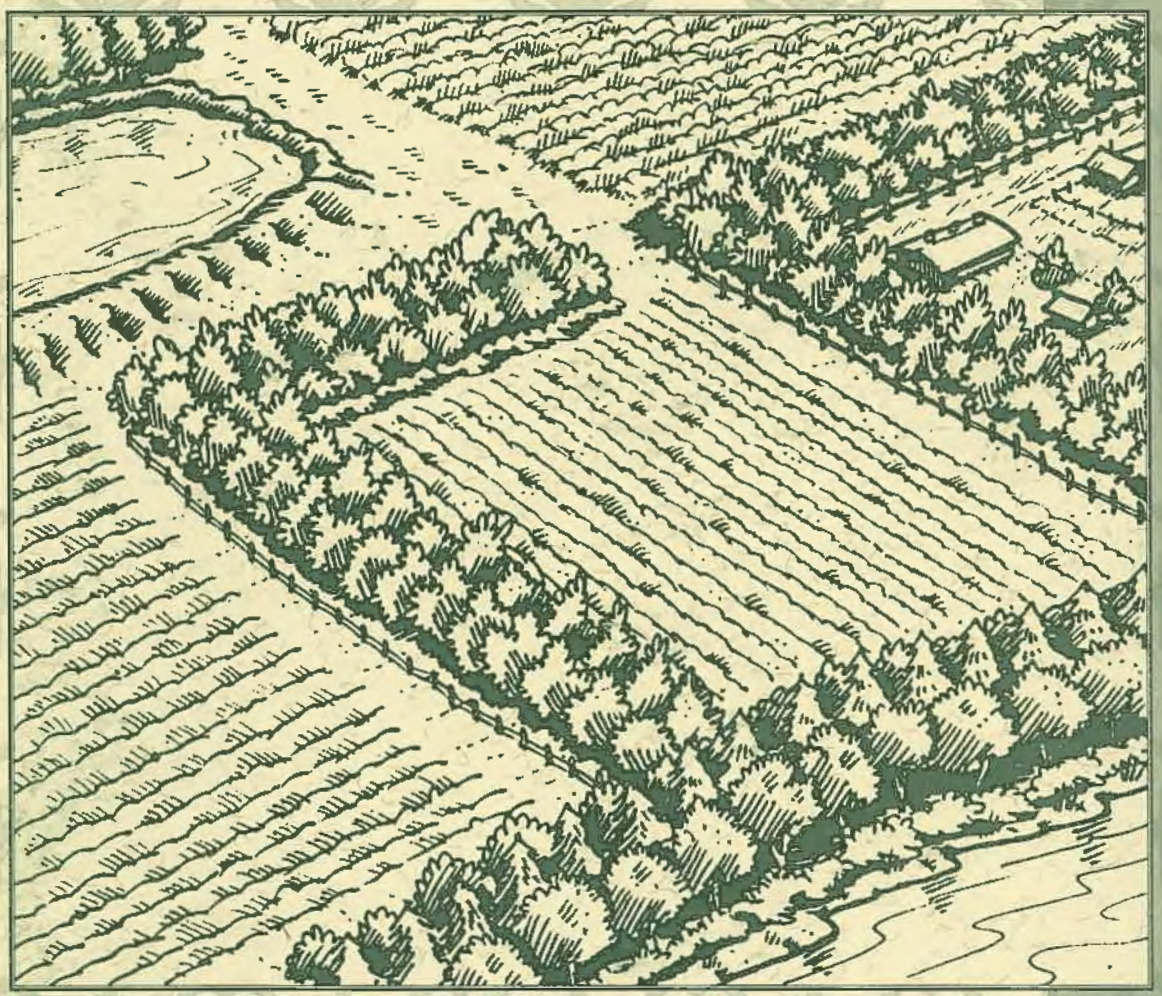
Growing trees on cotton farms

A guide to assist cotton farmers to decide how, when, where and why to plant trees



RURAL INDUSTRIES RESEARCH & DEVELOPMENT CORPORATION

Land & Water Resources Research & Development Corporation

FOREST & WOOD PRODUCTS RESEARCH & DEVELOPMENT CORPORATION

CRDC

JOINT VENTURE AGROFORESTRY PROGRAM

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A guide to assist cotton farmers to decide how, when, where and why to plant trees

The material in this book was coordinated by Peter Voller, who is a Senior Forest Extension Officer with the Queensland Department of Natural Resources with extensive experience in advising on trees on farms.

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Foreword

This book is the product of a project jointly funded by the RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Program and the Cotton R&D Corporation. The book has been specifically designed to provide key information to cotton farmers about how to maximise the benefits of integrating trees into cotton farming systems.

RIRDC's involvement in this project, and in the Joint Venture Agroforestry Program, is part of the Corporation's Agroforestry and Farm Trees R&D Program which aims to foster integration of sustainable and productive agroforestry within Australian farming systems.

Peter Core
Managing Director
Rural Industries Research and Development Corporation

Acknowledgements

A number of people have given considerable time and thought to assist in the production of this publication. Thanks are due to Sharon Davis of RIRDC, Ernie Rider of DNR, David Curtis of GANSW and Mike Raupach of CSIRO, who provided invaluable professional advice.

I would also like to thank John Watson, John Grellman, and Brian Kennedy, farmers who reviewed early drafts and provided much appreciated feedback and advice to help make the information in this volume well-targeted, useful and practical from a farmers' point of view.

About the editor

Judith Aitchison is a freelance journalist who specialises in environmental writing and editing. She edited the DPI Forestry publication *Between the Leaves* from 1992-6, and has written for *Wildlife*, *Timberman*, *National Forests and Timber* and other specialist publications. She completed her Master of Environmental Education degree at Griffith University focusing on ways of knowing and learning from nature.

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He travels south-western Queensland providing advice and running field activities for farmers and property owners interested in planting trees for a diversity of purposes.

David Curtis, M.Sc. Dip. Ed. David has 15 years practical and theoretical experience of conservation on farms in Australia. He has developed an extensive network amongst those involved in Landcare, trees on farms, revegetation and research right across Australia. David has spent the past eight years as Regional Manager for Greening Australia in north-west NSW.

Jake Davies, B.Sc. Jake completed his Bachelor of Science majoring in zoology in 1993. Since then he has done further study in landscape architecture and worked as a research assistant for the supervising scientist in Kakadu National Park and Greening Australia. Jake has also worked as a laboratory technician in the Animal Science Genetics Laboratory at the University of New England.

Kay Dorricott, (Qld Dept of Environment and Heritage). Kay has been involved in nature conservation extension in various parts of Queensland since 1989. Currently employed as a Regional Extension Officer with DEH in far north Qld, she has also worked for DPI Forestry, USQ and as a private consultant. Her main professional interest is encouraging landholders to plan and manage for biodiversity as part of standard farm management. She has co-authored two books and an external study course on nature conservation for landholders.

Susan House, BSc hons (Durh.), MSc (Lond.), PhD (ANU). Susan began her research work by drawing up conservation management plans for several National Nature Reserves in UK and Tunisia. Her research interests focus on the reproductive ecology of eucalypts and rainforest trees, particularly the influence of forest fragmentation on pollination systems and seed production. While with QFRI, she has been involved in research with hoop pine, tree species selection for the rehabilitation of saline sites and developing a physiological model for predicting tree growth in relation to environmental factors.

Judy King is Senior Extension Entomologist with DPI Forestry. She joined the Department in 1989 after several years of teaching and research in the Dept of Entomology, University of Queensland. Judy provides advice on insect pests of trees and timber for Forestry, other Government Departments, industry and to the public. Her areas of responsibility include exotic and native pine plantations, native hardwood forests and historic trees. Judy has produced a number of publications on insect pests in trees in Queensland.

David Taylor, B.App.Sc., has worked at the Queensland Forest Research Institute for the past 14 years first as a Technician and more lately as Scientist, Native Forest Research. During this time, he was extensively involved in Landcare research issues such as Agroforestry and Rehabiliration of Dryland Salinity areas.

Nicholas Woods, B.Sc. M Sc FRES is the director of the Centre for Pesticide Application and Safety, a research and consultancy group located at the University of Queensland Gatton College. Nicholas has some 17 years experience working with industry and government on pesticide application and environmental issues. His special research interests include aerial application of pesticides and spray drift management.

Gary Dorr, B.Eng (Agric), PG Dip App Sc is currently a senior research assistant with the Centre for Pesticide Application and Safety at University of Queensland. An agricultural engineer by training. Gary has specialised for the last 10 years in researching the physical and biological aspects of pesticide application.

About this book

Cotton farmers face particular problems that may not be shared by other farmers and property owners. For this reason, the information in this book has been especially designed to provide cotton farmers with the basic information THEY need to know if they are considering planting trees. Every effort has been made to focus on issues relevant to cotton farming areas, with particular reference to those of Qneensland and New South Wales.

Who should read it?

The advice in this book is based on suggestions by members of the cotton industry, and by farmers at field days and through the questions asked by farming families in Queensland and New South Wales.

What does it cover?

This book will take you step by step through:

- the many ways trees on farms can provide benefits
- the how, where and when of planting trees
- the types of species that will grow in your region
- the results of research into tree species grown in various locations similar to cotton growing areas
- case studies of what worked or did not work from farmers' own experience.

What's new in this book?

This book includes the most recent research results on growing trees for the particular problems of spray drift and pest control experienced on cotton farms. The research was undertaken at the Centre for Pesticide Application and Safety, at the University of Queensland's Gatton Campus.

As well, the book incorporates the latest research advice from CSIRO on windbreaks undertaken through the National Windbreaks Program funded by the RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Program (JVAP).

This book extends the broad general advice offered in the 1997 RIRDC/LWRRDC/FWPRDC JVAP publication, *Design Principles for Farm Forestry.*

It offers in-depth information on all aspects of tree planting relevant to cotton farms and cotton farming districts and includes species lists for different soil types and conditions, with case studies detailing those species that thrived and those that failed.

Where can I find more information?

If you want more information, at the end of each section there are directions to:

- a person or agency who is an expert in the topic or locality being addressed
- further articles or books to read on the topic.

You may wish to consult the following books that provide good, general advice:

Abel, N. Baxter, J. Campbell, A. Cleugh, H. Fargher, J. Lambeck, R. Prinsley, R. Prosser, M. Reid, R. Revell, G. Schmidt, C. Stirzaker, R. and Thorburn, P. (1997) *Design Principles for Farm Forestry,* Canberra, RIRDC.

Cremer, K.W. (Ed) (1990) *Trees for Rural Australia,* Melbourne, Inkata Press.

Campbell, A. (1991) *Planning for Sustainable Farming,* Port Melbourne, Lothian.

Introduction: How do trees fit into cotton farms?

Modern farms need to run as efficiently as possible, so any investment should be made with a clear goal and based on good information. Planting or retaining trees and other vegetation can be an investment in the future of your farm. Trees and vegetation have the capacity to provide positive benefits for farming, but if they are not included into an overall property plan, their benefits may not be optimised.

By preparing an overall tree retention plan at the development stage, many of the benefits of the trees can be maximised, and the need for future replanting minimised. Such plans can be developed with the best advice from land management consultants or relevant government agencies.

This hook outlines a number of uses trees could have on Australian cotton farms. In some cases, a variety of benefits can come from the same trees, but in other cases, you will need to use a different design, layout and management for each different purpose.

Costs for planting trees are estimated at between $1.00 and $10.00 per plant in the ground and growing. Such costs indicate that large scale planting is a sizeable investment.

Retaining existing vegetation such as remnant bush or regrowth can often be a cost-effective solution. In some cases such areas may need to be modified for example, thinning thick regrowth to make it more effective for drift capture, or thickening up some bush to make better habitat for beneficial insects.

Managing areas of trees or bushland can he very rewarding and it can provide diversity in a landscape dominated by farming. Such areas can be good for recreation as well as being functional for the farm.

This book is designed to help cotton farmers decide about and plan ways to include trees and native bush within modern and future farming practices.

In planning to make the most of trees on your farm, you need to consider the following points

- What are the main roles trees could play on your farm?
- What design principles are needed to make sure the trees do these jobs well?
- How much will it cost and how can it fit into existing farm layouts?
- What can you do to retain native bush and trees that have been planted?
- How much information on management and establishment do you need to make sound decisions before committing labour, finance and land for tree planting and retention?

Section One : How can trees help cotton farmers?

Planting trees as windbreaks

An efficient windbreak can reduce open wind speed by between 25% and 75%. The effects on the downwind side can extend to 25 times the height of the break, and on the side facing the wind, the effects can extend to 5 times the height of the windbreak.

Windbreaks must be designed well and they have to be well cared for if they are to be effective.

Much of the information in this chapter has been compiled with the help of Dr Mike Raupach, of CSIRO Land and Water. Dr Raupach has been part of a research team re-evaluating the usefulness of windbreaks on Australian farms under the National Windbreaks Program. His team's research results are soon to be published and provide some new approaches to the use and design of windbreaks.

Benefits from windbreaks

Wind erosion decreases

Effective windbreaks help reduce wind speed. The lower the wind speed, the less soil particles are likely to be blown great distances or to damage crops by sand blasting.

For cotton growers who have used windbreaks, this reduction in wind speed has greatly reduced the loss of young seedlings due to sandblasting seed burial or removal of seedlings by winds.

Crop yields can be protected

Strong or persistent winds can reduce plant growth. As part of a National Windbreaks Research Program, CSIRO researchers have discovered that the greatest benefit windbreaks can provide for crop growth is in reducing physical damage to plants at critical growth stages. This means windbreaks are of greatest value in times of high winds or when crops are particularly vulnerable to damage such as leaf rubbing or sandblasting.

Irrigation can be more efficient

Windbreaks can reduce evaporation from the crop canopy, soil surface and from the surface of dams by slowing wind speed. For farmers, the benefits could include longer irrigation cycles and less water wastage. Other benefits can include enhanced growth rates. In some cases, farmers have been able to obtain the same yield with less water.

Grass-fire danger lessens

Reducing wind speed slows the rate at which a fire spreads, making the fire easier to control. Windbreaks can stop a fire at its head, or protect buildings and other structures.

