This Best Practice Guide is being reviewed.

The future of Best Practice Guides will be decided during 2015.

Best practice guidelines for Tree Planting

Vision, knowledge, performance

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Competenz
SKILLS FOR INDUSTRY

He Mihi

Nga pakiaka ki te Rawhiti.	*Roots to the East.*
Nga pakiaka ki te Raki.	*Roots to the North.*
Nga pakiaka ki te Uru.	*Roots to the West.*
Nga pakiaka ki te Tonga.	*Roots to the South.*
Nau mai, Haere mai	*We greet you and welcome you.*
ki te Wãonui o Tane	*To the forest world of Tane.*
Whaia te huarahi,	*Pursue the path,*
o te Aka Matua,	*of the climbing vine,*
i runga, I te poutama	*on the stairway,*
o te mãtauranga.	*of learning.*
Kia rongo ai koe	*So that you will feel,*
te mahana o te rangimãrie.	*the inner warmth of peace.*
Ka kaha ai koe,	*Then you will be able,*
ki te tũ whakaiti,	*to stand humbler,*
ki te tũ whakahĩ.	*Yet stand proud.*
Kia Kaha, kia manawãnui	*Be strong, be steadfast.*

Tena koutou katoa.

First edition October 2000

Revised edition January 2005

These Best Practice Guideline are to be used as a guide to certain tree planting procedures and techniques. They do not supersede legislation in any jurisdiction or the recommendations of equipment manufacturers.

FITEC believes that the information in the guideline is accurate and reliable; however, FITEC notes that conditions vary greatly from one geographical area to another; that a greater variety of equipment and techniques are currently in use; and other (or additional) measures may be appropriate in a given situation.

Other Best Practice Guidelines included in the series:

- Cable Logging
- Chainsaw Use
- Fire Fighting and Controlled Burnoffs
- Ground-based Logging
- Land Preparation
- Loading
- Maintenance inspections of Yarder Towers
- Manual Log-making
- Mechanised Harvesting and Processing
- Mobile Plant
- Personal Protective Equipment
- Road and Landing Construction
- Silvicultural Pruning
- Transport
- Tree Felling
- Working with Helicopters

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Best Practice Guidelines
for
Tree Planting

Contents

Introduction

Purpose of these guidelines

The Best Practice Guidelines for Tree Planting have been designed by FITEC in conjunction with the forest industry to improve worker safety and performance. They combine industry training standards and best practice information to provide a valuable reference manual for people involved in tree planting.

These guidelines should be read in conjunction with the Approved Code of Practice Safety and Health in Forest Operations. In particular, these guidelines provide direct support for Part 3 - Section 12 (Land Preparation and Establishment) of the code.

They are a valuable reference document for the following Unit Standards registered on the NZQA framework:

Unit 1221 – Demonstrate knowledge of job prescriptions for forest operations

Unit 1234 – Plant plantation trees

Unit 1235 – Plant plantation trees in a production situation

Unit 1241 – Demonstrate knowledge of plantation forest establishment and silviculture

Unit 6923 – Demonstrate knowledge of planting plantation trees

How to use these guidelines

These guidelines have been arranged in two main sections:

- **Tree Planting Basics** - provides an overview of planting and land preparation operations, and hazard management.
- **Tree Planting Procedures** - details the step-by-step procedures for tree handling and planting, and fertiliser application.

The **Glossary of Terms** gives the meaning of terms used throughout these guidelines.

The **Index to Unit Standards** allows the reader to locate information specific to each of the Unit Standards listed above.

Acknowledgements

FITEC acknowledges the assistance of the Occupational Safety and Health and Service, Liro Forestry Solutions, and numerous forest industry trainers, forestry contractors, and forest company staff in the development of these Best Practice Guidelines.

About best practice training material

FITEC has developed the material in this publication. It has been reviewed by representatives of the forest industry. At the time of publication, FITEC considers the practices and approaches in this publication to exceed accepted industry standards with regard to production and business management. In addition, the practices recommended in the publication exceed all the New Zealand regulatory standards, in particular those related to health and safety, environmental management, and human resources / employment.

This material is reviewed and reprinted regularly by FITEC.

Tree planting basics

Planting objectives

The objective of tree planting is to (successfully) establish a uniform and healthy tree crop.

A recently planted site

Tree crops are generally planted to provide timber production and financial returns to the forest owner.

They may also provide environmental benefits including:

- Erosion control
- Water quality improvement
- Recreation opportunities
- Scenic improvement
- Shelter and shade
- Wildlife habitat
- Carbon uptake

Key elements of successful planting include excellent:

- Tree handling
- Soil cultivation
- Planting hole depth
- Root placement
- Tree firmness

The planting operation is a very important first step in the life of a tree crop. If not done properly, the following may result:

- Inadequate or excessive stocking rates
- Poor early growth
- Poor tree straightness, large branches and poor wood quality
- Tree mortality
- Toppling and subsequent windthrow
- Uneven growth within a stand

These effects may reduce future returns to the forest owner. In some cases, a site may need to be re-established, at considerable cost to the forest owner. It is therefore critical that planters do their job well.

Remember - a tree is a living thing and needs to be treated with care.

Effects of land preparation

Prior to planting, many sites receive some form of land preparation treatment. Effective land preparation can improve initial tree growth and survival, and lead to a more uniform crop.

Through appropriate land preparation, factors that limit tree growth are overcome. These factors include:

- Poor drainage
- Weed competition
- Compacted or naturally dense soils.
- Frost
- Heavy slash

Land preparation improves the site for planting by removing slash, cultivating the soil and elevating the planting spot without causing excessive soil disturbance or degradation. Combined with the use of proper planting techniques, land preparation will provide trees with a good start to growing.

The treatment of heavy slash, weeds, and dense soils can also improve planting productivity. Treatment will increase the ease of access and planting. This provides skilled planters with the opportunity to plant trees in the best spot for maximum survival and growth.

