forest owner can discuss the need to take up that training time when the job starts. If the job is well into the planting season, the crew may be fully trained and experienced on other planting jobs. Having a "training clause" at least gives the option, and the owner should ensure the contractor is fully aware of it.

It is also useful if a contract has a "work inspection clause" that allows the owner (or agent) to be satisfied that individual workers in a crew are proficient, and if not, to request that the worker(s) be trained. In such cases, there should be follow-up inspections and the contract should allow the owner to require that workers who still are not proficient are discontinued from planting.

There should also be a clause outlining the action for correcting planting faults, especially if the owner wants to specify that the contractor has to pay for replacement trees (see *Quality Control* on page 50)

There are normally three parts to a contract. The first part is the actual contract itself and is the document signed by the contractor and the forest owner (or their representatives). An example of this is in *Forestry Law and Precedents*, (available from the Ministry of Agriculture and Forestry), in the section *Contract for the Provision of Services*.

The job description is usually attached to the contract and is called the First Schedule. Contract conditions or planting prescriptions can also be attached to the contract, in which case they are called the Second Schedule. The draft contract in *Forestry Law and Precedents* has examples of First and Second Schedules for fire-breaking, fencing, scrub clearing, scrub-crushing and tree planting, which can be modified to meet the requirements of individual small forest owners.

Once a contract has been signed, it is possible to extend it to include extra work, for example by having an exchange of letters with new First and Second Schedules.

It is recommended that a law professional is consulted by both parties in matters concerning legal contracts.

HEALTH & SAFETY IN EMPLOYMENT ACT 1992

The main purpose of the HSE Act is to prevent harm to employees in places of work. It requires that employers take all practicable steps to provide a safe working environment. Employers must identify all hazards in the work place and eliminate, isolate or minimise hazards considered to be

"significant"[14]. All employees or visitors must be informed and educated about the hazards to which they could be exposed.

The Act also imposes responsibilities on what it terms "Principals"- for example, people or companies who engage contractors or consultants rather than employees. A Principal must take all practicable steps to ensure that contractors, subcontractors or their employees are not harmed at work, and document these steps. Forest owners are regarded as Principals if they employ a contractor directly or if they employ a consultant (or other intermediary agent) who in turn employs a contractor.

As a Principal, the forest owner should:

- undertake contract control, which may include spot inspections, safety audits, and regular meetings with the contractor.

This could involve:

  - viewing the contractor's safety plan, checking that the crew is regularly using checklists in the plan and checking with the contractor that any poor practices shown up on those checklists are corrected
  - borrowing and using some contractors' checklists for random checks, or obtaining local Department of Labour assistance in making up a checklist.

- provide information on safety at work sites. Forest owners should advise contractors (in writing) of hazards on the property that could affect the operation. This may include narrow culverts, unstable sections of tracks, bluffs or tomos, public roads or power lines. The contractor should also be notified in advance of any visitors to the site (including the forest owner).
- not give any directions or instructions which may increase hazards. If a contractor refuses to accept directions which may increase hazards, the owner will not be able to call in another contractor to carry out unsafe practices without incurring a high risk of liability under the HSE Act in the case of an accident.

Communication on matters relating to the HSE Act should always be in writing, signed by both parties with each keeping a copy. If an accident should occur, it may be useful as evidence that directions or instructions were actually given.

More information on safety in the workplace is available from the Occupational Safety and Health (OSH) Service of the Department of Labour. OSH publications include *Safety Code for Forest Operations and Guidelines for the Provision of Facilities* and *General Safety and Health in Forestry Work*.

Many of the above tasks can be carried out by a consultant (or other intermediary agent), but it must be stressed that the forest owner still carries a high level of responsibility. It is in the owner's interest to use only agents who are skilled and experienced, with a proven record of good conduct in their field.

FOREST INDUSTRY RECORD OF SKILLS

The New Zealand forest industry has developed an industry skill recognition system called the *Forest Industry Record of Skills* (FIRS).

It is administered by the Logging and Forest Industry Training Board (LFITB), and is based on assessed practical work skills completed as a series of modules for specific forest tasks. Operators

[14] The HSE Act interprets "significant hazard" as an actual or potential source of serious harm; or harm which is more than trivial (the severity of which depends on a person's extent or frequency of exposure to the hazard); or harm that does not usually occur (or is detectable) until a significant time after exposure to the hazard.

can attain a National Certificate in Forest Establishment and Silviculture upon completion of 11 modules and four years' work experience.