Other benefits

Windbreaks can also satisfy secondary purposes. They can produce timber, or be a source of nectar for bees. They can provide links between habitat areas for wildlife. Windbreaks improve the landscape and can increase property values. They can also provide shelter for beneficial insects and pest controlling birds.

Design factors

Careful design and management is needed for effective windbreaks. Windbreaks require regular maintenance and particular attention during the establishment phase. It is particularly important to close breaks or gaps in the windbreak, and to ensure complete foliage cover from the ground up.

In designing a windbreak, the following features need to be considered:

Density

Windbreaks should have a density of between 40% and 80%. This means that when looking from the side of the windbreak you should see 40 to 80% foliage and 20 to 60% daylight. The actual density is not so important as the evenness of the density along the windbreak.

Foliage should be roughly the same density from the ground up. Breaks in the canopy will funnel wind and destroy the windbreak effect.
A windbreak made up of a number of rows of trees, with trees spaced according to their fully grown size, should produce the desirable density. Recent wind tunnel studies undertaken by CSIRO have shown that density has little effect on the extent of downwind sheltering provided by the windbreak. However, high-density windbreaks (those with up to 80% foliage density) demonstrated the greatest reduction in wind speed.

Height

The taller the windbreak, the greater the zone of protection. On level ground, wind speed can be reduced for a distance of up to 25 times the height of the windbreak. Significant wind reduction can be up to 10 times tree height away from the windbreak on the downwind side.

The nature of the upwind terrain affects the effectiveness of wind sheltering on the downwind side. If the wind is coming off pasture or crop, it is less turbulent; if it is coming off wooded areas, the wind can be more turbulent.

Length

Windbreaks should be long and continuous. While the recommended approach is to plant at right angles to prevailing winds, because winds seldom blow on exactly the same angle, a longer windbreak gives a larger area of protection.

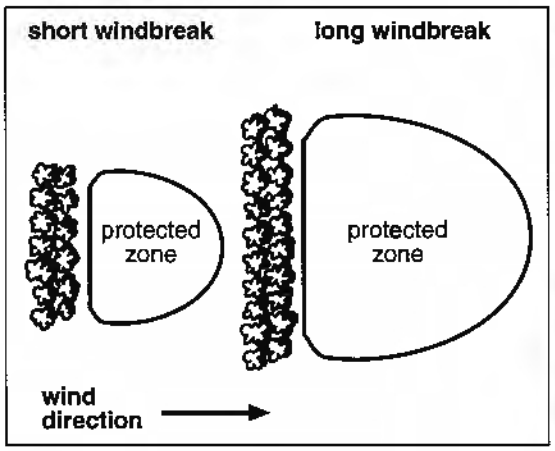

Fig 1. Sheltered area downwind is affected by length of windbreak.

A suggested minimum length for a windbreak is 20 times the expected height of the trees, which roughly translates to between 200 and 400 metres. Doubling the length of a windbreak can increase the protected area by up to four times. (Fig. 1).

Wind will swirl around each end of a windbreak leading to increased wind speed in these areas. For this reason, windbreaks should continue out into adjoining land if possible to protect crops at the sides of the fields.

Windbreaks that run around property boundaries or at right angles have the potential to create protected areas from winds of differing direction and to increase the size of the protected area in general. (Fig. 2).

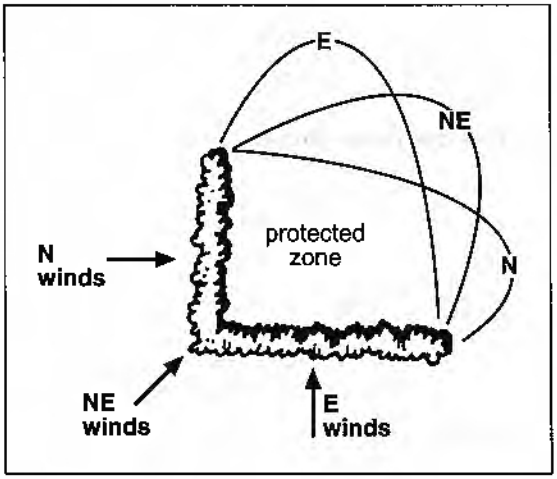

Fig 2. Windbreaks on more than one direction provide better protection from varying wind direction.

Gaps

Gaps or breaks in a windbreak are the greatest threats to effective wind reduction. Gaps effectively shorten the windbreak and allow wind to funnel through them at great speed. Gaps caused by dead trees or other damage should be refilled.

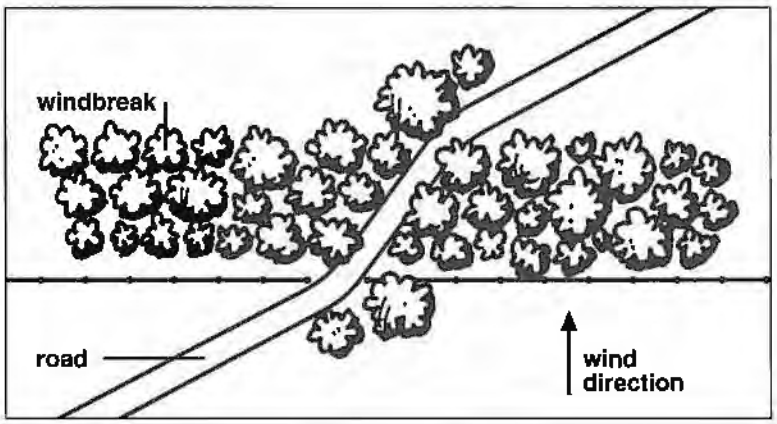

Fig 3. Gaps in windbreaks should be at an angle.

Gaps may be required for gates and tracks. The effect of these can be minimised in wide windbreaks by angling the gap at an angle of about 45 degrees to the prevailing wind direction. Other solutions are to plant trees outside the main windbreak to block wind approaching the gap. (Fig. 3).

Orientation

Windbreaks should be aligned at right angles to the direction of the main problem-causing winds. If problem winds come from several directions, longer straight belts are needed or the windbreaks need to be planted around the field facing the general problem wind directions.

Width and Formation

Multiple row windbreaks are generally more effecuve than single row windbreaks. Single row windbreaks may be useful if space is very limited. They are most effective where the tree species used have fairly dense foliage right from the ground (e.g. sheoaks, melaleucas). However, the disadvantage of single row windbreaks is that if one tree dies a gap is created which reduces the effect of the whole windbreak.

The intended secondary purposes of the windbreak can also affect which species are chosen. For example, a diverse range of local native species is likely to be best for wildlife habitat.

Multiple row windbreaks are effective for most farming situations and are less affected by gaps caused by missing trees. A variety of tree species can be used, with a range of sizes, shapes and foliage. A combination of different rows can also create a permeable barrier from ground level up to the height of the tallest trees.

Tall-growing trees provide the greatest shelter. These may be planted in centre rows with smaller bushy trees and shrubs on the outside rows. In drier areas, two or three rows are sufficient. With any more than this, the inner rows may suffer severely from competition for moisture.

Another approach sometimes used for wider multiple row windbreaks is to plant the trees in a more scattered pattern rather than in strict rows. Trees and shrubs of different types are planted across the area of the windbreak to create an overall effect of a permeable barrier.

This approach can be beneficial where the windbreak is intended to provide a wildlife corridor or habitat also. There is no evidence to suggest that a particular layout has better wind sheltering effects, as long as density remains reasonably even.

Windbreak life span

The lifespan of a windbreak depends on the species planted. Generally the faster a tree grows, the shorter its life span. If a windbreak is needed quickly, fast growing species such as acacias can be planted at a high density with slower growing trees mixed in amongst them.

Windbreaks will take time to grow to a size where they are useful. As the wiudbreak grows, the faster trees can be thinned out to allow full development of the canopies of the slower growing trees.

Choice of species

A list of species suitable for windbreaks is given in later chapters. Before selectiug which species to use, however, carefully consider which species grow best in your local area. Select species that will perform reliably. Gaps that are caused by the loss of trees reduce the effectiveness of the windbreak.

Establishment and maintenance

In establishing a windbreak, do everything possible to achieve uniformity of growth. Prepare the site properly and fence the area for permanent protection if stock are likely to be a problem. Plant the seedlings when conditions for survival and development are most favourable. (See Section Two *How to Establish and take Care of Trees on Cotton Farms,* for more information on tree establishment).

Plant tall trees four to six metres apart, and shorter species two to three metres apart. Encourage good growth by controlling weeds and grass around trees and applying fertiliser as needed. Slashing between rows can help to reduce fire risk.

Trees in adjacent rows should be planted in a staggered pattern to the prevailing wind direction

As the windbreak develops, inspect individual trees carefully. Replace dead trees, and any that have unacceptable growth patterns. For shorter trees, such as acacias, that are likely to have a limited life, plant replacements in time for them to become effective before the original tree dies.

Farmers need to be aware that trees in windbreaks will compete with nearby crops, which may cause reduced crop yields. The level may vary with the types of trees and other circumstances, but this competition will need to be controlled.

Controlling root competition

Competition between windbreaks and crops can be minimised. The best use of the less productive land close to trees is for tracks, machinery parking or some other use. If this is not practical, the windbreak could be root pruned every two to three years.

Root pruning should be started two or three years after planting. Ripping depends on the nature of the roots, but deeper ripping (to a depth of 80cms) will require heavy machinery. Do not rip closer to the trees than two metres. The cost of deep ripping should be weighed up against any crop production benefits.

Deep ripping will break off large feeder roots that spread into cropland, this should therefore stop competition. Breaking large roots however opens wounds for disease to infect the trees and roots of some species (such as brigalow) will sucker from the severed root section.

Trees and shrubs should be laid out at random, but each type should be spaced according to their eventual height and size. Tall trees (4-5 metres apart), Medium trees (3-5 metres apart) Small trees (2-3 metres apart).

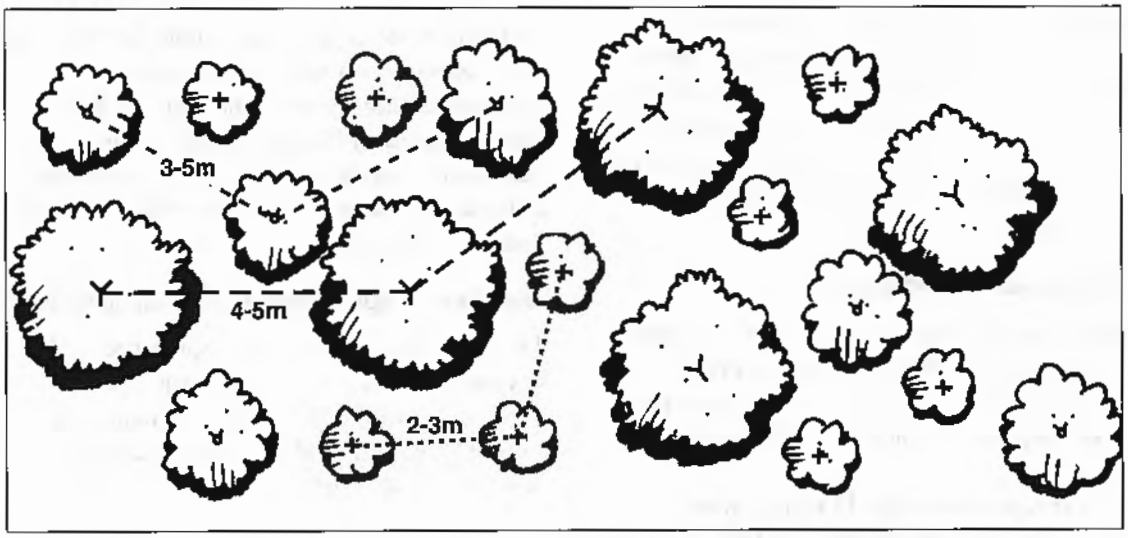

Fig 4. Possible layout of windbreak including a mixture of trees and shrubs at suitable spacings.

You may wish to consult the following book that provides good, general advice:

Abel. N, Baxter, J. Campbell, A. Cleugh, H. Fargher, J. Lambeck, R. Prinsley, R. Prosser, M. Reid, R. Revell, G. Schmidt, C. Stirzaker R. and Thorburn, P. (1997) *Design Principles for Farm Forestry*, Canberra, RIRDC.

Planting trees for spray drift buffers

To reduce the adverse impact of agrochemical spray operations, buffers should be used in accordance with best practice guidelines.

Tree planting can make a significant contribution to reducing the drift from agricultural chemical spray operations, but trees can never be a substitute for best practice in spray application.

This chapter outlines a number of roles that tree buffers can play in the safe use of agrochemicals, but it is important to note that the benefits of trees are no replacement for using clean, efficient equipment and taking great care in application. Some agricultural chemicals have the potential to cause damage to neighbouring crops, watercourses and neighbouring residents if they are not used correctly.

Trees in non target areas

Trials conducted by University of Queensland researchers have shown that planted buffers reduce the levels of airborne sprays drifting into non target areas (Spillman & Woods, 1989).

The effectiveness of this filtering is very dependent on how well the trees and shrubs are laid out. Unbroken single rows of sheoak trees were shown to reduce drift by 50% and wider buffers when properly designed can reduce drift by up to 90%. Tree buffers can act as a 'safety barrier' in the case of accidents, though these should never happen.

Buffers can be used in two key locations:

- close to where spraying is happening, or
- close to places particularly in need of protection.

Buffers close to spraying should be located on the edges of fields. Buffers to protect houses, non-target crops and watercourses or wildlife habitats should be planted quite near to these areas.

Trees as wind shelter for crops

Drift buffers are designed for a specific purpose and their placement and management should be primarily for drift capture. Other roles such as wind shelter should only be a side benefit. These buffers may also be suitable refuges for beneficial insects and pest controlling birds. (See also the section on *Trees as windbreaks on cotton farms*).

The effect of application method on spray drift

The most common method of applying pesticides involves mixing the active constituent (at the correct concentration for a particular purpose) in a body of liquid and breaking it up into a large number of small droplets.

Droplets used in spraying are small! (Table 1). Applicators often refer to droplets of 10, 100, or 500 microns, quantities that are invisible to the naked eye. A micron is equivalent to 1/1000 of a millimetre (mm) and thus a 500 micron droplet is half a millimetre (0.5 mm) in diameter. As an example, the full stop at the end of this sentence is approximately 400 microns in diameter.
400 microns is considered a large droplet in spray application technology.