Types of land preparation operations

A range of operations can be used to improve the planting site. Broadly, land preparation operations can be divided as follows:

Type of land preparation	Purpose	Land preparation operation
Vegetation treatment	Kill (desiccate) vegetation	• Agrichemical application by hand or helicopter
	Flatten and/or chop standing vegetation	• Manual (hand) and motor-manual land clearing • Tractor crushing • Roller crush (gravity or towed)
Slash treatment	Remove or redistribute slash	• Windrowing • Burning • Line blade • Line rake • Mulch
Cultivation	Loosen compacted soils Improve tree stability	• Continuous ripping • Spot ripping • Spot cultivation
Cultivation and mounding	Reduce frost risk Improve drainage	• Continuous ripping-mounding • Spot ripping-mounding • V blading • Spot cultivation and mounding

Agrichemical application

- The application of agrichemicals controls weed species that compete with the planted crop.
- Can either be broadcast (over entire site), or concentrated at individual spots or along continuous strips.
- Commonly applied by helicopter (broadcast), brush gun, knapsack sprayer (concentrated).

Manual land clearing

- These operations may include land clearing by scrub cutting, or preparation by line cutting or spot clearing/releasing.
- Typically carried out by groups of workers using slashers (or other hand tools).

Motor-manual land clearing

- The most common method of motor-manual land clearing involves the use of chainsaws or brush-cutters.

Tractor crushing

- Standing vegetation can be flattened by crushing with the blade of a tractor (or skidder).
- The machine moves across the site with the blade above the ground.

Roller crushing

- Roller crushing is used on both standing scrub and on cutover.
- It can be used as a pre-burn preparation (for standing scrub) or as a land preparation treatment on its own.
- It can be used on flat to rolling terrain (towed rolling) or on steep terrain (gravity rolling).
- Roller crushers are either towed or connected by winch to a bulldozer.

Windrowing

- Windrowing clears the majority of the heavy slash from the area to be planted, leaving it piled in rows. This allows planters to traverse the site without having to climb over the logging debris and ensure that trees are planted into soil.
- Typically bulldozers and excavators are used for windrowing.

Burning

- On sites with excessive slash or standing (but dead) vegetation, controlled burning may be used.
- A less favoured method because of the loss of organic matter from the soil surface and the potential for accidental burning of surrounding areas.

Line blading and line raking

- Line blading and line raking operations are very similar to each other and are intended to clear lines through sites covered in heavy slash or scrub.
- Bulldozers and excavators can be used for line raking. Bulldozers are used for line blading.

Mulching

- On some sites, removing slash by windrowing or burning is undesirable. On these sites, mulchers attached to excavators or tractors can break the slash into a coarse chip-like mulch.
- They can also be used to treat live vegetation as an alternative to spraying.
- Mulchers can be attached to excavators or bulldozers.

Continuous ripping (and mounding)

- Ripping and mounding is used to cultivate soils where soil compaction (density) or drainage is limiting early tree growth. Ripping and mounding machines work best on clear sites. If they are working on cutover with logging residues, a path needs to be cleared through the slash prior to the cultivation pass.
- Bulldozers are used for ripping and mounding operations.

Spot ripping-mounding (and mounding)

- Spot mounding and spot ripping-mounding are very similar operations.
- They are typically carried out with cultivation tools mounted on an excavator. These include custom built spot cultivation heads,a ripping tyne and bucket, or rotary head.

- They also improve compacted and poorly drained soils.
- Spots can be positioned in the best location. Slash can be cleared before cultivation is carried out.
- Elevation of the planting spot reduces the impact of frost on young trees.

V-Blading

- V-blading is a bulldozer-based operation for creating high continuous mounds of cultivated soil.
- This operation is used for drainage on very wet sites or to overcome frost problems.

Tree stocks

Radiata pine and other species are grown either from seed, cuttings, or tissue culture plantlets.

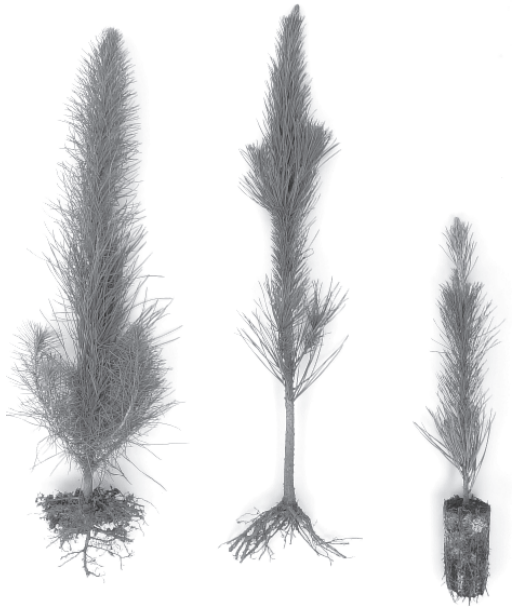
These plants are either bare-root or container-grown. They generally remain in the nursery for 1 year, which allows them to grow big enough to withstand transplanting shock.

Tree stocks are genetically improved to provide better growth, form, wood properties, and resistance to disease. A GF Plus™ rating identifies the degree of genetic development for each of the tree growth, form and quality traits.

When considering the number of trees per hectare to be planted on a site, forest owners will take into account:

- Tree mortality (how many trees will die)
- Selection of the biggest, straightest, and most healthy defect-free trees in future pruning and thinning operations
- Competition between trees to control stem diameter and branch growth.

This may vary from forest to forest.



Bare rooted Seedling, cutting, and container grown tissue culture plantlet

Planting

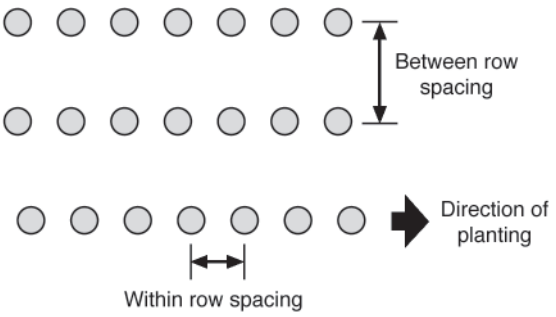
Tree planting can be divided into the following tasks:

- Selection of planting spot
- Soil cultivation and opening the hole
- Filling in loose soil
- Quality control
- Screefing (if necessary)
- Root placement in hole
- Straightening and firming in

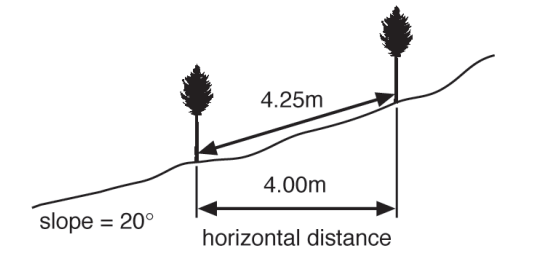
Selection of Planting Spots

Trees are planted in rows to:

- Make it easier to achieve the required stocking
- Allow planted trees to be identified from regenerated trees for future tending operations (e.g., post-plant spot spraying).
- Produce uniform branch and diameter growth.
- Assist in the management of later silvivultural operations



Row and tree spacing



Tree spacing on a slope is higher than on the flat

The steps for selecting planting spots are:

(1) Identify good planting spots.