It is recommended that one of the criteria forest owners use when selecting contractors is that workers they employ are trained or undergoing training for the tasks they are doing, and that this training is recognised under the FIRS system.

Establishment Records

Maintaining records either in writing or on computer is an important part of forest management. Good records of establishment are helpful in later management of the forest and can be used to evaluate the cost effectiveness of various operations.

The following information about establishment operations are useful management records :

Site preparation: Site preparation records should include the method used, any herbicides applied and the rate of application, and the year and month the site preparation was done.

Planted area: The area finally planted should be recorded in hectares. This area should be accurately identified on a map or aerial photograph. A common method of measuring the area is to have large scale (1:10 000) aerial photographs taken of the forest as soon as the trees are old enough to be seen on the photo (usually around age two). A line is drawn on the photo around the edges of the area(s) stocked with trees and the number of hectares within the stocked area is measured using a dot grid or planimeter. Aerial photographs can be obtained from local aerial photography firms.

Other maps may be suitable, such as large-scale farm maps with accurately measured paddock areas, where whole paddocks have been planted in trees. Another option may be to use a large-scale property map and mark tree planting boundaries onto it from the results of a simple triangulation survey.

Most forestry consultants have the equipment and skill necessary to accurately measure stocked area.

Date of planting: Record the year and month of planting.

Species and seed source used: Where radiata pine is planted, this should include the breed and improvement rating, eg, GF17. The type of stock and the nursery it was obtained from should be recorded, eg, open-rooted seedling GF17 radiata pine 1/0 from NJZFRI Nursery, Rotorua.

Stocking established: The average stocking measured in quality control plots at planting should be recorded.

Survival: At the end of the first growing season, plots can be used in the planting area to record the number of dead trees. Percentage survival may then be calculated and recorded. The plots can be laid out in the same way as for quality control plots, described on page 85.

Releasing undertaken: The method of releasing, the area treated and the date it was applied should be recorded. Where herbicides are used, the chemical and rate of application should be included.

Appendix 1:

PLANTING PRESCRIPTION

This example of a planting prescription may form part of a contract Second Schedule (see *Contracts* on page 74), or can be a separate appendix to the contract

PLANTING PRESCRIPTION

Forest: _____ **Stand**: _____

Species: Radiata pine **Planting Stock**: Open rooted, GF17, 1/0

Stocking: 1000 Stems Per Hectare (sph) *Maximum*: 1050 sph *Minimum*: 950 sph

Spacing: Between Rows 4m
Between trees within the row 2.5m

Planting Method

A triple cut planting method will be used as described below and as demonstrated.

1. Cultivate a good planting spot 30 centimetres x 40 centimetres to a minimum depth of 30 centimetres.

2. Open a good planting slot, more than 25 centimetres x 10 centimetres at the bottom of the cultivated spot.

3. If the depth is less than 25 centimetres, the hole opening operation must be repeated to increase hole depth.

4. Place the tree roots at the bottom of the hole. Some roots may be slightly twisted but they will be straightened later.

5. Fill the hole, burying the roots deep in loose soil.

6. Give the tree stem a positive pull-up (10 centimetres, a hand width) to straighten any roots that may have been twisted up and to point lateral roots down slightly.

7. Still holding the stem, firm soil around tree roots by pressing down firmly with the soles of the boot (one either side). Never stomp down with the heel as this crushes and damages roots.

Other Requirements

1. Trees must be handled carefully and not be left exposed to the sun and wind. Trees that will not be planted immediately must be left in a cool sheltered location.

2. When planting, avoid damaging the root collar (stem at ground level) during firming of soil with the boots.

3. Practices such as knocking the soil off roots or throwing boxes of trees will not be tolerated.

4. Plant the tree in a spot free from obstructions such as rocks and roots that may cause root distortion and retard growth.

5. Only one box of trees to be planted from at a time, ie do not cram trees from a second box into a single box.

6. Only one tree to be out of the box at any one time, ie do not carry several trees in the hand.

7. Seedlings must be firmly planted so that they will not move when held between the thumb and forefinger and given a light tug.