Class	Size	Uses
Fog	<15 microns	Insecticides
Small droplets	<150 microns	Insecticides & Fungicides
Medium droplets	150 to 250 microns	Insecticides & Fungicides
Large droplets	> 250 microns	Herbicides

Table 1. Droplet size classes

Spray equipment can be selected or adjusted to produce droplets within a desired size range which is best suited to particular uses. The previous table (Table 1) shows the normal parameters for 'small' to 'large' droplets and indicates the size to use relationship for best results.

The influence of size on a droplet's physical behaviour can significantly affect the efficiency with which a target is reached by a chemical spray and also the potential for spray drift.

Small droplets have the highest risk of spray drift. Under normal spray conditions, large droplets will only move sideways a short distance with the prevailing wind before falling to earth.

When spraying cotton, good coverage of plant leaves and terminals must be obtained to create the potential for insects to absorb a lethal dose of insecticide. Traditionally in the Australian cotton industry, this has been achieved by generating small droplets and using local (or mechanically induced) turbulence to distribute the spray droplets in and around a canopy.

By reducing droplet size, large numbers of droplets can be created out of low volumes of material and the coverage levels (droplet numbers) on the canopy increased.

When insecticides are applied using agricultural aircraft, oil based ULV formulations are often used which help prevent the evaporation of small droplets. This is an efficient method of pesticide delivery, however, the selection of small droplets can increase the drift potential of this type of spray application.

To help reduce spray drift, large droplets (say 250 microns plus) can be applied and spray volumes increased accordingly. Even so, evaporation and the inability of most nozzles to totally eliminate the production of fine droplets means that some short range downwind drift can be expected from most types of spray application.

Large droplets, because of their greater mass and fall speed, tend to land on horizontal surfaces such as the ground or broadleaf weeds. In contrast, application to vertical surfaces or the underside of leaves is usually achieved using small droplets that are influenced by horizontal air movement and turbulence.

How trees catch spray drift

The aim of a tree buffer is to use the natural surfaces (including leaves, stems, flowers and seeds) of the tree/shrub to catch the droplets as they move in the air and pass through the vegetation.

As air approaches an object such as a stem or branch it is forced to go around the object. Very small droplets tend to follow the air around the object and pass straight on without impacting. Larger droplets have greater mass and take a longer time to change direction in an accelerating airstream and therefore tend to impact more readily on a target.

The smaller the catching surface is, then the greater the chance of intercepting smaller droplets. Consequently, trees and shrubs that have small needle-like leaves or stems are more efficient at removing small droplets from the air than broad relatively smooth eucalyptus leaves.

Large leaves that are covered in small hairs can also be very efficient at removing droplets. Most natural surfaces are not smooth. Many plants may have a complex rough surface comprising of small protruding spikes or hairs and leaf veins.

In choosing plants for buffers, trees and shrubs that present a small profile to the moving droplets are the most successful at catching droplets. Trees such as the Sheoaks (Casuarinas) that have needle-like foliage, and numerous small branches are particularly suitable for drift capture.

All these factors help to increase the efficiency of the plant in catching droplets. The movement of the leaves caused by the flow of air around shrubs and trees can also increase the catch efficiency.

Designing drift buffers

Tree buffers intercept spray drift:

- from the side by horizontal filtering of spray being blown through the buffer, as wall as
- from the top through the spray being deposited downwards onto the rough vegetated surface.

The design of tree buffers varies depending on which of these processes is most relevant to the local situation.

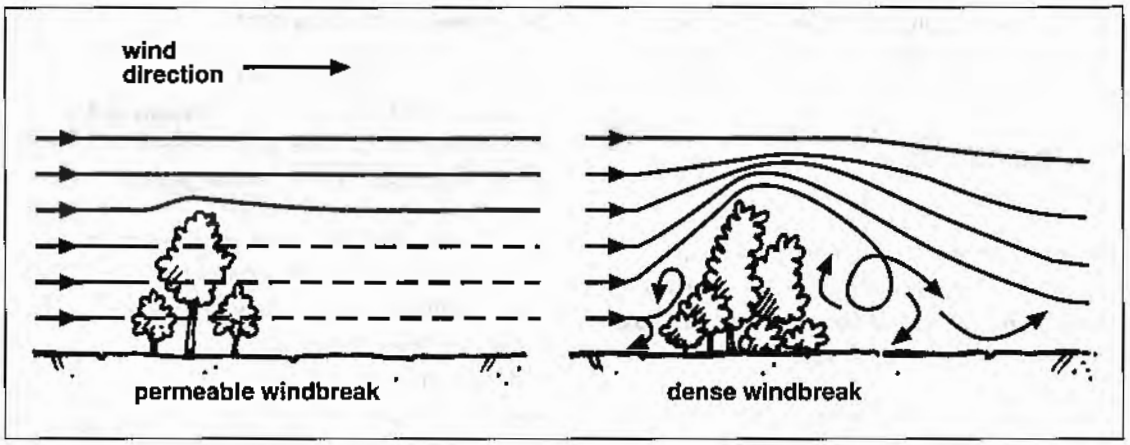

Fig 5. Wind flow characteristics in relation to density of windbreaks.

A narrow open belt of trees provides the greatest drift capture through horizontal filtering. The belt should be tall and the trees of a range of foliage types.

Top-down filtering can be maximised by using wide belts of vegetation (minimum 300 metres wide) including grass, shrubs, trees or non sensitive crops. These belts should have a high level of aerodynamic roughness, which means that the top of the canopy should be variable in height and density. Buffers such as these are often recommended in situations where rural activity meets populated areas.

Often, such areas occur naturally, for example, where native woodland areas, pasture areas or cropland border towns. Including these areas in a spray drift management program may be simply a matter of identifying them and ensuring they are maintained as natural or open space for the purpose of drift capture. These areas may also be valuable as a haven for beneficial insects and birds that may rednce the need for some pesticide applications.

The advice in the remainder of this chapter is devoted to buffers that are designed to capture horizontal drift. These may be made up of planted or retained trees.

Designing buffers to capture horizontal drift

The following need to be considered when laying out drift buffers on the farm.

Buffer Density

The density of a tree buffer has a big effect on how well it filters air. The denser the buffer the more likely it is that drift will simply be deflected over it rather than pass through it. This has the result that a drift cloud may be lifted higher and become more turbulent after passing the buffer

Buffers should be dense enough to filter air, but porous enough to allow air to pass though them. Droplets can be carried through a less dense buffer and this increases the chance of capture within the structure. Present knowledge suggests that the ideal density for a drift buffer is between 30% and 50% and that the belt is consistent in vegetation width and height. A suitable buffer should ideally consist of more than one row of vegetation. (Fig. 5).

When planting trees for a drift buffer, the layout for a preferred density planting would include rows of trees spaced about five to six metres apart with trees in rows about five metres apart. As the trees grow some thinning may be needed to reach the

Points to consider

Tree buffers are effective at catching spray drift, and as a result may be damaged or killed when herbicides or defoliants drift through them. Although species vary in their tolerance of chemicals, no plant is totally resistant. For this reason, buffers that are established to protect towns, dwellings and wildlife habitat from insecticide drift should not be exposed to herbicide drift.

The closer a vegetative buffer is to the release point, the greater the proportion of spray that can be intercepted. For example, a vegetative buffer at position A would intercept a greater proportion of the spray cloud than a buffer at position B. The concentration through the spray cloud is not constant and usually tends to be greatest near ground level. A buffer at position B could still be expected to intercept a reasonable proportion of the airborne droplets.

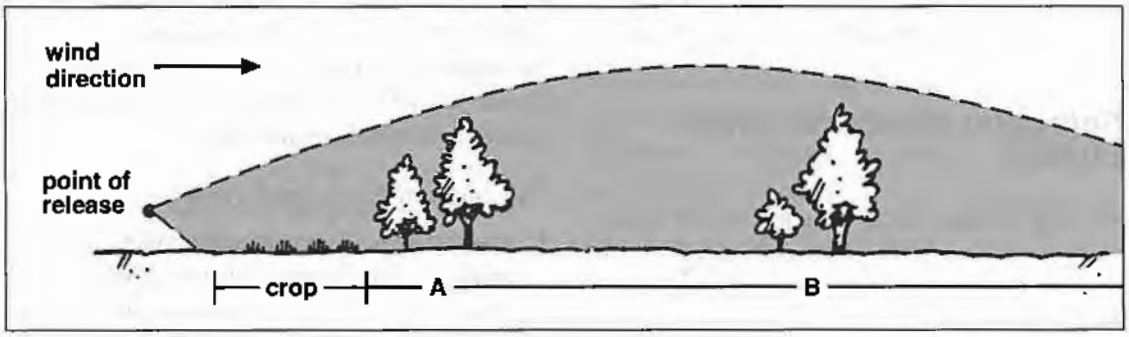

Fig 6. Spray capture in relation to distance between buffer and spray release point.

desired density. A desirable width would include five rows of trees spaced five metres apart, though narrower buffers can still provide some benefits provide their density is between 30-50%.

Buffer height

The taller a buffer is (and the closer it is to the sprayed field), the better it will be at catching spray drift. You may need to take into account factors such as powerlines, field layout, or aerial spray plane paths, when deciding where best to plant your buffer, and when considering the fully-grown height of your buffer.

The minimum height of a tree buffer is related to how dense it is. The more dense the buffer the taller it should be. As a general rule, buffers should be a minimum height of 1.5 times the height of spray release. For example, if a buffer can be established with a density of around 50%, then the height should not be less than about one and a half times the height of spray release. Where the buffer is more dense then the height should rise to twice the height of spray release.The height of a buffer will be determined by the types of plants used so that if a specific height is desired, consult nursery staff for advice on species selection.

Buffer length

Planted buffers should be long enough to enable the movement of spray to be intercepted. Allow for the fact that wind direction often may not be perpendicular to the buffer, but may blow at some angle to the barrier. If the buffer distance is only as wide as the area sprayed and the wind is offset, some spray can drift around a buffer as shown below. This problem may be overcome by planting on two sides of the field, or by planting extra long buffers on the main downwind side of the field.

Buffer Width

The width of a tree buffer has a big effect on the density. If a buffer is too wide, it is likely that air will be deflected, too narrow and it may not be effective as a filter. If a planted buffer is to be established, it should be around 20 metres wide.

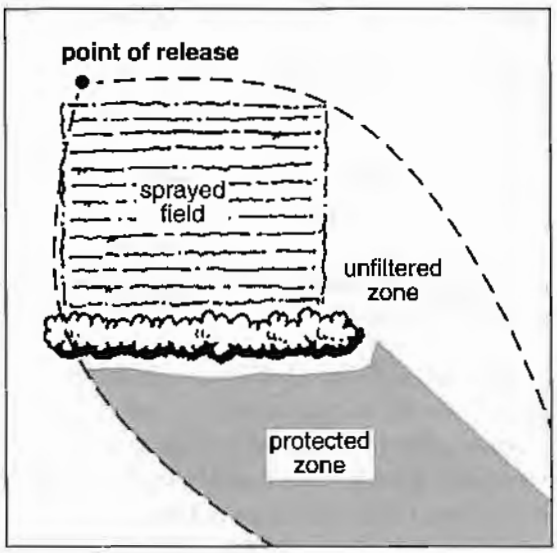

Fig 7. Relationship of drift to wind direction from a sprayed field.

Distance from spray release

When a spray is released in the atmosphere, gravity and wind influence the movement of droplets. The

larger the droplet the sooner it falls to earth. The wind can lift smaller droplets to significant heights from the point of release. These wind-borne droplets may travel a considerable distance before eventually coming to earth. For this reason, planting a buffer close to non-target areas will allow greater protection.

Selecting plants for drift buffers

Selecting the most effective species for drift buffers is important because the physical characteristics of leaves and branches can have a big influence on droplet capture.

Ideally, drift buffers have a variety of plants in them with different leaf shapes, growth habits and heights. The buffer should be uniformly dense from the ground up, which is best achieved by using a variety of plants. The most effective trees for drift capture are those with narrow leaves, and especially those with cylindrical leaves (like sheoaks). This is because they do not deflect wind as much and small particles tend to drift into them rather than flowing past. This type of plant should make up 30 to 60% of the trees in the buffer.

Information on the effects of various kinds of herbicide sprays on native or planted trees is best sourced from the product manufacturer. In some cases they will be able to supply information from trials or reports from other growers.

Other species which would be suitable for drift buffers would include fine leafed eucalypts such as green mallee *(Eucalyptus viridus)* or swamp mallett *(Eucalyptus spathulata)*, long lived wattles such as myall *(Acacia pendula)*, doolan *(Acacia salicina)*, and tea trees *(Melaleucas)*.

Tree species planted in a buffer zone should be carefully selected to complement each other, so as to create a network of foliage with low density from ground level upwards. Plants should be mixed randomly for maximum variation in canopy and height.

Tree susceptibility to spray drift

The potential for drift into native timbered areas or planted buffers must be given careful consideration in planning a herbicide application. The relative merits of aerial application versus ground rig must be weighed up. Chemicals such as 2,4-D ester should not be used where alternatives are available. Most importantly, landholders and applicators must be totally aware of the prevailing weather conditions and its likely effect on the job. There has been very little information written on the subject, especially in regard to local native trees on Australian cotton farms. In 1993 the Queensland Department of Primary Industries reported on field observations by farmers and advisers.

This information is outlined below.

- Damage seems to be seasonally influenced, with greater damage apparent when trees are in vigorous growth. During fruiting or flowering, herbicides appear to have less effect.
- Desiccant products such as Sprayseed® produce leaf spotting from drift but translocation of herbicide is limited. These products may cause significant damage but because the herbicide is not translocated, the damage could be considered similar to fire or other physical damage. It is generally felt that if a plant can survive low intensity fire it will survive desiccant drift.
- Glyphosate (either alone or mixed with dicamba or 2,4-D ester) has caused damage to trees.
- 2,4-D ester is particularly notorious for producing vapour drift from sprayed leaf or soil surfaces as it can be volatile for some time after application, especially with damp soil and hot windy conditions. Ally® is another dryland broad acre product with tree damaging ability.
- Sheoaks and belah *(Casuarina)* appear to be some of the most susceptible species to more commonly used herbicides. Other species with high susceptibility include wilga *(Geijera parviflora)*, brigalow *(Acacia harpophylla)*, leopard wood *(Flindersia maculosa)* and many broad leaf trees and shrubs. Kurrajong *(Brachychiton populneus)* appears to be slightly affected by glyphosate drift, but very susceptible to 2,4-D alone or in mixtures. Most eucalypts will suffer transient burning or defoliation from glyphosate but recover readily in the absence of other stresses.