(2) Identify required row spacing.

(3) Identify required tree spacing within rows.

The required stocking is achieved by planting trees at the correct spacing within and between rows.

The row and tree spacing (and stocking rate) should be identified in the job prescription.

Rows may be planted further apart than trees within the row to reduce planting and tending costs.

The stocking rate needs to be uniform over the site. Stocking is based on a flat area (plane). Therefore, tree spacing will need to be different on flat and sloping ground to maintain the same stocking.

For a given stocking rate, tree spacing is greater on a slope than on flat ground. If the correction for slope is not made the stocking rate will be too high.

If planting is around the contour, adjust the between-row spacing for slope.

If planting up and down the slope, adjust the within-row spacing for slope.

Planters maintain the required between-row spacing by working alongside each other. The planter then paces out (where possible) the required within-row spacing.

The best planting spot is:

- within the row
- at the correct tree spacing
- located to maximise the chance of the tree surviving and growing well.

The following guidelines should be used when selecting planting spots.

- Planting spots are ideally clear of all weeds and heavy slash. The planter may need to clear the spot with the spade or boot before cultivation (screefing).
- Preferably it will be slightly raised above the surrounding ground. It should have the topsoil intact and not be compacted by any machines (wheel ruts).
- Where mechanical cultivation has taken place, trees should be planted on top of the cultivated area.

Trees should not be planted in the following positions:

- Ruts
- Dips or wet spots
- Among weeds
- Heavy slash
- Next to stumps and rocks.
- On the edge of banks or batter slopes

In cutover planting, weeds and slash are common. They should be cleared from the planting spot by “screefing” with the spade.

If a spot has to be placed outside the correct spacing, it should remain in row. Trees planted off the row may be missed during later operations or mistaken as lower quality regeneration.

Where a site has been spot or strip-treated before planting, the job of selecting planting spots is much easier.

Between-row spacing needs to be checked on sites that have been continuously line treated. This will allow the correct within-row spacing to be determined.

Further information on land preparation is presented in the **Best Practice Guidelines for Land Preparation**.

Soil cultivation

Soil cultivation involves two steps — first loosening the soil, and then opening a hole large enough to allow the root system to be placed in it with minimal distortion.

Tree planting

The most common way of planting trees in the field is with a purpose-designed planting spade. In some situations, tractor-towed planting machines may be used. Their use in cutover sites is very limited in New Zealand due to the difficulty of manoeuvring the planting machine over stumps and debris.

Planters need to handle the tree stocks carefully to avoid damage to them.

Roots need to be placed to ensure that the lateral roots are not pointing up or bunched below the stem (see right).

Correct orientation of the roots is achieved by pulling the tree up slightly before the soil is firmed around the tree stem. At least 10 cm of the tree stem should be below ground level.

Root system on the left is distorted; the one on the right is correctly orientated

Job prescriptions

The forest owner should provide a job prescription for every job undertaken in the forest. This is the set of instructions which the planters must follow in order to carry out the task. A prescription should be written simply and clearly, and outline in detail the requirements of the job. A job prescription should have:

- Specified the operation to be carried out
- The location of the site (forest/compartment/road)
- A map showing:
  - boundaries, area to be treated
  - streams
  - hazards
  - sensitive areas to be avoided
  - planting line orientation or direction
- Anticipated start date
- Expected completion date
- Contact name, address, and phone numbers for the operation supervisor
- A detailed list of technical specifications for the job to be undertaken. This will vary with the operation. For example, a planting operation should have:
  - The type of trees to be planted (species, plant type)
  - Where the trees are to be collected from
  - Maximum time between nursery and planting
  - The quality specifications for the planting stock (e.g., minimum root length) and a description of unacceptable trees that should be discarded
  - A quality specification for planting including planting tools, cuts to be made, planting depth
  - Stocking and spacing requirements
  - Tree stock storage and handling requirements
  - Penalties that will occur for poor quality work and required re-work areas.

Planting quality

The main factors affecting the quality of tree planting are:

- Planter technique (skills)
- Tree handling
- Slash cover
- Terrain (slope)
- Weather conditions.
- Tree stock quality
- Soil conditions
- Vegetation cover
- Quality monitoring

Planter skill is the most important factor affecting quality. If incorrect techniques are used, survival, stability, tree growth, and form may be of low quality. Planters need to be aware of how handling and planting technique affect the tree. Quality control is critical to ensure planters meet the planting specifications detailed in the job prescription.

Site factors, including soil, slash and vegetation can combine to make the clearing and cultivation of a planting spot more difficult. Shortcuts should not be taken during these stages, as poor spot clearing and cultivation can lead to poor quality establishment.

The major factors contributing to poor planting are:

- Planting hole not deep or wide enough
- Inadequate soil cultivation
- No positive pull up
- Stem, root or collar damage
- Poor planting site selection
- Trees not firmed in correctly
- Incorrect planting depth
- Poorly trimmed roots
- Incorrect spacing
- Incorrect root and stem placement (roots bent up and stems not vertical)

Training and supervision

Tree planting is a very physically demanding job.

Training and supervision are very important in tree planting operations because of the effect of physical workload on hazard incidence and a poor quality job. Both can result in a cost to the worker or contractor.