8. All seedlings must be vertical after planting.

Appendix 2:

TREE PLANTING QUALITY CONTROL

The description of a tree planting quality control (QC) method can be used by a small forest grower either to carry out quality control themselves, or as an example to check against a contractor or consultant who claims to be using a formal QC system, as discussed in *Quality Control* on page 50.

QC assessments are made in random strip plots throughout the area that is being planted. Assessments should be done while the job is in progress so that any deficiencies can be corrected while the workers are still on site. The results from QC assessments may be used to approve payments for the work when it has been carried out satisfactorily.

The person carrying out or overseeing QC needs to be well versed in all aspects of the operation and needs to know the job description and contract conditions.

Workers carrying out the planting should be supplied with the job description and a map of the area. They should also be aware of the definition of the QC items and any demerit system (and any subsequent effects on payment).

Planting Specifications

A correctly planted tree:
- is the correct distance from trees on either side
- is vertical
- has had satisfactory cultivation of the planting spot
- has its roots aligned both laterally and vertically
- is planted at the correct depth.

Sample Intensity

An intensity of at least 2 percent should be aimed for. This is one 400-square-metre plot for every two hectares being assessed (the assessor needs to know approximately how many hectares are involved). The intensity of the sample should be increased if planting quality is suspect, so it is not always practicable to pre-determine plot locations.

Demerit System:

Each tree is assessed according to the definitions described below. A demerit system translates these into an objective measurement where demerit points are "awarded".

The total demerits are calculated on a field sheet and the planters are immediately informed of the results. There should be a pre-determined maximum number of demerits (for example, 15 demerits), beyond which a rework is required. A rework entails the planting crew walking back through the area just planted, looking at each tree, and rectifying mistakes (eg, by pulling out the problem trees and replacing them properly with fresh trees).

Calculating Payments

A demerit point system may also be used when withholding payments for unacceptable work. For example, the full price (100 percent payment) could be paid if the average demerits for all QC plots in

a payment period were 5 or less, with a sliding scale thereafter (eg, 6 to 10 points = 95 percent payment, 11 to 15 = 90 percent payment, and over 15 = a rework).

If this system is to be used, it must be clearly outlined in the job prescription and included as part of the contract. However, it should be remembered that the objective is to have the trees planted correctly, rather than reducing payments. The contractor should be given every opportunity to achieve this, which means ensuring that QC is carried out immediately behind the crew, and not a day or two (or more) later.

Definition of Terms for Demerit Points

Distance within Row: The average in-row horizontal distance of five consecutive trees is plus or minus 10 percent of the prescribed distance. *Half a demerit point.* (Where a tree is ± 10 percent of the prescribed distance, the next four trees should be checked before the fault is recorded.)

Distance between rows: The average between-row horizontal distance of five consecutive trees is ± 10 percent of the prescribed distance. *One demerit point.* (Where a tree is ± 10 percent of the prescribed distance, the next four trees should be checked before the fault is recorded.)

Note: In checking distances, allowances should be made when obstructions such as rocks, stumps/roots, harvest debris, etc. The QC operator will have to make a value judgement in such cases.

Tree missed: A tree should have been planted but was not. *Two demerit points*.

Note: Where an obstacle makes it impossible to plant at the correct spacing, the tree should be planted in line at the next available correctly spaced location.

Not firm: Insufficient effort has been made to firm the tree and it can easily be removed from the soil. *Two demerit points.*

Not vertical: The tree is more than 25 degrees from vertical. *Two demerit points*

Cultivation: The cultivated planting spot is less that specified (usually a minimum of 30 centimetres x 40 centimetres to a depth of 30 centimetres). *Two demerit points*.

Roots: The roots are pushed up inside the planting hole, instead of being orientated downwards. *Two demerit points.*

Slit planting: A good planting hole has not been opened up and all the roots are aligned in one plane. *Two demerit points*.

Incorrect depth: The tree is not planted within the prescribed depth limitations. *Two demerit points.*

Acceptable: The planted tree satisfies all planting requirements.

Quality Control Equipment:

- Transect line (or tape) 80 metres long.
- A pole marked in metres and centimetres for measuring plot width and spacing between trees.
- Planting spade.
- Steel probe for checking cultivation depth.