Limitations of trees as spray drift buffers

Trees can be successfully used to reduce the drift from pesticide application but there are some limitations.

- Tree buffers should not be considered as the primary method of drift control where

agricultural land use adjoins urban or residential land. However, they can reduce the potential for conflict between residential and agricultural land uses and improve the quality of the environment by reducing spray drift across boundaries.

- Tree buffers are not designed to (nor can they) remove 100% of a spray drift load reaching their upwind side.
- Planting a buffer does not guarantee that droplets cannot move through, across or around the structure.
- Tree buffers can be damaged or killed by spray drift, they do not have a role in normal drift minimisation, and they are only really effective for accident situations.
- Buffers need to be maintained for maximum effect eg trees pruned and/or replaced when necessary.
- Trees take time to grow and establish as an effective buffer. They only provide benefit in the medium to long term.
- Trees and foliage will not significantly reduce odour movement

How do drift buffers differ from windbreaks?

Drift buffers are designed much like windbreaks in their structure except that buffers are more open (less dense) and contain specialised species with better filtering capacity. Drift buffers and windbreaks may need to be located in different places, and drift buffers are generally wider. Windbreaks are generally planted perpendicular to prevailing winds, whilst drift buffers are planted close to spray release areas or protected areas such as houses or watercourses. In many ways drift buffers and windbreaks are very similar in structure, but their greatest difference is in where they are placed in the property layout.

It is up to the property manager to determine what is the best spray management strategy depending on immediate and long-term needs.

Drift buffers need to be less dense than windbreaks and there also needs to be variation in the species mixture. Fine leafed high surface area plants should be favoured for drift buffers. Essentially, a drift buffer is needed downwind of sprayed areas or near to areas which need to be protected from spray drift.

Windbreaks on the other hand are best on the upwind side of crops they are intended to protect. In some instances it may happen that both of these functions could be provided by the same trees, particularly if they are planted as rows through cotton fields.

The ideal property layout for drift capture and wind shelter would have belts of trees on all boundaries and in rows perpendicular to prevailing winds about 100 m apart across the property.

This is not always practical and could be very costly in terms of land and maintenance.

Further Information

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Using trees in salinity management

Salinity is a potentially serious problem for cotton farmers, especially those who irrigate. Salination of soil is a process which occurs as a result of a rising watertable bringing salt laden water to the surface where it evaporates and leaves raised levels of salt in the topsoil layers.

In many instances, increasing occurrence of soil salinity is linked to broadscale clearing of land within catchments. If land is being developed for cotton farming, salinity hazard should be considered as part of the planning process.

Plants used must be able to handle the level of salinity already existing as well as the waterlogging which may be periodic or permanent.

Salinity research agencies can provide information of potential risk from salinity on a range of land types. If the risk can be identified, then planning for salinity avoidance through reduced or strategic clearing is desirable.

The most important activity when dealing with a developing salinity or waterlogging problem is to identify the source of water and try to control it.

This may be reasonably simple if it can be tracked to a leaky dam or irrigation channel, or it can be very complex if the watertable is rising because of catchment changes such as overclearing.

Identifying the problem

Salinity problems in flood plains or flat lands usually come about after a period of high water tables. If a water table remains within 1.5 metres of the surface it can evaporate leaving saline deposits on the soil. The first symptom of a developing saline problem can be wet patches or areas where crop yields are depressed.

Trees can be useful in controlling small outbreaks of salinity because they have the capacity to use soil water throughout the year.

In these situations, the main function of the trees is to remove soil water by taking it up through the roots, and releasing it through transpiration.

Naturally the more leaves the trees have the greater the chance of high water use, fast growing and vigorous plants are therefore the most useful for salinity management. The rate at which trees transpire is affected by stress levels, the more stressed a plant is the less it will transpire. Trees which are unsnited to a site become stressed and are often therefore useless for controlling salinity.

Placement of the trees in relation to the cause of a salinity problem is critical to their effectiveness. Salinity problems will reqnire an integrated approach. This may involve several landholders working together as well as the use of expert help from salinity researchers and advisers.

Careful planning is the key to cost-effective treatment of salinity. Clearly, prevention is better than cure. If salinity problems can be identified early, there is a much greater chance of control.

If the cause is not easily identified or fixed, then planting trees at or near the affected area may help to lower the watertable.

Deciding where to plant

On sites where salinity and waterlogging are slight to moderate, plant trees, pasture or other permanent vegetation across the whole affected area. Planting may be in the form of belts of trees with sheltered areas between, wide spaced trees with pasture amongst them or forestry-style woodlot plantings. Careful selection of suitable species, site preparation and establishment techniques will be required.

On sites with a combination of severe salting and waterlogging, planting may initially have to be concentrated around the fringes of the affected area. Once the trees are successfully established, they will contribute to local lowering of the watertable around the root zone. Once this occurs, planting can be extended to previously severely affected areas. Using drainage works may speed this process.

If the sonrce of the waterlogging or salinity

problem can be identified, such as a leaky channel or dam, planting between the source of water and the wet crop land is desirable. If planted correctly, trees will help to intercept water as it moves laterally in the soil.

If areas of cleared land or large recharge areas can be identified as the cause, belts of trees across the landscape between these areas and cotton fields will be beneficial. This may be done in combination with perennial pasture or legume crops.

Timing of planting

An ideal planting time is in early spring or early autumn when conditions are mild. On sites without waterlogging, planting is probably best done once rainfall has provided sufficient soil moisture and follow-up rainfall is expected. Watering in, essential at planting, may allow earlier planting on drier sites.

When planting on waterlogged sites, avoid the wettest part of the year to reduce the risk of early deaths through waterlogging before root systems are established.

On severely salt-affected sites, there may be some benefit in planting after a period of high rainfall has flushed some salt from the soil surface and upper soil profile. The lowering of salt levels in the topsoil will allow for easier plant establishment but, it is important to use plants which can tolerate the high salt levels which could return to the site.

Plant density

Trees should be planted at a density that allows each tree to produce a good canopy and an extensive root system. The intention is to grow trees that have large areas of leaf and which are not competing for light or nutrients, either of which will reduce vigour. Access for follow-up management such as slashing, should be considered when planning the planting layout.

Wider-spaced trees develop a higher leaf area and their root systems can access larger soil volumes, leading to higher water use per hectare planted. Moderately saline sites may be suitable for wider spacings combined with the establishment of salt-tolerant pastures such as lucerne or Rhodes grass.

Dense planting will be most effective in using soil water, reducing seepage and lowering the watertable. For dense planting, row spacing of four to five metres is suitable.

Trees can be planted at two to three metres along the rows, maximising early water use and shading. Early shading reduces evaporation from the soil surface, thereby slowing the accumulation of salt on the soil surface. Progressive thinning should be done over the first five years to an average spacing of around five metres (400 trees per hectare). This will maximise the growth rate which is important for a high rate of water use.

On severely salt-affected sites, there may be some benefit in planting after a period of high rainfall has flushed some salt from the soil surface and upper soil profile.

Ground cover

When planting near saline areas, some form of ground cover vegetation should also be encouraged. A perennial ground cover will reduce soil erosion by raindrop impact and wind and will assist water use by trees.

Ideally, the ground cover is sown during site preparation and before tree-planting takes place. The whole site can be chisel-ploughed and sown with a mixture of salt tolerant plants such as Rhodes grass and lucerne. Mulching at the time of site preparation will have a similar, protective effect.

Grazing control

Controlling access of grazing animals is critical on saline sites. Fencing will be necessary to prevent browsing damage and maintain ground cover. Fencing costs may be reduced by integrating planting with existing fencing layouts. Fencing will allow controlled grazing when the trees are tall enough, after about three to five years.

Some insect control may be required while the trees are young. Defoliation by insects on saline sites can be severe and may kill trees if left unchecked.

Species selection

Seek local, expert advice when selecting trees and planting designs to deal with a salinity problem.

The Department of Natural Resources in Queensland and the Department of Land and Water Conservation in NSW have salinity researchers who can help in this regard.

Planting mixed species (eucalypts with wattles and paperbarks) reduces the risk of high damage levels due to pests or disease.

Tree species recommended for planting on saline discharge sites are described in the species selection chapter. The plant's ability to tolerate waterlogging and the influence of soil type should be considered.

The potential of trees to have more than one use can be an important factor in species selection. As well, planting mixed species (eucalypts with wattles and paperbarks) reduces the risk of high damage levels due to pests or disease. Multi-purpose uses of the trees can include timber, wind shelter, nitrogen fixing and fodder, for example.

A valuable guide for tree species selection is a recently released Queensland Department of Primary Industries (QDPI) publication, *Trees for the rehabilitation of saline sites in south-east Queensland.*

Site preparation techniques

Soil improvement

Tree establishment on clay soils with poor soil drainage, waterlogging, or a high soil pH will benefit from the addition of gypsum (and organic fertiliser), incorporated before planting. Gypsum improves soil structure and permeability, root penetration, leaching of salts and is particularly useful on sites with hardpan clay subsoils and cracking clay soils. Advice for a suitable application rate can be obtained from crop consultants.

Site drainage

Sub-surface or surface drains help to reduce waterlogging and to allow rainfall to flush salt from the affected area. Drainage works may assist tree establishment on saline areas and are likely to be beneficial for site rehabilitation.

Mounding

Mounding helps tree survival and early tree growth on most saline and/or waterlogged sites. Mounding provides improved drainage for the plants and may reduce surface salinity levels through associated leaching (the downward movement of salts in water). Mounding is particularly useful on very waterlogged areas.

Benefits of mounding to tree root establishment include:

- reducing initial salt concentration around roots through leaching
- improving drainage
- reducing the rise of salt to the surface
- improving soil tilth
- achieving further improved results when combined with hay or other mulches.

Mound design

Larger mounds are generally more successful than smaller mounds. M-shaped or flat-topped mounds are better than peaked mounds (Fig. 8). Monnds around half a metre high and at least one metre wide are ideal. However, even mounds as small as 150 mm tall may be able to improve survival, particularly if they are used in conjunction with mulch to reduce capillary action resulting from evaporation.

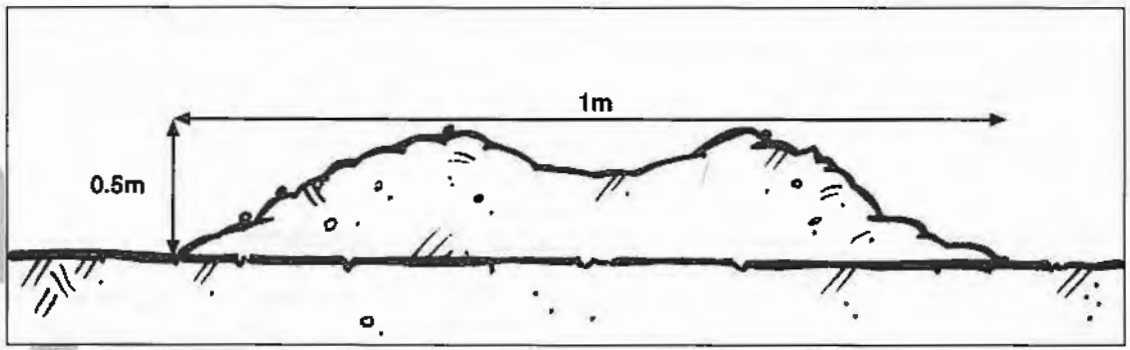

Fig 8. 'M' Shaped mound profile.

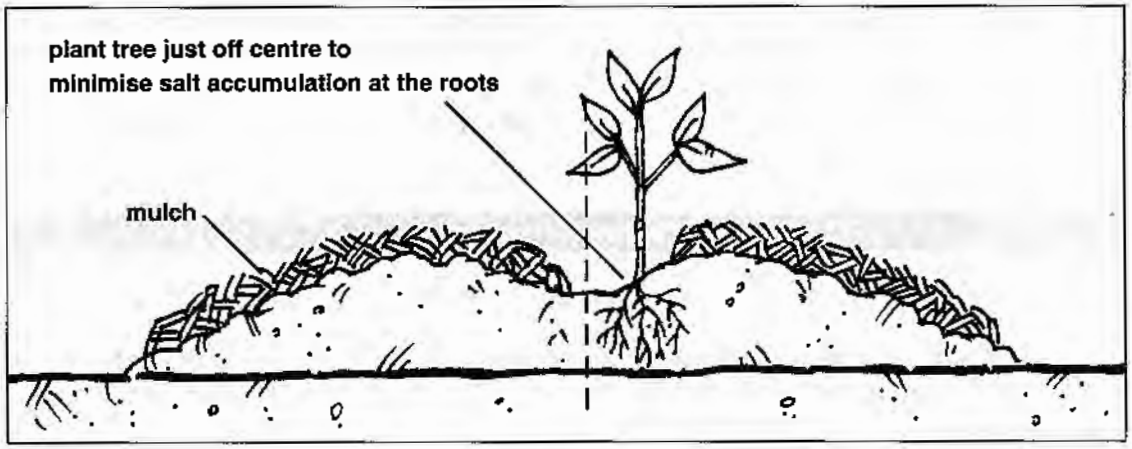

Fig 9. Tree placement in relation to mound profile and mulch.

Maximum benefits in soil drainage and leaching can be achieved by ensuring that the top of the mound is flattened at planting. The effects of salt accumulation due to evaporation from the peak can be minimised by the use of mulch, by making the mounds very broad and by planting the trees slightly to the side of the mound. (Fig. 9). M-shaped mounds may serve to decrease capillary rise due to evaporation, but are more difficult to construct than flat-topped mounds.

Mounds can be successfully constructed as a continuous line with two passes of a disc plough and then flattened. Often mounding over a rip line provides a good mound profile.