The Approved Code of Practice for Safety and Health in Forest Operations requires that before **any** worker begins a tree planting operation, the employer must place them under the close supervision of a competent person. That person must continue to supervise the worker until the worker can plant safely and is not likely to harm him/herself or anyone else.

Extra attention must be given to the training and supervision of new or inexperienced operators as most serious injuries occur to operators with less than 6 months' experience.

All operators must be under a documented training programme and should be aiming to pass the relevant NZQA Units that apply to tree planting.

Workers involved in tree planting need to be fit, active, alert, properly trained and supervised, and appropriately equipped.

Workers should also understand the need for adequate rest, good nutrition and sufficient fluid intake.

Knowledge of hazards

As part of the supervision and training programme, planters need to be **shown** the hazards they will face on the job and the controls to avoid being harmed by those hazards.

Before starting any new block, all planters must be involved in identifying any significant hazards **on the site** and the way those hazards will be controlled. There must be documented evidence on site listing the hazards and controls and showing all operators have been run through those hazards and controls.

The two main hazard categories are **Health Hazards** and **Operational Hazards**.

Health hazards

Tree planting is a very physically demanding job. To maintain peak performance and prevent accidents through fatigue, planters must take special care of their bodies, including their physical fitness, diet, water intake, personal hygiene, sleep, and how they treat their bodies away from work.

Health hazards

Hazard	Control
Lack of rest/sleep	• Build short frequent rest breaks into your work routine. • Take at least two evenly spaced 30-minute rest breaks during the working day.
Early starts	• Ensure each night you replace the sleep you lose in the morning. If you get up earlier go to bed earlier. • Allow your body to adjust to the new starting times.
Alcohol abuse	• Avoid drinking alcohol for at least 24 hours before carrying out any hard physical work.
Lack of nutrition	• Start each day with a high carbohydrate breakfast like porridge, cereal, toast, bananas, pasta, or potatoes. • Eat high protein foods like lean meat, chicken, eggs, milk, and cheese at night. • Eat at the start of a break and rest to allow digestion. • Always eat a high-carbohydrate snack straight after work.
Drugs	• Before receiving any medication, tell your doctor what you do for a living. • If you are on long-term medication for a serious health complaint, inform the boss or crew of your condition in case you are involved in an emergency at work. • Inform the boss if you are on any medication that may affect your work. Stay home if necessary. • Non-prescription drugs may affect your ability to work, if in doubt about any medication consult your doctor.
Exposure to sun	• Wear sun block. • Wear light shirts on hot days. • Wear a hat. • Carry out regular health checks.
Early over-exertion/sprains and strains	• Start each day with a 10–15 minute warm-up and then a few stretches • Start the day slowly until muscles are warmed up properly. • If starting a new job, allow time for the body to get used to it before working flat out. • Do some stretches at the end of the day. • Take particular care when starting back at work after the holidays.

Health hazards (cont...)

Hazard	Control
Hypothermia/chills	• Polypropylene clothing (thermal underwear) is excellent for cold wet weather. (Do not wear polyproperlene at fires). • If necessary also wear warm hats, rainwear, or chaps. • Put a hat and warm clothes on when you stop for a break. • Bring spare dry clothing even on fine days. The weather can turn bad very quickly.
Lack of hygiene/infection	• Clean and dress any cuts or scratches received on the job as soon as possible and keep them covered. • Make sure the first aid kit is kept fully stocked. • Carry water and soap on the job to wash your hands before smokos. • Bath or shower every night. • Eat a balanced diet to keep your body healthy. • Wear clean clothes against the skin every day.
Occupational overuse syndrome (OOS)	• Use correct techniques. • Maintain planting tools. • Have regular medical examinations. • Use pre-work warm up and stretching techniques throughout the day. • Avoid jarring hands, wrists, and elbows by selecting the planting spot carefully and pressing the spade into the soil with your boot.
Dehydration/heat exhaustion	• Regularly drink fluids at a rate of 0.5 litres per hour and up to 1 litre per hour in hot conditions. • Drink before you feel thirsty. • While at work do not drink fluids that have more than 8% carbohydrate content, like soft drinks and cordials. • Drink high carbohydrate drinks after work to replace energy levels. • Drink plenty of water at night to recharge the body. • Drink a couple of glasses of water before leaving for work.

Operational hazards

Planting is one of the most physically demanding of tasks undertaken by forest workers. This, combined with the often varied terrain and underfoot conditions, can contribute to operational hazards.

Operational hazards

Hazard	Control
Ineffective personal protective equipment (PPE)	• Don't perform operation if PPE is ineffective. • Clean dirty hi-vis garments. • Replace any worn, damaged, or expired PPE • Routinely check the condition of your PPE
Steep or unneven ground conditions	• Wear approved safety footwear, which provides ankle support. • Change direction of planting to minimise risk of slipping • Be sure of your footing when walking. • Watch for holes or drop-offs, notify all workers if encountered. • Keep well back from rock ledges. • Use more experienced planters in hazardous areas.
Loose debris or material on slopes	• If working on steep slopes do not work directly below another planter. • Maintain adequate distance between workers. • Avoid knocking rocks and woody debris downhill towards other workers. • Wear hard hats on steep rocky terrain.
Lifting objects	• Do not lift heavy items alone. • Use correct lifting techniques. • Do not overload your planting frame. • Have good straps and padding to support the load of the planting frame and distribute its weight. • Bend your knees, not your back. • Stretch and warm up before commencing work.
Working alone	• Have a method of communication with other members of the crew. • Work in groups or pairs where practicable.
Undergrowth	• Clear undergowth from each planting spot before cultivating. • Wear leggings to protect the front of your legs.
Carrying hand tools	• Carry hand tools in one hand, below shoulder height, spade edge facing down.
Skin irritation from needles	• Wear gloves and long sleeved shirt.

Operational hazards (cont...)

Hazard	Control
Dry, chafed and cracked skin from mud and cold	• Wear gloves, apply hand cream.
Rubbing, chaffing and bruising from belts and frames	• Use well-padded, properly adjusted, carrying bags or frames.
All-terrain vehicles (ATVs) (including quad bikes)	• ATVs must be operated within the manufacturer's guidelines. • Wear appropriate protective equipment, including full body clothing, safety boots, and gloves (if there is risk of hand injuries). • Operators must be trained in the use of ATVs. • Carry passengers only if stated in the manufacturer's design specifications. • Ride to the condition of the trail, maintaining control at all times.