- Recording sheet (an example is on the next page) or notebook.
- Cans of spray paint.

Field Procedure

It is generally more efficient and accurate for two people to do planting quality control plots.

1. Choose the start of each plot randomly, eg by throwing a stone and starting the plot where the stone lands.
2. Tie the end of the transect line (or tape) to a piece of vegetation, or something like a spade stuck in the ground.
3. Clearly mark the start of the plot with spray paint.
4. Where the trees are planted in lines up and down the slope, the plot should run along the slope to avoid the need for slope correction. Where the lines are planted along the contour then the plot should run up (or down) the slope to cross a minimum of four lines of trees, in which case slope correction tables will be needed (available in *Managing a Small Forest For Timber*).
5. Measure 2.5 metres horizontally on either side of the line to determine which trees are "in" the plot. In may help if the plot boundary is marked with spray paint on the ground.
6. Using the measuring pole or the tape, measure the spacing of trees between rows and within the row.
7. While checking the spacing, visually assess all trees for faults. At least one tree in each 20-metre section of the plot should be dug up to check that the roots are correctly aligned and that the planting spot has been correctly cultivated.
8. Record details of all trees assessed on an appropriate field sheet. An example of a field sheet which can be photocopied for use, is on the next page.
9. Clearly mark the end of the plot with spray paint (marking the plot will allow it to be relocated if anything needs to be checked later).
10. At start of the planting job, or if work quality deteriorates during the job, the contractor should accompany the quality controllers to ensure a full understanding of the work standard required.
11. Class each tree as either acceptable or unacceptable and recorded in the field book.
12. Total all the trees in the plot and multiply by 25 to calculate the stocking achieved.
13. Replanting is indicated if stocking does not conform to the prescribed tolerances.

TREE PLANTING QUALITY CONTROL PLOT SHEET					
CATEGORY		Demerits (a)	Tally	Number (b)	(a) x (b)
Distance within row	A	0.5			
Distance between rows	B	1			
Tree missed	C	2			
Not firm	D	2			
Not vertical	E	2			
Cultivation	F	2			
Roots	G	2			
Slit planting	H	2			
Incorrect depth	I	2			
			Total (J)		
			Total demerits for plot		
Acceptable	K				
K x 25 = total acceptable stems per hectare (L)					
J x25 = total unacceptable stems per hectare (M)					
L + M = total stems per hectare					

Appendix 3:Notes on Establishing Special Purpose Timber Species

Most of the information and principles on establishing a small forest described in this book apply to any tree species. However, some special purpose timber species have particular establishment requirements. Further information about choosing a site for special purpose timber trees, and how to manage them, is in the *Small Forest Management* series' *Special Purpose Timber Species*.

Cypress

Cypress trees need to be planted in sufficient numbers to achieve a selection ratio of not less than four to one, that is four trees planted to one final crop tree. If the final crop is to be 300 stems per hectare then it is recommended that at least 1200 stems per hectare be planted. Where better quality planting stock is available, the ratio may reduce to three to one (900 planted for a final crop of 300 stems per hectare). Where cuttings are available, they may be planted at 600 stems per hectare on fertile, sheltered sites.

Cypress has a very dense root system that is slow to spread, so early root competition (especially from grasses) needs to be eliminated. Herbicides with a residual action should be applied before planting to obtain the maximum benefit. If weed growth is still a problem after planting, a knockdown herbicide should be used, in conjunction with tree shields.

Blackwood

Blackwoods need shelter, especially side shelter, to achieve maximum growth rates and good tree form. They grow best in situations where side shade is provided by indigenous vegetation or a nurse crop such as a eucalypt species, but some annual form pruning is often necessary to keep a single straight leader and to reduce any tendency of the tree to fork. In other situations, such an area planted with just blackwoods, annual form pruning is required from age two or three years until around age six to eight years. All branches over 25 millimetres diameter should be removed, no matter where they are on the tree. The best way to do this is to use a calliper to measure the branches as close as possible to the trunk and use loppers or a pruning saw to remove those branches that are larger than the calliper

Eucalypts

Rapid development of young eucalypts depends on the ability of their roots to extend into the surrounding soil. Compacted soils should be ripped before trees are planted. Where possible, full site cultivation methods such as discing should be used to improve soil properties, assist rapid early growth, and reduce frost damage in frost-prone areas.