Mounds may become wet from the water table below or from water collecting in the furrows. To avoid water collection (and associated salt accumulation as the water evaporates) in the furrows, the mounds should be constructed as wide and as high as possible and designed to surface drain, preferably into grassed waterways. On very saline sites, large single mounds up to one metre high may be needed.

Constructing mounds well ahead of planting allows the soil to settle, reducing the air content and therefore improving plant survival.

Early construction also allows time for some leaching of salts, prior to planting. Early weed control or mulching can also be done when mounds are constructed some time before planting.

Mounds direct water, potentially creating an erosion problem. Continuous mounds will channel and divert run-off water. The top of the mound should be flattened and the gradient should not exceed 1%.

Thought should be given to maximising drainage of surface water from the site. Interception banks may be used in association with mounding to avoid excess surface flow on the mounded area.

Weed control

Competition from weeds may severely reduce early tree growth and some form of pre-planting weed control may be necessary. An application of a knockdown herbicide (such as glyphosphate) may be desirable after the mounds have been constructed.

Residual herbicides should be avoided before planting, but can be useful after planting.

Tree establishment techniques

Where possible, planting should be undertaken when there is sufficient moisture in the soil, or when rainfall is expected.

Fertilisers should not be used on waterlogged sites as this may kill the seedlings.

Mulching reduces evaporation and so reduces the rise of water (and associated salts) to the surface. This maintains better soil moisture around the plant and also provides some weed control.

Suitable mulch materials include cotton trash, wood chips, hay, sand and biodegradable plastic film. Organic mulch provides the additional, long-term benefit of improving soil structure. Ideally, mulch should be applied over an area of 80 cm to one metre diameter.

Trees should be watered in well at the time of planting. Repeated watering may contribute to leaching salt from the root zone.

Plastic tree guards can improve survival and early growth of young trees on saline sites. This may only be cost-effective if required for additional reasons, such as protection from grazing by wildlife.

Further Information

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Planting trees to stabilise creek banks

In natural systems, vegetation plays an important role in slowing the rate of change in stream condition. Trees, shrubs, grasses and sedges cover the banks and function to protect it from slumping and scouring erosion.

Because of the range of environments present along the banks of a watercourse, a wider range of plants can be found there than in surrounding areas. This makes it quite an important area for wildlife conservation.

In larger watercourses and perennial streams, trees may be important in bank stability and erosion control, especially during floods. These roles include providing barriers to the erosion caused by flows of water, reducing the incidence of bank slumping with stroug rooting and helping to confine flows to the centre of the channel.

Where trees (typically willows) establish themselves in the channel, flow is constricted which can lead to localised intensive erosion.

Revegetation in stream bank situations should try to include a wide range of plants including a large proportion of native rushes like Matt rush *(Lomandra)*, native vetiver *(Vetiveria filipes)*, common reed *(Phragmites)*, some shrubs like bottlebrushes *(Callistemon)* and a few trees like sheoaks *(Casuarina)* and rivergums *(Eucalyptus camaldulensis). (Fig. 10).*

A number of specialised plants assist streambank stability. These plants have flexible branches and foliage, fibrous root systems and an ability to withstand water logging.

When planting on riverbanks, staged planting up the bank is the best approach. Put plants that have low resistance to flow and good ground covering ability close to the normal flow levels. Plant larger, more deeply rooted plants further up the bank. Then, as water levels rise, plants at the bottom of the bank can protect and hold the surface soil, and maintain channel integrity. As water levels rise higher, the larger plants are needed to direct flows into the centre of the channel and to hold steep bank soil which can slump as flood waters recede.

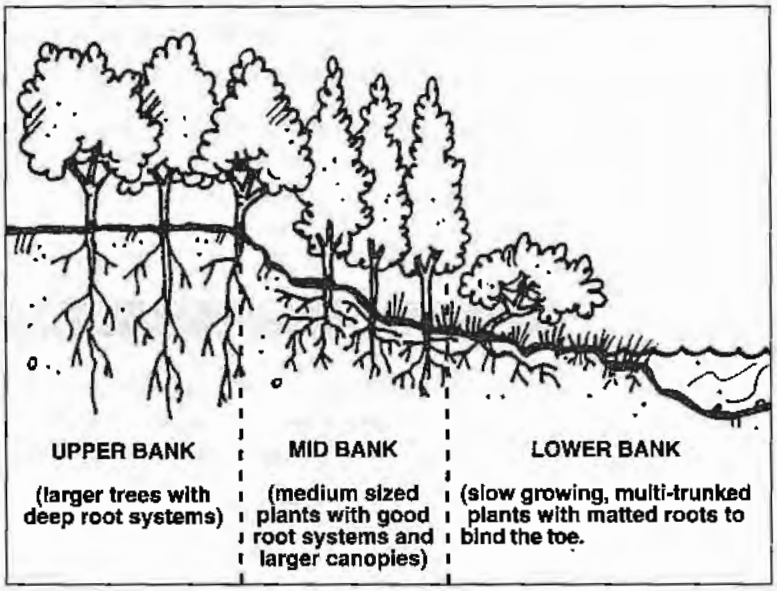

Fig 10. Vegetation placement in relation to bank position.

Ideally trees and other vegetation should be retained on stream banks and for an additional 10 to 20 m from the high bank. Encouraging good grass cover in this area will act to filter silt aud nutrients from flowing into the stream during floods.

Planting on creek and river banks

Creek banks are some of the most difficult areas for successful establishment of plants. Weeds are more competitive; soils may be low in nutrients (particularly if planting near or on slumped or scoured out areas); sites are prone to extreme conditions such as floods and erosive flows; and grazing or damaging stock and wildlife are more likely to be present.

Planting trees and shrubs as seedlings will require good weed control for at least twelve months, this may best be achieved by the use of heavy mulches. They may also need to be fertilised with about 100 grams of a good slow release fertiliser to give them a start. (Fertilisers should be used with discretion in watercourse areas, high application rates may

encourage algal growth or some other form of aquatic pollution.) Fertilisers should always be buried just under the soil surface on creek banks to minimise washing onto the stream.

Sites should be prepared individually and on sloping banks a flat spot may need to be cut with a mattock to create a good planting site.

Sedges and rushes may be transplanted into a degraded area from nearby areas. This should be done when the soil is moist and plants are actively growing. Hand digging tussocks and pruning off about half of the top growth will allow the plants to survive the shock of transplant more readily.

Planting layouts need to be carefully designed so that planting does not cause erosion or stability problems. In NSW the Rivercare program provides specialised advice on stream revegeration projects and can help in developing overall plans for stream management in a local area.

In Queensland, no such service presently exists, but advice should be sought from Department of Natural Resources advisers if available.

Points to Consider

Removal or damage to trees or planting trees on the banks of watercourses may be restricted by state laws. A permit or other permission may be required before undertaking such works. Please check with relevant government departments.

Growing trees for timber

Farm forestry in cotton growing areas is unlikely ever to deliver large returns. Most cotton growing areas are low in rainfall, have unsuitable soil types and are not close enough to markets for conventional forestry enterprises. However, some small commercial returns are possible on cotton farms, and by considering farm forestry as part of a larger property management program, timber can become another benefit from planting trees.

Some commercial or potentially commercial species could be planted into windbreaks, drift buffers, wildlife habitats, salinity management or just landscaping. Planting designs can allow for extra rows of trees, or can be planted more thickly with timber trees that can be removed as the planting ages.

Planting for timber production is a long-term investment. Tree crops vary in age to harvest from 25 to 80 years. There are some trees that are promoted for harvest in much shorter periods, but generally, the faster a tree grows, the softer and less durable the wood is likely to be. There are opportunities being promoted for timber production in short time frames and with high returns. Some of these programs may sound highly attractive, but as with any investment, they should be well researched before any funds are spent.

Planning your plantation

Careful planning and discussion are required to ensure that plantation forestry is appropriate for your land and a good investment in your area. This section offers broad general principles to consider when deciding whether to plant trees for timber, as well as some specific advice on the possibilities for timber production on cotton farms.

Investigating products

Forestry plantations can be established with many products in mind. Each product will need some specialised management if a successful result is required and often only certain types of trees will be suitable to grow. Plantations for firewood, for instance, will be differently managed from those for sawlogs or pole crops.

Because of the long-term nature of timber crops, the profitability of the investment is hard to predict. In some cases specialised processing is required for timber products. However, the viability of producing specialised wood products depends on having a sufficient quantity of wood products to support a processor. If the quantity is insufficient, the operation would be non-viable. Despite this, demand, as well as economic returns, should rise as timber sources decline.

Finding markets

The profitability of any production system depends on good market research. This is especially true for forestry because not only are there factors such as product quality, quantity, and uses, there is the complication of trying to predict market forces when the trees are ready for harvest, which may be more than twenty years away.

Farm forestry can also be a way to use hard to farm patches of land or areas which are just lying spare.

Timber growers removed from existing or conventional forestry markets may be need to consider producing unconventional products such as low volume, high quality products for furniture markets, or cheap products for local markets such as fencing materials or structural timbers.

Tree varieties suitable to the site and chosen markets

Tree species should be selected from those that are known to tolerate and grow well in the environments selected for a plantation. Species should be chosen that will deliver the type of products that are desired in the market place.

The better the tree suits the environment, the more likely it is to grow well throughout the production cycle. Many tree species will appear to grow well for the first few years, but later growth rates slow, and trees may even die out before reaching harvestable size. This is common with plants from overseas, or other parts of Australia, where natural habitats may be far different from your own.

Some checking around in the local area may show up some species which have promise. Advice from relevant government advisers or professional forest consultants could be a good starting point.

Managing the plantation

Forest plantations have a high demand for labour for planting and weed control in the early years. However, often people do not realise that ongoing work is required in terms of fire protection, fertilising, prnning and thinning that can be required throughout a plantation's life.

Additional inpnts such as fertilising and irrigation may be reqnired to shorten the growing cycle or improve tree quality. The cost of such inputs should be considered carefully as they may end up costing more than the value of the final product is worth and so may not be justified. Implications of irrigation on ground water recharge should also be considered.

Costs and likely returns

For forest plantations, most of the investment is in the early years and then there are long waiting periods before gaining a return. Generally, keeping investment costs to a miuimum will increase the net return. For this reason, plantations involving high cost outlays such as irrigation, expensive site preparation or excessive management are considered unlikely to be profitable.

Firewood plantations are unlikely to generate significant income, but growing your own firewood supplies could be worth considering, rather than having to buy it.

Private plantation managers can increase returns by value adding their product. This conld include taking on tasks such as form pruning, harvesting, snigging, hauling and sawing logs prior to sale. These issues are worth discussing with an accountant or forestry adviser to ensure that a forestry investment is viable.

Tax advantages from commercial forestry are possible, but it must be demonstrated that the plantation has the potential to return a profit as a stand alone business. This should be discussed with an accountant for exact details.

Careful consideration of these points and others will help in deciding if a forestry investment is a good move. It is often a good idea to consult widely before planting. The government department that manages forestry in your state will have advisers who can help, but it may also be helpful to consult sawmillers and industry groups for their advice.

Unwanted side effects

When establishing a plantation, particularly with a species unknown to the area, it may be advisable to check that it does not develop problems which may be costly to manage. Examples would include:

- Trees that are potential weeds. These are trees that produce viable seeds or suckers freely from roots or branches, and are likely to be considered a weed risk. Some species of Pines have shown weed potential in South East Queensland and Paulownia is becoming regarded as a weed in Victoria.
- Trees that provide poor wildlife habitat, for example, exotic trees. Exotics are of limited value to native wildlife, and single species plantations of any kind are often limited in this regard. Retaining or planting a mixture of habitat plants can be a desirable addition to a large plantation area.
- Trees that can become havens for undesirable pests such as pigs, parrots or wallabies.

Some options for saleable products on cotton farms

Firewood

A number of species such as mugga ironbark *(Eucalyptus sideroxylon)*, river gum *(Eucalyptus camaldulensis)*, doolan *(Acacia salicina)* and sheoak *(Casuarina cunninghamiana)* are considered to be suitable for firewood purposes. These species will also grow qnite well in most cotton growing areas. Firewood plantations are unlikely to generate significant income, but growing your own firewood supplies could be worth considering, rather than having to buy it.

Farm and structural timbers

There are some tree species that have the potential to grow into suitable farm timber from plantations on cotton farms, some examples would include most of the box group of eucalypts, mugga

ironbark *(Eucalyptus sideroxylon)* and Chinchilla white gum *(Eucalyptus argophloia)*. These trees could be managed to produce short length round timbers for sheds, fencing, rails or other uses. Some form pruning (removing side branches) will be required to produce this type of timber, bnt this is not so critical for this type of product.

Appearance timbers

Several species of tree could be suitable for growing for appearance grade (or cabinet wood) products. These offer potentially higher returns than other timber products, provided there are markets and the prodnct is of good qnality. This type of plantation has, to date, not been proven to be viable in cotton growing areas. Therefore, such investment should be considered speculative.

An example of a potential appearance grade timber suitable for cotton growing areas would be doolan, also called black wattle or sally wattle, *(Acacia salicina)*.This tree produces a high quality timber suitable for furniture making, and has the potential to be sold in the market alongside timbers such as Tasmanian blackwood *(Acacia melanoxylon)*. The tree is also considered to be a weed in many areas and is generally a spreading, poorly shaped tree. For doolan to be converted from a weed to a commercial crop, it needs to be regularly form pruned and provided with the best chance to grow tall and straight. The returns will never come close to cotton or other crops, but it could be suitable for planting on less productive, saline or waterlogged land.

Another species which may be worth considering is Chinchilla white gum, or western white gum *(Eucalyptus argophloia)*. This species has been planted on the Darling Downs for some 30 years as an ornamental tree and recent timber studies on plantation grown specimens indicate that the tree produces a useful red coloured hardwood timber of similar strength characteristics to ironbark (Bill Leggate, QFRI Timber Processing and Seasoning Scientist pers.comm.).

The tree has a naturally straight growth and there is minimal taper in the log. Both of these characteristics mean that there is potential for high recovery of timber from the logs and that they could be used for a range of uses such as sawlogs, poles, fencing timber, veneers or craft wood.

At this stage, it appears likely that white gum will prodnce timber within 30 years on the Darling Downs. The tree has been snccessfully grown at Moree, St George, Biloela, Emerald and Theodore, but timber characteristics and long-term growth rates are not yet known for these areas.