Personal protective equipment

The minimum safety requirement for planting is:

- Safety boots

In addition, the following items are suggested:

- Hi-vis shirt or vest
- A hat to protect you from sunburn, or in cold weather a balaclava for warmth
- Safety glasses where there is potential for eye injury.

A planter with the required equipment

Establishment tools

The basic tools are a planting spade and a frame for carrying boxes of trees.

Planting spade

Planting spades need to be purpose designed and built. They feature a strengthened blade and a footplate on the top of the blade.

The blade is typically 25 to 30 cm long to ensure that the desired depth of cultivation can be achieved.

Spades should be kept in good solid condition, with no loose handles or cracks in the spade.

The edge of the spade should be kept sharp.

Carry spade in one hand, below shoulder height, with the edge facing down.

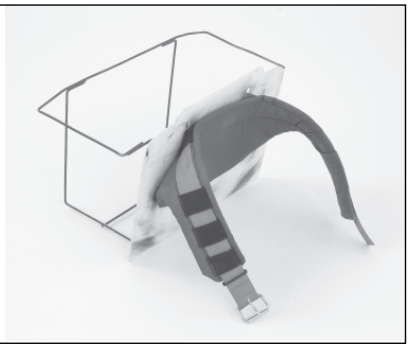
Whilst working, soil may build up on the spade. This should be cleaned off by scraping, not by bashing it on a solid object such as a stump. On heavy clay soils, a curved trenching spade may be more suitable as it can reduce the build-up of soil on the blade.

Carrying frame

The planting frame is designed to carry a planting box. It is fitted with a waist belt to allow the box to be carried comfortably and efficiently.

The waist strap should be made of a wide belt and fitted with padding. Also, it should be adjustable.

Bags are sometimes used in place of the carrying frame and box. This is not a recommended practice, as root distortion and stem damage can occur.



Carrying frame

Planting stock quality

All trees being planted should be of good quality and should be properly hardened off at the nursery to reduce transplanting shock. Poor handling can result in damage to trees. Common causes and effects of poor handling are shown below.

Cause of damage	Effect on trees
Seedling stored or carried in soft bags Rough or excessive handling Removing more than one seedling at a time	• Root damage and distortion • Root and stem damage, drying, loss of soil and mycorrhizas from roots
Excessive soil removal during lifting or transport	• Root drying • Root damage • Loss of mycorrhizas
Stored in poorly ventilated or insulated containers Trees left exposed to sun or wind	• Sweating • Moisture stress • Drying of roots • Stem wilting

Planters need to check stock quality before planting. Planters and supervisor should check that the following quality requirements are met.

Quality planting stock should:

- Have a label showing the name of the nursery, the stock ID number and the date they were lifted from the nursery beds.
- The label should include the species and any rating (e.g., GF Plus)
- Be 20 to 40 cm in height
- Be 5 to 12 mm in diameter at the root collar
- Have a stem diameter: height ratio of 40–60 (see below).
- Have the roots trimmed uniformly to a length of 8 to 10 cm (may differ from company to company)
- Have no insect or fungal damage
- Have no damage to tips roots or stems
- Have plenty of fine roots
- Be moist and firm, not dry or limp or sweating
- Have mycorrhizas (white fungal spores) present on the roots

The stem diameter to height ratio is calculated by dividing the height (mm) by the stem diameter (mm). For example 200 mm high ÷ by 5 mm diameter = 40. A ratio higher than 60 is not acceptable.

Trees that **do not** meet these criteria should not be planted, and the contractor and supervisor should be notified.

If the entire batch is faulty, the planting contractor and forest owner should notify the nursery.

In addition, containerised stock should have:

- A root collar diameter greater than 4mm
- A root plug that does not fall away from the roots
- Roots that are not growing around the root container
- A root that is not root bound

Planting procedures

Handling, storage, and transport

Trees are living things, and need to be treated with care. A critical issue in getting trees from the nursery bed to the planting site successfully is moisture retention in the trees. If they dry out they will suffer drought stress and will take longer to recover and begin to grow. In extreme cases, they will die.

At all points of the chain, between the nursery and the planting spot, the key considerations are:

- minimising damage
- retaining water in the tree.

Planting boxes being unloaded from the crate and loaded in a back pack for transport to the planting site

Trees absorb water through their roots, so it is essential that the roots retain some soil and moisture during transport and storage.

After lifting, trees should be packed and covered immediately. If conditions are dry, extra water (watergell) can be added to boxes or bags. When the boxes and crates are full they should be placed in the shade or in a cool store.

The date and time the trees were lifted from the nursery bed should be noted and written on the crate, box, bag, or packing slip.

When trees are being transported they must be covered, and not exposed to sun or wind. When trees are being stored at the planting site they should be in the shade. They must be covered. Crates used to store trees should be painted white to reflect heat.

Trees should not be stored for more than 2 days in the forest.

Some forests and nurseries still use plastic bags and large cardboard boxes to store and transport trees. The recommended system is the crate and box system, with trees packed into planting boxes and crates in the nursery.

Handling of boxes

- Crates or boxes are generally used to deliver trees in boxes or bags to a planting site. The crate is suitable shelter for the trees for 1 to 2 days. The crates should have holes to allow the trees to breathe and for air to circulate.
- Trees must be kept cool and moist at all times and should always be stored under cover, out of the sun and wind.

Before commencing planting

- Check the general condition of the trees, to ensure they meet the specifications required in the prescription and are suitable for planting.
- Ensure they have not dried or over-heated, as this may affect survival.
- Remove boxes from the crate only when they are ready for use, and place within the carrying frame. Close the crate door when not in use.
- The boxes containing the trees can be re-used several times. Empty boxes should be returned to the crate. Boxes should be handled carefully.

Unacceptable practices

- Planters have been known to whack the soil from the roots to lighten the load, and allow more trees to be stuffed into the planting box. This practice is unacceptable as it damages the roots and removes the mycorrhizas, resulting in increased mortality and poor early growth.