Where full machine cultivation is not feasible, alternative methods of soil disturbance should be used. On sites where a previous tree crop has been harvested, the mounding of topsoil with a V-blade can be very effective. On steep sites, thoroughly cultivating the soil around the planting spot with a spade is recommended. If the vegetation has been removed by burning or chemical spraying, subsequent cultivation may not be essential if the soil is friable enough to allow free root growth.

Care must be taken to ensure that eucalypt seedlings are planted correctly. With open-rooted seedlings, the roots should be spread on planting and the soil replaced and firmed around the stem without excessive compaction. Container-raised eucalypts need to be planted in well-cultivated soil to encourage the rapid development of a vigorous root system. If peat-based containers have been used, the rims should be removed, otherwise they will project above the soil surface and can act as a

wick, allowing moisture to evaporate and making the pot walls impenetrable to the roots. The base of the pot should also be removed immediately before planting because it can act as a barrier to taproot development.

Good weed control after planting is essential for the successful establishment of eucalypts. While mechanical cultivation could be an option on flat, obstacle-free terrain, weed control generally requires the use of herbicides. Many of the herbicides commonly used in forestry operations can kill or damage young eucalypts, so weed control measures are best carried out before planting. Because eucalypt seedlings are susceptible to so many herbicides, no herbicide should be used operationally until the forest grower is satisfied that the chemical has performed satisfactorily under similar conditions, either in small trials or in other forests. If a grower has any queries about the use of herbicides on eucalypts, specialist advice (for example from a chemical company representative) should be sought

Open-rooted and container-grown eucalypts respond well to nitrogen fertiliser; a common recommendation is for 60 grams of urea or 80 grams of diammonium phosphate (DAP) applied in a spade slit 20 centimetres to one side of the seedling at or soon after planting. It is essential to accurately place the urea, because if this fertiliser is placed closer to the roots it will kill them. Maximum response to any fertiliser does, however, depend on keeping the seedling free of direct weed competition during the first growing season after planting.

Deciduous Hardwoods

When planting deciduous hardwoods good weed control is essential to ensure the survival of the young trees. They are particularly susceptible to moisture stress caused by grass competition. Because of its low tolerance to herbicides, *Robinia* should be planted into sprayed spots, prepared three months before planting, but other species may tolerate a release spraying of some grass control herbicides. If there is any doubt about the use of herbicides on a particular species, specialist advice should be sought before use.

Poplar

As a general rule, the depth of planting poplars should be one third of the length of the planting stock. A crow bar or special pole can be used for planting. It is stuck in the ground and forced down using the planter's weight. The tool is then removed, the tree pushed into the hole and the surface rammed tight. A small, hand pole driver consisting of a 60 centimetre length of 100 millimetre steel pipe with handles attached can be used to drive larger thicker tree poles with sharpened ends.

Planting density is usually 200 to 280 trees per hectare for stakes and trees, and 150 per hectare for poles.

Competing vegetation, especially grass, must be controlled by hand tools or herbicides, throughout the first two growing seasons, particularly with unrooted stake planting stock. If the planted stock is protected from grazing animals (by individual tree protectors) continuous grazing of the planted area by livestock is possible. For plantings that are unprotected, the area should be retired from grazing for about three years to allow the trees to attain sufficient size and rough bark to resist damage from grazing livestock.

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Where to go for Help

NZ FARM FORESTRY ASSOCIATION
The New Zealand Farm Forestry Association is a national organisation representing the interests of the small forest grower. The Association has branches throughout New Zealand that hold regular field days and meetings where experiences in establishing small forests can be shared.

FORESTRY CONSULTANTS
Private forestry consultants throughout the country advise on small forest management. The New Zealand Institute of Forestry (NZIF) operates a recognition scheme for forestry consultants, and there are also a number of independent consultants who are not in the NZIF scheme.

FOREST INDUSTRY ORGANISATIONS

The following forest industry organisations have a range of information referred to in this handbook.

Logging and Forest Industry Training Board
New Zealand Forest Owners' Association
Logging Industry Research Organisation
Forest Research

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