Estimates of the retnrn on investment from this type of plantation are abont 3 to 5 per cent Internal Rate of Retnrn over a 25-30 year growing cycle. This is not a large return, but when a plantation can also provide additional benefits, it may be a more attractive investment. Value adding in this system could increase returns, in particular by removing side branches whilst the trees are small. This will produce knot-free wood which will achieve a premium in the market place

Chinchilla whitegum has a naturally straight growth and there is minimal taper in the log. Both of these characteristics mean that there is potential for high recovery of timber from the logs.

White gum are mostly planted in lines from 3 to 7 rows wide, planted around fields to provide windbreaks, visual screening or some other purpose. Block planting has also been done on pieces of land which may be difficult to manage or do not fit into cropping layouts.

Other species tried for timber plantations include mugga ironbark *(Eucalyptus sideroxylon)*, spotted gum *(Corymbia variegata)*, river red gum *(Eucalyptus camaldulensis)* and grey box *(Eucalyptus moluccana)*. In general these species have grown well in selected sites, but their commercial potential is variable. They may have potential as firewood, or as farm timber.

Design

Plantations are best managed as a dry land (non-irrigated) operation. Trees may need some irrigation in the first year, but it is unlikely to be economic to irrigate timber plantations in cotton growing areas.

Timber plantations are usually established at fairly high densities and then thinned out several times before final harvest. In dry land (non-irrigated) operations, trees are planted at a spacing of 5 metres by 3 metres (667 trees per hectare) and thinned out to approximately 100-150 trees per hectare for final crop harvesting.

Thinning must be carried out ruthlessly and on schedule to produce superior quality trees for final harvest. High levels of thinning are required, in two stages. At about 3-4 years of age, a non-commercial thinning should remove obvious runts and trees of poor form; the second thinning would be a commercial harvest to open up the tree canopy at about 12 to 18 years. The wood from this second thinning may be sold as fencing materials, firewood or other products depending on available markets.

If the major goal is a financial return from timber, the highest returns would come from single species planting, followed by clearfelling, that is, harvesting every tree in a planting area in one operation.

Further Information

Contact Bill Leggate, Queensland Forestry Research Institute (07) 3896 9803.

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Benefits of conserving nature on farms

Fig 11. Native vegetation provides habitats for many animals.

Conserving nature on farms has many benefits, ranging from simple personal satisfaction through to providing habitat for wildlife such as insect-feeding birds and spiders, which can have direct advantages to agriculture.

Providing for wildlife on farms also has a broad community benefit, after all, more than 70% of all wildlife habitat across the Australian continent exists on farms. Farmers are, therefore, one of the most influential groups in the conservation of our native wildlife.

Single properties can seem to have only small areas for nature conservation. However, when combined across a district, small patches can be very valuable when linked with road reserves, stock routes, and large patches of vegetation on nearby properties or in reserves. Rural land can accommodate a surprising number of animals, particularly birds, and this wildlife offers benefits the farmer may not have considered.

Natural pest control

Many native animals have an effect on pests that affect farming. Magpies, ibis, bustards and other insect eating birds can reduce numbers of crop feeding insects considerably.

Predatory insects, spiders, birds and reptiles can play an active role in reducing insect pest pressure and help remove disease-carrying organisms. Wolf spiders, scorpions, hover and robber flies and certain ground beetles feed on insects affecting crops such as scarab beetle larvae, moths and grasshoppers. These predators shelter under the peeling bark of trees and in leaf litter and depend on healthy native vegetation to survive.

Keeping soils healthy

Microbes, reptiles, snails, worms and ground dwelling insects like ants and termites help to keep soils healthy. They break down organic matter, loosen the soil, increase moisture penetration and cycle nutrients.

These types of organisms are also active in the processes of biodegradation of manufactured products such as pesticides, detergents and organic refuse which can affect soil and water.

They depend on good habitat and a diversity of vegetation to function effectively. This includes having leaf litter, fallen branches and ground layer plants in their habitat to provide shelter and sources of food.

Rural land can accommodate a surprising number of animals, particularly birds, and this wildlife offers benefits the farmer may not have considered.

Protecting the farm

Areas of vegetation retained for wildlife habitat can act as firebreaks or shelter crops from the wind and frost. Wind protection can have great benefits for crops affected by frost or sand blasting.

Native vegetation along watercourses provides some of the most valuable wildlife habitat on any property. This vegetation also protects banks from slumping, filters overland flows as they enter the stream and helps to keep flood water flowing in the channel.

The environment surrouuding and on the farm will usually be less subject to, and recover better from, natural catastrophes such as insect plagues and disease outbreaks where a diverse range of plants and animals are present.

Conserving biological diversity

Conserving diversity of animal and plant species is an issue of global importance, with both Federal and State Governments acknowledging the need for immediate action regarding the adoption of ecologically sustainable agricultural and pastoral practices.

Modern agriculture relies on plants from a very narrow genetic base, which are susceptible to pest and disease epidemics. Wild species are important as a gene pool from which to breed new, resistant strains of crops. Breeding with wild relatives of cotton has produced transgenic cotton, and new hybrids with greater yield, vigour or other desirable qualities. The production of these new strains is a multi-billion dollar industry, and helps industry improve agricultural yields.

An integrated approach to pest management includes making the best use of natural pest controllers.

Farmland is important for conservation, both in providing links between the major remnants of native habitat, and in preserving natural ecosystems based on fertile land, which are poorly represented in reserves. Because these reserves are fragmented and isolated, species find it very difficult to move to another breeding population, often resulting in inbreeding, and a gradual decline towards extinction.

Providing future income-earning opportunities

Remnant vegetation may be the basis for new industries not yet discovered. The more diverse the range of native plants and animals on a property the greater the chance for future income diversification.

Some examples of this opportunity include recent work on extraction of oils from native plants. Cypress pine *(Callitris glaucophylla)* for instance contains leaf oil with commercial potential as an insect repellent for horticultural crops and possibly cotton. Other species such as False Sandalwood or Budda *(Eremophila mitchelli)* and several of the eucalypts contain alkaloids and bioflavinoids which are useful in medicine and manufacturing industries

Bushfoods such as the native lime *(Eremocitrus glauca)* and warrigal greens *(Tetragonia tetragoniodes)* are now being produced commercially, while others such as the native capers *(Capparis arborea)* are delicacies just waiting to be exploited.

Natural pest controllers on cotton farms

Over 250 species of potentially beneficial insects, spiders and other creatures have been identified in Australian cotton crops (Room 1979). Although few could be regarded as major pest predators, together they are capable of consuming significant quantities of pests such as insects.

Predators include bugs, beetles, lacewings and spiders. Numerous wasp species are parasites that infiltrate larvae, pupae or eggs of cotton pests. Many of these predators and parasites rely heavily on native vegetation for survival.

Beneficial creatures have been shown to impact on aphids and mites, but seem to have less impact on heliothis, the most destructive, and persistent pest of Australian cotton crops. While many pests of cotton can be held below critical levels with little or no use of insecticide, this does not seem to be the case where heliothis is concerned. Heliothis has thus created special problems within the Australian cotton growing system.

To be effective, natural pest controllers require some specialised management. Loss of habitat for natural controllers can reduce the numbers of beneficial insects and spiders that survive from crop to crop.

An integrated approach to pest management includes making the best use of natural pest controllers. This approach requires:

- maintaining refuges for beneficial organisms (refuges for beneficial insects are areas that provide shelter, breeding sites and safe places for such insects to retreat to during non active seasons)
- using food sprays and/or insecticides that have lower risks of broadscale environmental damage to fish or non-target animals to help attract and conserve beneficial creatures
- monitoring pest levels. This can reduce unnecessary spraying.

In recent years, there has been a great deal of interest in the use of wildlife refuges for controlling pests of cotton, most of which has concentrated on

alternative crops, such as sunflower, safflower, sorghum and lucerne. These refuges can be any vegetation, crop or non-crop, which is not subject to the normal crop spray regime.

Studies have shown that by growing lucerne crops amongst cotton fields, and using food sprays which attract beneficial insects from the lucerne onto cotton, the number of insecticide sprays needed per season can be reduced significantly. Lucerne strips have also been shown to reduce the rate of egg laying by heliothis, and provide effective control of secondary insect pests such as mirids.

The role of native vegetation in natural pest control

Native trees and vegetation can contain abundant and diverse varieties of beneficial insects. Unfortunately, remnant vegetation, windbreaks alone cannot offer sufficient habitat to supply the quantity of beneficial insects for effective pest control in cotton.

However, linking areas of native vegetation, planted trees and specialised refuge crops such as those described above, provides a larger area of habitat and allows species to move to seek food, shelter or to find a mate. In addition, windbreaks, shelter belts and remnant vegetation are also extremely useful in protecting specialised refuge crops from the effects of spray drift.

The numbers of beneficial creatures existing in natural or planted refuges should not be underestimated, and their potential to contribute to integrated pest management programs can be significant. Unless protected from spray drift, such areas may suffer declines in beneficial creatures similar to those in the crops themselves.

Another factor in pest management strategies is the advent of BT transgenic cotton. This new breed of cotton will require an industry-wide management strategy to combat resistance. Growers using this new technology are required to manage insect refuges as part of their pest control program, allowing populations of heliothis to breed without selection pressure. If these refuges are unsprayed, they will also provide essential refuges for predators and parasites that attack heliothis. Transgenic cotton is likely to be extensively planted in the near future, and currently reduces sprays by 40-50%.

Other useful native animals

Insects are not the only natural pest controllers that might prove useful in integrated pest management. Most species of birds feed on insects and spiders as part of their diet and in doing so contribute to controlling some crop pests. Small bats are also significant feeders on flying insects. They are generally dependent on trees and shrubs, particularly eucalypts and other natives, for food, shelter and nesting.

Some beneficial birds and bats on cotton farms include:

- **Noisy friarbirds** and **red wattlebirds**. These honeyeaters feed mostly on large insects during the summer or when nectar sources are limited
- **Small honeyeaters**, **pardalotes**, **thornbills** and **wrens** eat a wide range of insects
- **Black faced cuckoo-shrikes** eat large numbers of beetles and caterpillars
- **Whistlers** snatch leaf beetles and caterpillars from foliage
- **Fly catchers** and **swallows** take beetles and moths as well as flies
- **Parrots** include insects in their diet
- **Magpies** and **crows** regularly feed on grubs in crops and in the soil nearby
- **Owls** feed on mice, rats and large insects
- **Microbats** (several species) feed exclusively on flying insects and feed in cropping areas near wooded habitat in the early evenings.

The numbers of beneficial creatures existing in natural or planted refuges should not be underestimated

Most of these animals will incorporate several kinds of pests in their diets, from a range which includes caterpillars, cicadas, locusts, grasshoppers, wire worms, army worms, cut worms, flies, bugs, leaf hoppers, frog hoppers, ants, thrips, scale, aphids and lerps. Other bird species will consume pests such as weeds and mice.

Potential bird predators of moths such as heliothis include cuckoos, thrushes, wrens, thornbills, flycatchers, robins, fantails, chats, sitellas, tree creepers, pardalotes, mistletoe birds, honeyeaters, magpies, ravens, butcherbirds and plovers, all of which will benefit from adjacent native vegetation.

Insectivorous bats are able to eat the equivalent of their own body weight in insects each night. Bats can also be present in surprisingly high numbers during warmer months.

Planning for nature conservation

Leaving large blocks, or any areas for wildlife, should be well planned, as they are areas that must remain intact for long periods to be of benefit. Patches of native habitat that include watercourses, natural wetlands, unusual features or well-established native plant life are most important.

Birds that are predators of crop insects are more likely to be found where agricultural land and woodland meet.

Retaining large trees and trees with hollows is very important in farm nature conservation. Much of our wildlife depends on mature or over-mature trees and also on the diversity of plant species, plant sizes and ages present in remnant bushland or old regrowth.

When first developing a cotton farm, property planning should include large patches that can serve as wildlife habitat and provide refuges for beneficial insects and animal.

Principles for reserving native habitat

To assess an area's suitability for native wildlife habitat, consider the following:

1. Size

Most forms of wildlife require large areas of suitable habitat to survive and prosper. To encourage the greatest diversity of native wildlife, you will need large areas of the vegetation that was native to the area.

Larger areas of vegetation also have a higher survival rate in the long term because they are less susceptible to damage by fire, wind exposure or tree dieback.

Larger areas will provide a range of environments from the semi-open edge areas to the specialised habitats in the centre of the area. These areas away from the edges provide habitat for many of the original wildlife species, and are often the places where endangered wildlife can be found.

Birds that are predators of crop insects are more likely to be found where agricultural land and woodland meet. Large blocks of natural bushland are more desirable, and are better for attracting birds, than thinly scattered trees. Most birds require a minimum breeding territory, often in the range of 1-3 hectares.

2.Shape

Shape is important. An area of bushland with the smallest perimeter or edge length is least affected by outside disturbances. An area of bushland that is close a square or a circle shape, has the best chances of long-term survival.

3.Location

How close an area of bushland is to other areas of natural bush is important in conserving diversity of plants and animals. Many species need continuous or near-continuous bushland for breeding and for re-colonising areas after disturbances such as fire, drought or human activity. Small species in particular cannot move across large expanses of unsuitable habitat.

4.Connection

Wildlife needs corridors of trees and shrubs to move through from one area of bushland to another. These corridors also provide habitat for some species. Shadelines, roadside vegetation strips or windbreaks can act as links between patches of retained bushland and can also provide habitat for some wildlife. Linking vegetation along creek lines with adjacent remnants also provides a network of retained bushland across the catchment.

Studies of roadside vegetation strips have found these areas capable of conserving and supporting mammals such as sugar gliders and bats, plus various reptiles and bird species. Many species require larger areas of habitat to remain viable, but vegetation corridors linking areas of remnant vegetation provide an important means of connecting animal, insect and bird populations.(Fig. 12).