- Planters sometimes transfer the trees from the planting boxes to the box permanently secured to their planting frame. This procedure is not recommended as it encourages the removal of soil from the roots and results in root damage.

Selecting the planting spot

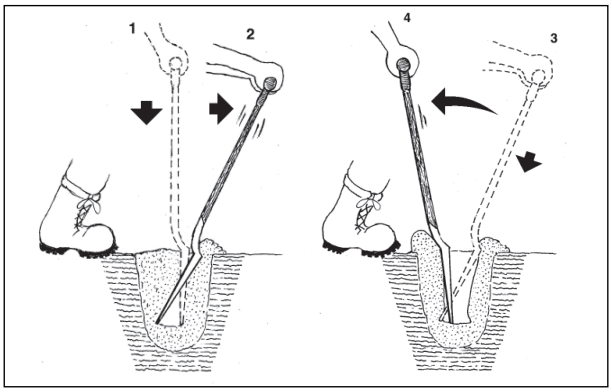
- One member of the planting crew will establish where planting is to begin and in what direction planters will work. This will often be parallel to an obvious feature, such as a road, compartment boundary, windrow, fence line, stream, or ridge.
- Planters will space themselves to achieve the desired row spacing. Marker poles are sometimes set across the planting area to allow planters to keep the lines straight.
- Generally, the more experienced and faster planters will be located on the inside rows.
- Select the first suitable planting spot. If a spot meets all the criteria except that it has weeds on it, these can be cleared off with the spade. This is referred to as screefing. The cleared spot should be at least 50cm square.
- The distance to the next planting spot is stepped out according to the specified within-row tree spacing.

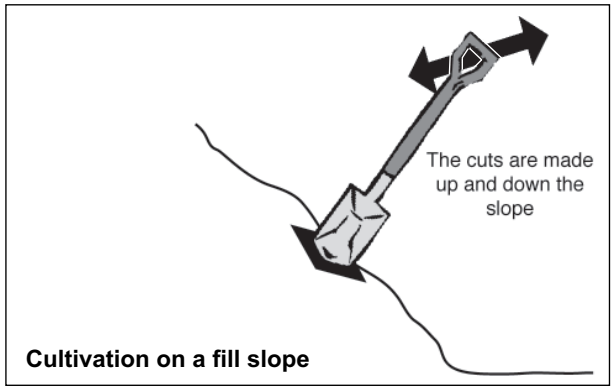
Cultivating the soil

The method used to loosen the soil will depend on soil firmness and whether there is a grass cover.

Method for cultivated (loose) soils

Thrust the spade into the ground and use your foot to push it in to its full depth (25–30 cm) (1). Lever the handle back and down to loosen the soil (2). Thrust the spade down (3) so that the blade bites, and lever the spade forward (4) to further open the hole.





Cultivation on a fill slope

Where the planting spot is located on an erodible slope (such as a fill slope), angle the spade cuts so they are up and down the slope, rather than across it.

This minimises the soil disturbance and soil loss.

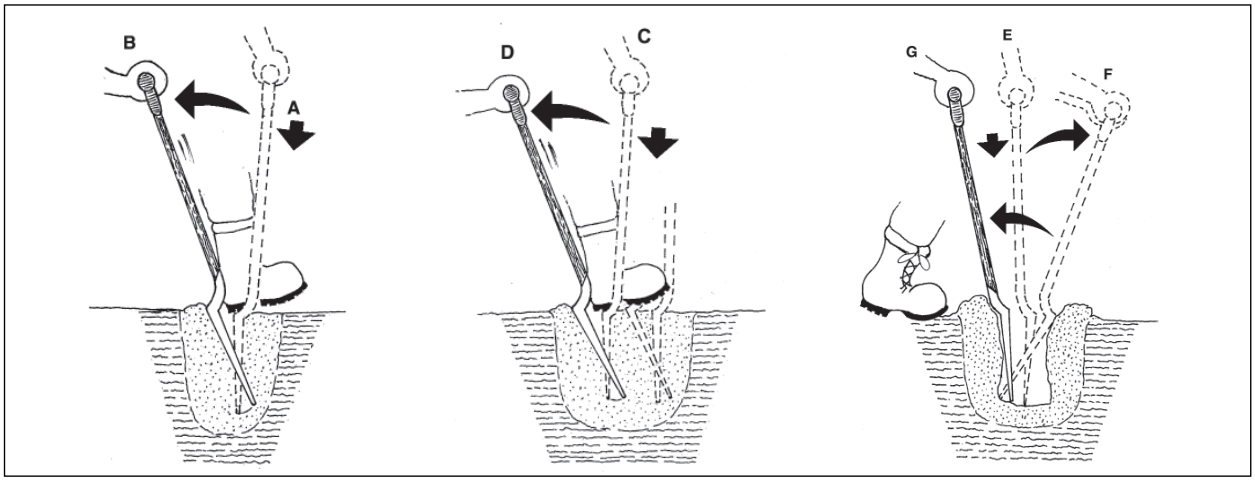
Method for firm soils

Thrust the spade into the ground and use your foot to push it in to its full depth (25–30 cm) (A). Lever the handle back and down to loosen the soil (B). Several thrust/lever actions may be required to get the spade to full depth in compact or heavy soils (clay).

Remove the spade from the ground and make a second cut parallel to the first (C), about 20 cm from the first. Again, lever the handle back and down to loosen the soil (D).