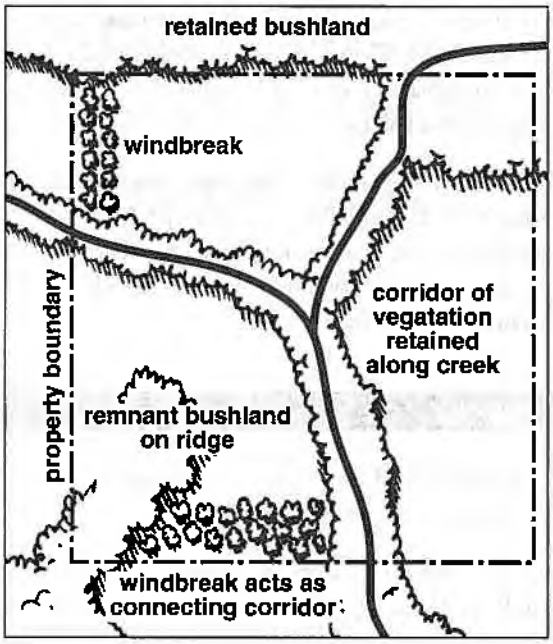

Fig 12. Possible vegetation retention and replanting layouts for nature conservation.

5.Diversity

Maintaining diversity in native vegetation is essential. The greater the range of plants and landforms, the greater the value for wildlife. The understorey is particularly important. These layers of shrubby vegetation, herbs and grasses beneath the taller trees provide cover for small animals, insects and spiders and reduce wind and heat damage to the soil surface.

Most forested areas consist of different layers [or strata] of plants (for example tree, shrub, herb and grass strata). Many birds and animals live in one or two levels only, while others range more widely.

A wide range of plant species of different heights, widths, flower and leaf types, etc. will also help increase the diversity of birds and other wildlife. Flowering shrubs like bottlebrushes, melaleucas and grevilleas will attract honey eaters, while wattles provide food and shelter and will encourage birds. Winter-flowering plants are especially valuable, as they encourage nectar feeding birds to stay through times of insect scarcity, enabling them to switch rapidly to a diet of insects in spring.

A dense shrub layer will help provide safe nesting sites for some smaller bird species, and a refuge from aggressive native birds such as noisy miners and predators such as hawks and feral cats.

Putting the rules into practice

Nature conservation areas are most valuable along rivers and streams. Conserving these stream bank areas not only provides a diverse wildlife habitat, it also protects river banks from collapse and filters silt and other pollutants entering streams in flood waters. (See also the section on planting trees to stabilise creek banks). Large patches that link up across the farming landscape and into adjoining areas are also valuable.

If property development is in progress, local environment department or Greening Australia advisers can help develop plans which allow for development but also identify core areas for wildlife conservation. These plans will help in long term planning and can maximise the beneficial effects of wildlife. Such advisers could also explain how to replace habitat, and where funding is available for such projects.

Protecting existing patches or blocks of native vegetation is the most desirable form of nature conservation. These patches may be uncleared forest, a patch of regrowth or native grassland.

If there are no natural areas around, or they are quite small (say less than two hectares), then the next best thing is to try to encourage regrowth. Removing grazing animals, managing fire or selective weed control will encourage regrowth. Results may be sporadic and slow to start, and depend on suitable sources of regeneration, either a seed tree or a source of suckers.

Planting trees and other vegetation is generally the last alternative it costs more than regeneration and is slow to produce results. Planting to provide links between native patches, or to thicken up depleted areas, is the most beneficial for wildlife. Planted trees will take a long time to re-create the natural structure occurring in native bush. If planting trees as part of a nature conservation program, then collecting local seed is desirable. Try to plant as many of the species that originally grew in the area as possible.

Dams and other still water structures can benefit wildlife, but generally a narrow group such as waterfowl do well, while other species which need running water or natural wetland areas (including the adapted plants which live there) may be disadvantaged.

Big old trees, particularly if they have hollows in them, are one of the most important sources of habitat on a farm. These old trees, which may be up to 400 years old, provide homes and habitat for an amazing array of wildlife. Around 400 of Australia's birds, mammals, reptiles and frogs use tree hollows. Many cannot survive without them. Of Australia's fifteen species of possums and gliders, eleven depend on hollows, while one in five bird species nests in hollows. Many bats and reptiles use tree hollows for shelter and as places to hibernate during winter. Trees with suitable hollows take 150 years to replace. That is a long time for a glider to wait to have babies!

Some dead trees and branches should be left as these provide nest holes for tree creepers, pardalotes, tree martins, kingfishers and parrots. Dead trees or trees with hollows also provide roosting sites for bats.

Further Information

Further information on integrated pest management can be obtained from the Cotton Research and Development Corporation, government agriculture departments or crop consultants.

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Section Two:
How to establish and take care of trees on cotton farms

Getting started

Many people who have trouble growing trees find that their failures occur in the first six months. Often trees fail to grow because farmers were not properly prepared for growing trees. Planting trees is the easy part; getting them to grow is often the hard part.

Ideally a tree planting project should be planned ahead for at least one season, allowing time to decide where the trees will do the most good and cause the least interference with property operations. Time should be allowed for thorough site preparation including weed control, cultivation and moisture retention. Tree species should be selected in advance and ordered to make sure they are going to be on hand when needed.

Three simple checks will make the job of planting easier and increase the chances of plant survival:

- Good soil moisture is required at least a 60 cm moisture profile, or, if this is not possible, watering will be required until good rain falls.
- No weeds or grass should be allowed to grow within one metre of the trees for at least 12 months. The planting site should also be totally weed free at planting.
- No grazing animals, fire and damaging sprays should be allowed around the young trees.

These are important in establishing any crop, but it is especially important for trees because they take a long time to grow, and setbacks in the early years will slow growth rates for many years. (Fig 13).

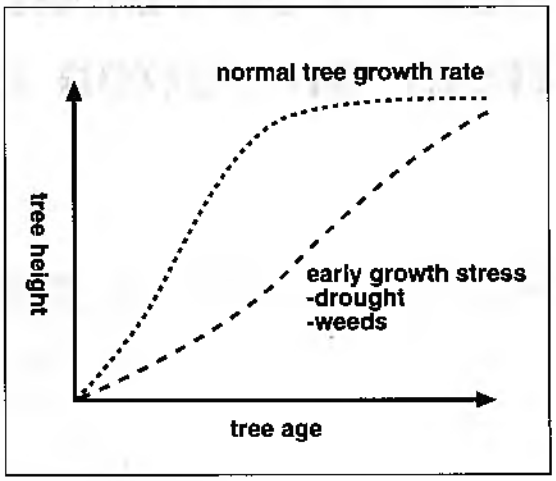

Fig 13. Effects of early stress on long term growth rates of trees.

Good soil moisture

Most successful tree growers in the heavier soil areas spend some time increasing soil moisture before planting trees. This can be achieved by simply spraying out weeds or some form of cultivation and fallowing. Planting lines can be deep ripped to a depth of 40 cm to increase water infiltration in areas where a hard pan is suspected. In heavy clay soil areas this should be done well before planting so that heavy clods have time to break down with wet weather.

Planting should coincide with the most likely season for rainfall. In most cotton -growing areas, ideal planting times are early spring or early autumn. Autumn planting is probably preferable in northern areas because the trees are going into a less stressful, dormant season which allows them to get over transplant shock more easily. Spring or autumn planting is OK in southern areas and is a matter of what best suits the grower.

Planting may have to fit in with other activities on the farm and this may result in some compromises depending on labour and machinery availability. In these cases, keeping the planting site weed free will help to retain moisture deep in the soil.

Watering

Trees should always be watered in at planting. Even if soil moisture is good, a small amount of water will help to settle soil around the trees and help to reduce transplant shock. A good amount of water to give a tree at planting is between five and ten litres. If water injection planting machines are used, they generally supply 300 ml per plant. This amount should be adequate if placed correctly, but it is advisable to check trees for moisture stress the following day.

If soil moisture conditions fail, and the trees need to be watered after planting, they should be given infrequent heavy soakings. Each tree can be watered with between 20 and 40 litres over the space of one or two days. Do not repeat for up to eight weeks in winter or four weeks in summer. This will allow the soil to dry out around the tree and thus force it to develop a drought-tolerant root system. Watering too frequently will encourage the tree to develop a small root system that will always be dependent on regular watering. Frequent watering may also produce trees that are not firm in wind.

It should not be necessary to water trees after they reach 1 to 2 metres in height as their root system should be self sufficient by this time.

Hand watering can be costly and/or time consuming. Setting up a permanent trickle system is relatively simple, but adds considerably to cost. If planting is to be done over a number of years, pipes may be recycled from one planting to the next, which will offset the initial purchase cost.

Furrow irrigation is simple, and is a good way to establish trees and water them in the first year. Furrow irrigation is easily set up on farms with suitable equipment and access to water. However, this method of irrigation is not particularly efficient. Care must be taken to ensure that such irrigation does not contribute to groundwater recharge.

When selecting tree species to minimise the need for watering, local rainfall patterns should be considered.

Weed control

To establish trees successfully each tree needs to be surrounded by a weed-free zone until it is 2 to 3 metres high. The size of the zone varies with both the species and the size of the tree but weeds should generally be kept at least half to one metre away from the trunk of the tree. (Research in forestry plantations in Queensland suggest the optimum weed free zone is a 1.4 metre radius around young trees.)

Weed-free zones can be created by applying herbicides as spots, bands or overall. Glyphosate can remove existing weeds either before or after planting. Mixtures of glyphosate and residuals can be used post planting as a guarded spray.

The Queensland Forestry Research Institute in Gympie has been conducting herbicide screening trials for some time with eucalypts and the following table outlines some herbicides which have been shown to be useful for application around eucalypts. (Table 2).

Of these herbicides, Glyphosate as a knockdown and Simazine® as a residual are probably most effective for heavy soils.

Herbicides can be applied using a number of techniques, the best being a guarded spray which includes using a shield between the tree and the nozzle. Commercial spray shields are available, these may be simply a shroud for the nozzle of a knapsack spray or a large dome which fits onto a spray nozzle mounted on a tractor or four wheeler.

If trees are to be watered with poor quality or saline water, it is advisable to minimise water application and pay attention to water conservation practices such as good weed control and use of mulches.

Spray drift is a problem when using herbicides such as glyphosate, especially on to un-guarded trees in the general area.

Non-chemical weed controls such as heavy mulchiug can provide an excellent alternative, but they are labour intensive. Mulching young trees helps rerain soil moisture, control weeds and can contribute organic matter to the soil. Mulch should be kept away from the stem of the seedling to avoid collar rot.

Check the mulch for possible seed loads. Grain stubble may introduce a number of plants which will compete with the trees or could create an extra weed problem. Cotton trash is quite suitable for

PREPLANT		POSTPLANT (Guarded spray)	
Knockdown	Residual	Knockdown	Residual
Glyphosate	Simazine®	Fusilade®	Simazine®
Fusilade®	Atrazine®	Glyphosate	

Table 2. Herbicide options for tree planting

mulch, but dust problems may be a health concern for workers applying the mulch.

Animal control

Keeping animals away from young trees is particularly important if trees are being grown for timber, windbreaks or ornamental reasons because grazing can have a big effect on the shape of the trees and may reduce survival considerably.

Domestic animals such as sheep or cattle should be fenced out from tree plantings, but feral and native animals which are harder to fence may need to be strategically controlled, repelled or specialised tree guards may be required.

Cultivating between rows and close to trees may help improve moisture storage but problems with root damage and continuing weed growth close to the trees make this approach limited if used alone.

Shooting at night can generally control hares. Where hare populations are too large for shooting, or where native animals are involved, tree guards may be an option

There are a number of commercial tree guards available. Most are designed to protect trees from small animals and fences are needed to exclude larger animals.

Commercial guards can consist of specialised moulded tubes of plastic, plastic sleeves held up with bamboo stakes, empty 1 litre milk cartons or wire netting. Such guards vary in price from about 10 cents each for a milk carton and stakes to $2.50 for a one metre plastic sleeve and srakes. Each has advantages and disadvantages. Generally, choose the guard that will protect trees from the most common pest.

The paper one litre milk carton folded out at each end and held up with two small stakes or a loop of fencing wire is a cheap and effective guard. They can be bought in bulk through groups like Greening Australia at a low price.

Tree guards should be removed from the trees when the plant is about twice as high as the guard. Really tall guards (greater than 60 cm) should be avoided as they tend to force the trees to grow tall quickly and may induce weak stems which are unable to support the tree when the guard is removed.

Electric fencing can also be an option if there is a large planting and a small range of grazing pests. Fence designs can be obtained from specialist electric fencing suppliers.

Netting fences may also be used but these should include a barbed wire on the top to deter larger animals.

Fire protection

Young trees are highly susceptible to fire damage. To reduce fire risk, slash tall grass in the immediate area around the trees. As the trees grow, allow stock to graze to keep grass down and reduce fire risk. This is best done using young stock and crash grazing for a short period.

Spray drift

Trees are susceptible to herbicide and defoliant damage at all ages but especially when they are young. Trees on corton farms are essentially like canaries in mineshafts, they are good indicators of drifr accidents but many times they are set back considerably. If you are planting trees which are not designed as drifr buffers, these should be located where the risk of damage is minimised, such as upwind of the main spraying areas.

Fertilising

Trees will grow reasonably well without applying fertiliser, but early growth rates can be increased by their application. Fertilising trees after the first year is unlikely to provide great benefits unless they are being harvested for foliage or other producrs. Trees can effectively recycle nutrients after some years and to extract nutrients from their local surroundings.

Mixed nitrogen(N), Phospherous(P), potassium(K) fertilisers are best used, with traces generally only required if deficiencies are known or symptoms appear. Common fertilisers used are di ammonium phosphate (DAP) or NPK mixes with high N and K but low P.

Normal application rates vary depending on soil type and condition. Rates of between 50 and 150 grams per tree are common. Applying the fertiliser at planting is probably convenient,

but the plants are unlikely to need it until they start active growth and get over transplant shock. Applications in the spring or autumn following planting will produce best results.

Fertilisers can be spread in a ring around the tree if the area is relatively flat, but otherwise on the uphill side of the tree. An alternative method is to dig one or two holes 10 cm deep about 20 to 30 cm from the tree place the fertiliser and bury it. This will form a lump in the soil that will slowly release nutrients and will reduce evaporation of nitrogen.

Specialised fertiliser tablets are available for tree plantings, these are generally a slow release mixture which will give the trees a good start. They can be costly relative to using granular fertilisers but they are convenient and easy to use. They can be purchased through nursery industry supply companies.