Remove the spade, turn it around 180° and use it to open a hole (not a slot) between the first and second cuts as follows: (see over page)

- Push the spade to the bottom of the loose soil
- Press down on the handle (F)
- Repeat until a wide hole is cleared particularly at the base.
- Lever it back (E)
- Lever it forward



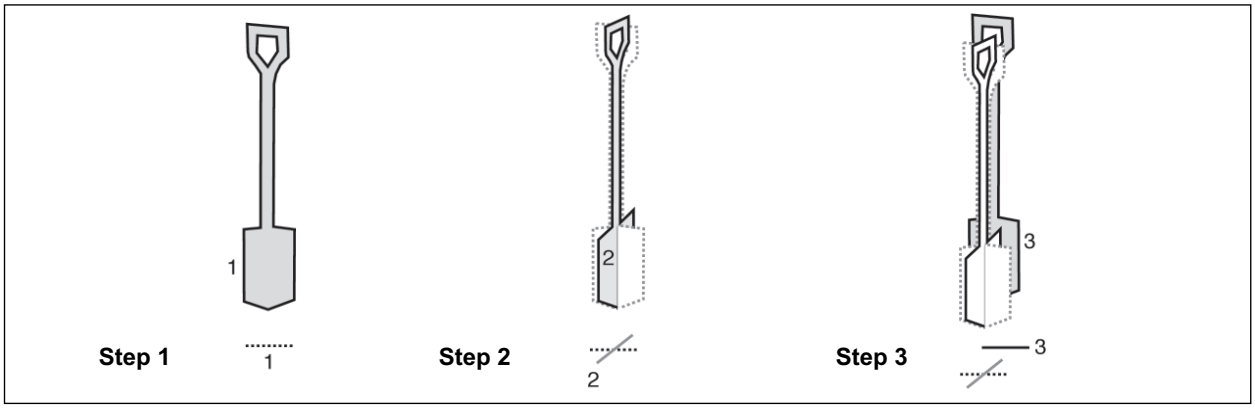
Method for grass-covered sites

(1) Thrust the spade into the ground and use your foot to push it in to its full depth (25–30 cm). Lever the handle back and down to loosen the soil. Several thrust/lever actions may be required to get the spade to full depth in hard or heavy soil (clay).

(2) Remove the spade from the ground and make a second cut 90° from the first to form a cross. Lever the handle back to loosen the soil.

(3) Remove the spade and thrust it into the ground in front of the first two cuts, and open a hole between the first and second cuts as follows:

- Push the spade to the bottom of the loose soil
- Press down on the handle
- Repeat until a wide hole is cleared.
- Lever it back
- Lever it forward



Opening a planting hole (on a mechanically cultivated spot)

Where a site has already been cultivated, the planter will need to open a planting hole before planting a tree.

- On very loose cultivated ground, the soil may need to be firmed with the feet before a hole is opened. This reduces the chance of the soil instantly falling back into the hole made by the spade.

In all cases:

- Trees must not be held in the hand whilst the cultivation and hole opening is being done. The trees must remain in the bag until the hole is opened.
- Trees must be planted into mineral soil, not into litter or duff.

Planting the tree

(1) After opening the hole, take **one** tree at a time from the planting box.

(2) Place the tree in the hole with the roots in the bottom.

(3) Lift the spade clear of the hole

(4) Holding the stem, low down the tree, use your boot to push soil into the hole until it is filled.

(5) Give the tree a positive pull upwards 5 to 10 cm to straighten roots. This should leave the stem buried in the soil to a depth of about 10 cm. The tree will be planted deeper than it was growing in the nursery. Some foliage may be underground.

Note: if using container-grown stock, a positive pull-up is not required and if applied will rupture the tree.

(6) Firm the soil around the tree by standing on it with the front of the boots. Be careful not to rub bark or foliage off the tree. Never use your heel to firm in. There should be no air pockets at the bottom of the hole.

Note: Containerised trees require only minimal firming to avoid root plug damage

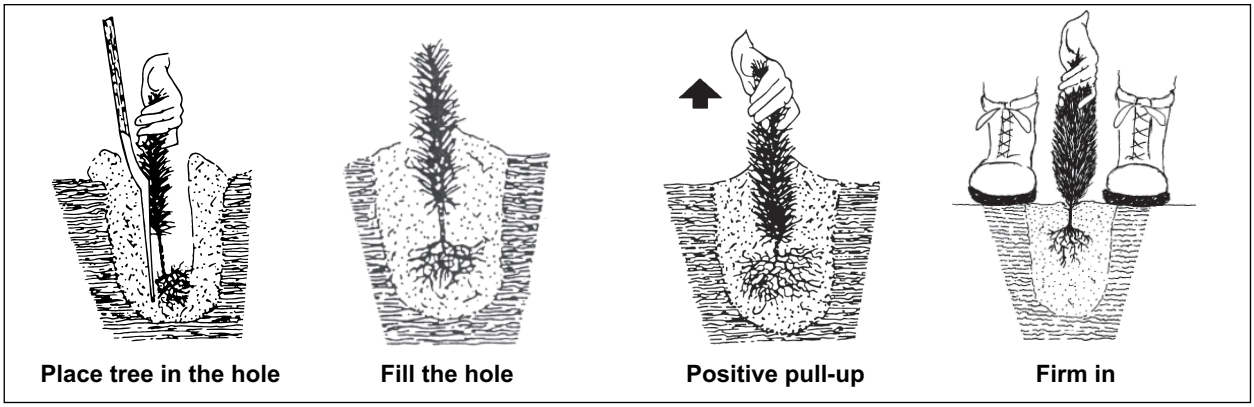
(7) Make sure the tree is vertical.

(8) If the tree is damaged during planting (top pulled off during pull up or firmness checking) it should be removed and replaced with an undamaged tree. Do not pull the tree up using the tip.

DO NOT stamp the soil in with your heel.

If the soils are very loose, the hole opening and tree planting are combined as one movement.

Note: Some variations to the planting methods described may be agreed upon between the forest owner, supervisor, contractor, and planters. When other methods of creating a planting hole are used, it is always important that good cultivation is achieved and the specifications in the job prescription are met. For example, planting depth may be specified as 1/3 of the stem height, or to the first branches above the root collar.



Place tree in the hole **Fill the hole** **Positive pull-up** **Firm in**

Rows of trees should be kept straight. This can be achieved by one worker setting out sighting poles which indicate where a planter should be aiming for as he/she walks forward. With experience, it may not be necessary to have a sight pole for every line, as some planters can space themselves by eye.

Quality control

- The quality control (QC) person should follow closely behind the planters to ensure that any problems can be dealt with quickly.
- The QC person will routinely assess each planter's performance according to the job prescription. Specifically he/she is looking at the indicators listed in the table below.
- The QC person should use a checklist and record planter's name and planting quality.
- If dug up carefully, an assessed tree can be replanted.

Left: Checking cultivation depth.
Right: Inspecting the seedling

Quality indicator	Assessed…
Tree stock	By visual assessment following delivery of trees to the site
Tree storage and handling	By checking: the suitability of the location of the crate or tree dump: • Handling of boxes, bags, and trees during transfer from store to planter • Planters' handling of trees during planting
Planting spacing	Using a measuring stick or pole. Visually assess selection of planting spot
Cultivation area and depth	Using a graduated steel rod to probe cultivation depth and area
Planting depth, root orientation, root plug deformation	By carefully digging up the tree and visually assessing
Tree firmness	By pulling up on the tree

Applying fertiliser

Fertiliser is sometimes applied manually following planting, either by hand or by applicator, to boost tree growth and to correct soil nutrient deficiencies, such as nitrogen and phosphorus.

This fertiliser is usually pelletised or granulated, and is applied in a separate operation to planting. Fertiliser is normally applied individually to each tree. This increases cost effectiveness by reducing application rates of fertiliser per hectare. It also reduces the uptake of fertiliser nutrient by weeds.

Care must be taken to place the fertiliser correctly, as per the job prescription. If the fertiliser is in contact with, or too close to the roots it can damage or kill the tree.

Applying fertiliser by hand requires the following equipment:

- a planting spade
- a planting bag or box to carry the fertiliser
- a measuring container so the right amount of fertiliser is applied

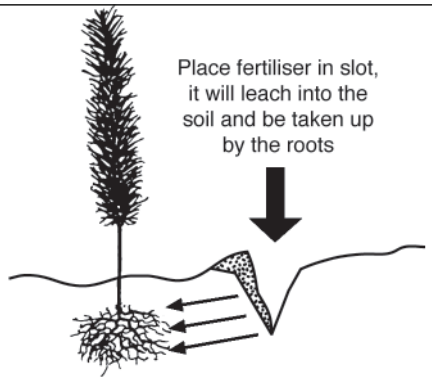
The following steps should be followed to hand-apply fertiliser.

(1) Open up a spade slot approximately 30 cm upslope (if possible) from the tree being fertilised. The slot should be 15 to 20 cm deep.

(2) Fill measuring scoop with the required amount of fertiliser.

(3) Place in the slot.

(4) Close the slot over the fertiliser with your boot.



Applying fertiliser

Environmental management

While planting has minimal potential for damage to the environment, planters must ensure that all planting boxes, planting bags and rubbish are removed from the planting site on completion of the planting operation.

Burying of rubbish and planting bags is an unacceptable practice.

Glossary of terms

Agrichemical	(Herbicide) Chemical applied to a site to control unwanted vegetation.
Air pockets	An air space around the roots of a planted tree, which can result in drying out of the roots. Usually caused by poor planting technique and poor cultivation. An air pocket may reduce tree growth or cause death.
Bare root stock	Planting stock grown in nursery beds, not in containers, with good covering of soil on the roots.
Butt sweep	A bend in the butt of the tree. Results from the tree not being planted vertically, soil movement, or toppling.
Conditioning	When a tree is prepared in the nursery for planting out by wrenching and root trimming.
Container-grown stock	Planting stock grown in containers and planted with growing medium intact.
Cutover	Area of forest which has been recently harvested.
Cultivation	Loosening of soil to improve root development and tree growth.
Cutting	Planting stock grown from cuttings (piece of plant cut from tree or stool bed), not seeds.
Element deficiency	A lack of nutrients available for the tree to uptake. May be able to be corrected by applying extra nutrients as fertiliser.
Erosion	Uncontrolled movement of soil downhill.
GF Plus™ rating	Rating given for each of the tree growth, quality, and health characteristics. Higher numbers indicate better levels of genetic improvement.
Granular herbicides	Weed-killing chemicals manufactured as small grains.
Hard stock	Well-conditioned planting stock with no fresh growth (soft tissue).
Herbicides	*see* Agrichemical
Hi-vis	High visibility clothing or helmets, usually a bright fluorescent colour.
Job prescription	Detailed specification for a job, covering what is to be done, where, and to what standard.
Land preparation	Operations preceding planting used to modify land to enhance tree growth and planting.
Malform	Any tree that has a stem defect which is unacceptable.
Mattock	Hand tool for digging and planting in hard ground.
Mortality	Percentage of the trees planted that have died at the time of assessment.
Mycorrhizas	White fungal spores on the roots which aid nutrient uptake into the tree.
Nursery collar	A mark (where the dark-coloured bark starts) on the tree stem usually just below the foliage, indicating how deep the tree was grown in the nursery.

Glossary of terms (cont...)

Positive pull-up	Upward pull applied to the planted tree to ensure roots are pointing downwards.
Prescription	*see* Job prescription
Releasing	Manual or chemical operations to remove competing vegetation from around young trees.
Root collar diameter	The stem diameter of the seedling or cutting just above the roots.
Ruts	Tracks left in the soil by harvesting machinery, where soil is compacted and disturbed.
Screefing	Using hand tools to clear weeds and light slash from a planting spot before planting a tree.
Seedling	Planting stock grown from seed.
Slash	Layer of logging residue (branches, etc.) left on the cutover after logging.
Soil compaction	Compression of soil; can inhibit root growth.
Stocking	Number of trees per hectare.
Survival rate	Percentage of the trees planted still alive at the time of assessment.
Sweating	Moisture lost from the tree foliage and stem. Occurs when ventilation is poor or trees are stored in warm locations.
Toppled trees	Trees which fall over in a storm event.
Tap root	The large root which grows downwards to anchor the tree and uptake water.
1/0	A code that describes the age of the tree stock grown for 1 year in the nursery bed. The first digit is the age of the seedlings in years, and the second, the time they have been lined out.

Index to unit standards

Poroporoaki

Whaia te huarahi	*Pursue the path*
o te mātauranga	*of learning.*
Ka piki ake koe,	*The higher you climb,*
ka whānui atu nga pae.	*the wider the horizons.*
Rapuhia nga pae	*Seek also the horizons*
i roto, I tōu nei ngakau.	*within your self.*
E tipu, e awhi, e tū.	*Grow, embrace, stand tall.*

Vision, knowledge, performance

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