Organic fertilisers such as blood and bone or composted poultry manure can supply nutrients. These products are generally slower to release nutrients, and may repel hares or attract dogs. The dogs may dig up trees looking for the source of the odour.

To get the maximum advantage from fertiliser application, good weed control is essential.

Planting techniques

There are three options for planting trees: planting seedlings by hand, by machine or by sowing tree seed directly. Hand planting is generally more accurate and successful but can be slower and more labour intensive. Planting by machine is quick but requires very good soil preparation and skilled operators. Direct seeding requires highly specialised conditions in clay soils and specialised machinery, it has had limited success and is not widely used or recommended in cotton growing areas due to unsuitable soil conditions and high levels of weed competition.

Hand Planting

In all cases, the site should be well cultivated; have reasonable moisture and good weed control. This also makes digging holes and planting the trees easier. Planting when the soil is dry or very cloddy will reduce the number of trees that survive considerably (and it is harder work).

When planting small numbers of trees, take some time and enjoy the work. If large numbers are to be planted, consider using a specialist tree planting team or a machine planter to help.

The traditional gardener's method

The traditional gardener's method of planting is successful and reliable, but very labour intensive and really only suited to small lot plantings.

Holes should be dug about twice as wide and twice as deep as the pot the seedling is in. There is usually no need to add manure or other organic material to the soil in the hole. If the soil is dry, fill the hole with water and allow to soak away before planting. Seedlings should be premoistened before planting, this will ensure that the root ball is wet and also make the plant easier to take out of the pot. Try not to damage the root ball, there should be no need to 'tease out' the roots if trees are supplied from a good nursery. The root ball contains many fine feeder roots which are easily damaged and it may also contain soil microorganisms which the tree needs to survive.

Cultivating between rows and close to trees may help improve moisture storage but problems with root damage and continuing weed growth close to the trees make this approach limited if used alone.

Trees should be planted as soon as possible after removal from the pot.

Plant the seedling a little deeper than it was in the pot (about 1 to 2 cm and not much deeper) and press the soil firmly around the root ball. You should not be able to see potting mix exposed after planting. The potting mix is usually quite porous and will dry out quickly if left exposed.

Create a small water catching dam around each tree to catch rainwater and to concentrate irrigation water. Trees should be watered in well at planting. They may wilt slightly the day after planting but this is normal transplant shock.

The "high tech" method

This method involves the help of four or five well trained workers and can result in up to 2000 trees per day being planted. The team includes a plant supply controller, a planter (who uses special planting tools such as 'pottiputki' planters or

shaped diggers), a tree guard carrier, a tree guard installer and a water tanker driver.

The team use small seedlings grown in specialised containers such as 'hiko' trays, 'speedling' trays or net pots and plant trees which have been sun and drought hardened.

Teams are readily available in NSW but as yet have not made a significant presence in cotton growing areas of Queensland. Costs for these planting teams is a matter for negotiation with the contractors.

Machine planting

Tree planting machines have been developed to suit a range of soil types and applications, they are expensive to buy and are probably best accessed through tree planting contractors or local landcare or catchment groups.

Avoid planting on very hot or windy days. This will reduce transplant shock and increase the chances of survival.

These machines consist of a ripper tyne, furrow opener, plant delivery system and press wheels. The machines are generally tractor mounted, either three point linkage or drawn. They require good soil tilth before planting, this is so the press wheels can pack soft soil around the trees. On clay soils they require specific soil moisture conditions to work effectively.

Typical planting machines will allow a team of three people to plant 2000 trees in a 7-8 hour day. People required are a tractor operator, tree planter (who sits on the machine) and a water truck driver/ waterer.

If a large planting is planned it would be advisable to get a couple of quotes for contract planting. Many contractors can source trees quite cheaply and have specialised expertise to plant trees quickly and with high survival rates.

Selecting a good quality plant.

Apart from selecting the most suitable tree species for planting, the quality of the seedlings is important. Planting poor quality trees is often a waste of time and money.

The ideal farm tree should have the following characteristics:

- **A good ratio between size** of the pot (root ball) **and the top growth.** Trees that are overgrown for their pot size will have had their growth restricted, and may not grow quickly after planting or may go through transplant shock. Seedlings which are too small may not have filled the pot with roots and so may fall apart at planting.
- The plants **should be well rooted.** Gently shake a few trees from their pots in the nursery, if there is evidence of rooting to the edge of the root ball the plant is well grown, the root ball should not fall apart in your hands. White roots on the edge of the root ball are an indication of plant vigour, if there are many white roots, the plant will be in active growth and should grow quickly following planting. You may also wish to break open the root ball of a couple of plants to check for tangled or knotted roots, these defects will seriously reduce vigour and wind firmness of the trees as they grow.
- **Plants should be hardened off.** This means the trees have been exposed to full sun conditions for at least a couple of weeks. Many nurseries grow young trees under shade and if they are planted out without hardening may suffer severe transplant shock including sunburn.
- **Trees should also be drought hardened.** This means they have been allowed to dry out a bit between waterings, thus preparing the tree field conditions.
- If trees are to be planted into harsh conditions, such as late spring or autumn they should definitely be sun and drought hardened. If the site is slightly dry it may be advisable to tip prune the seedlings. By cutting off lush soft growth, you lower the seedling's water demand immediately after planting.

If planting conditions are expected to be good (that is, there is good soil moisture and temperatures are mild) planting hardened trees may not be as important.

The following general guidelines will help you with cost effective plant selection:

- **Big is not necessarily better.** Trees which are growing well in smaller pots are likely to grow away well when planted out in the field. They will need less watering to establish, they are likely to survive transplant shock better and in many cases will out grow trees planted from larger stock. The ideal pot size for farm tree planting is 40 to 50 mm square and 80 to 120 mm deep. Trees should be no taller than 300 mm high in these pots. These trees are generally much cheaper to buy as well.
- **Check genetics.** Most farm trees are grown from wild seed or seed collected from local gardens or parks. There could be quite a bit of genetic variation within these seed lots. If trees are contract grown, check that they are even in height and size and cull the weaker ones before leaving the nursery.

Well-grown farm trees will have already been culled up to 15%. If culling is not done weak trees or cross-breeds may appear in the planting. This may not be important for general farm plantings, bnt if the trees are to provide a specialised role such as wood production or surviving on a saline site, then this is an important issue.

The nursery manager should be able to provide information of seed sources for trees they supply. Specialised seedlots may be requested if planting for specific purposes. Selecting varieties to tolerate saline or polluted sites would be examples where selecting a suitable seedlot would be important.

There are specialised seedlots available for particular purposes, and seed orchards have been established to produce genetically improved planting material. This usually costs more, but if the trees are needed to perform a particular role, then this may be a good investment. Commercial seed banks can be contacted through your local farm tree nursery for more information.

The Australian Tree Seed Centre at CSIRO Forestry and Forestry Products, (026) 281 8218, is an excellent source of high quality seed.

Contract grown plants may suit your needs better. Many nurseries are prepared to grow special lots of trees for a project under contract. This will generally allow for negotiation of a lower price, specified seed lots and delivery times. The down side of contract grown trees is that you are obliged to take the trees at the agreed delivery date regardless of whether conditions are suitable for planting.

Further Information

Dell, B. Malajczuk, N. and Grove, T.S. (1995) *Nutrient Disorders in Plantation Eucalypts,* Canberra, ACIAR.

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Growing trees in frost prone areas

In many areas, frost can affect tree planting programs. To reduce the effects of frost on planted trees, the following points should be taken into consideration before tree planting begins:

Severity of frost on the site

The severity of frost on a site is affected by broad climatic factors as well as local site factors including location (such as hill top or valley floor), cold air drainage and heat radiation from the soil.

Local knowledge or climatic records should tell what types of frost occur in the area and the expected frequency. Extreme or black frosts may only occur occasionally but are still likely to kill some tree species.

Frost tolerance of available trees

Frost can affect plant species differently depending on tolerance. Some species are known to be tolerant at all stages, some are only susceptible when young and others are affected at all stages of growth.

Local nurseries could be good sources of information on frost tolerance. Local native trees may well be the best starting point when searching out suitable plants for use in a frosty area.

Planting trees in frosty areas

Site selection

In order to reduce frost damage, tree plots should be located where cold air does not accumulate. Sloping land or hill tops are often the best places.

Frost hollows can form in places where buildings, belts of trees or even patches of tall weeds can trap cold air, preventing its flow to lower areas. Removing or avoiding these barriers can help in reducing frost damage.

Trees which are particularly valuable, but which are likely to be frost affected in the local area, can be planted close to other plants or buildings where they may be sheltered. Planting close to buildings also provides the benefit that the building radiates heat stored through the day.

Site preparation

Trials in New Zealand and Queensland have shown that moist bare soil absorbs the sun's heat and warms during the day. At night this stored heat is radiated from the soil, warming the air close to the ground by up to three degrees. This factor may be sufficient to prevent plant damage by a light frost.

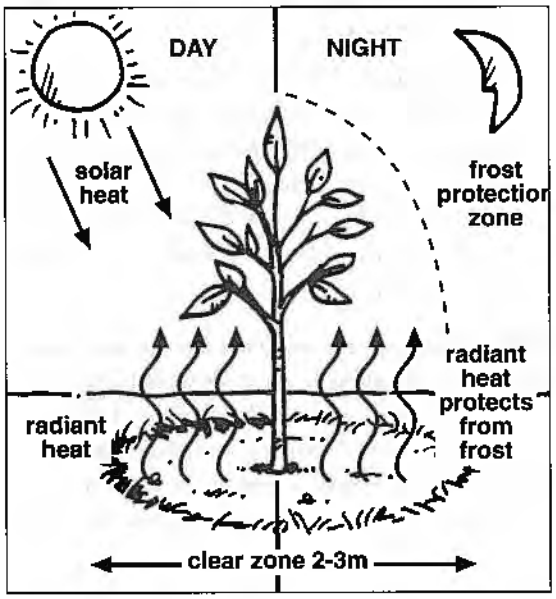

Fig 14. Radiant heat stored in the bare soil surface reflects back at night and protects from frost.

Careful attention to weed control before planting to give an area of bare soil about 2-3 metres diameter around each tree may therefore help in reducing frost damage. (Fig. 14).

Mulch around trees during winter will insulate the soil and so reduce the effect of stored heat on frost protection. Scrape mulch away from the trees during the frost season.

Planting

Since most trees are susceptible to frost when young, planting in frosty areas should be done in spring or early summer to maximise growth before frosts start. Ideally tree growth should be slowing going into winter. Fertilising and watering should be avoided in autumn and winter to reduce the number of fresh shoots which are easily burnt by frost. As the trees grow, the foliage

gets progressively higher above the frost layer, the bark hardens and the dangers of frost damage tend to reduce.

Tree guards

Tree guards such as milk cartons or plastic sleeves with solid sides and which are taller than the seedlings can help in reducing the effects of mild frosts on sensitive plants. In areas where heavy frosts occur guards of hessian which cover the whole tree may be used, but this is labour intensive and really only suitable for particularly valuable trees.

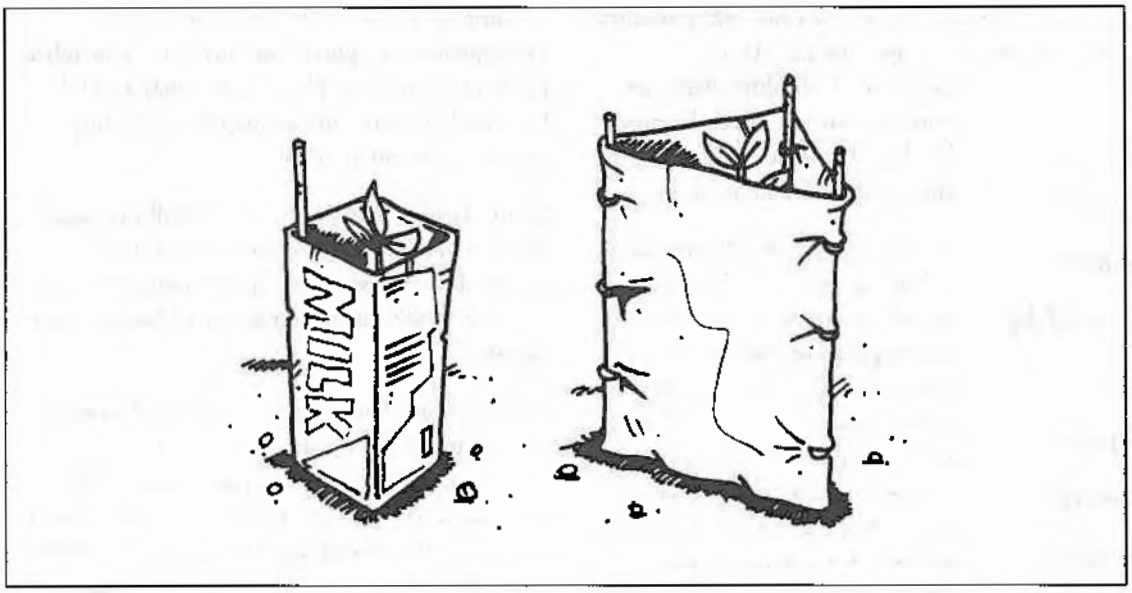

Fig 15. Some types of tree guard.

Further Information

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Insects that can affect trees on cotton farms

Heavy insect attack can indicate that trees are not in their preferred environment. If particular plants are heavily attacked by insects while others around them are not, it is a sign that the plant is unsuitable. Unhealthy plants are more attractive to insects because they have higher levels of nitrogen and sugars as a result of stress.

Mature trees which suddenly come under attack may be stressed by old age, drought, waterlogging, physical damage (such as bark damage) or some other problem.

Insects can play a role in 'weeding out' sick or unsuited plants in natural environments and this is what happens in plantations as well. If there is a particular tree which is repeatedly attacked, it is probably genetically unsuited. If individuals of a species are attacked while similar plants are fine then the plant itself may have defective root systems or may need to be removed or planted elsewhere.

In many cases insect damage can be effectively controlled by reducing stress on the plant. If insects are in high numbers, the population can be controlled with sprays or other means, but encouraging healthy new growth is also important. This can be done by watering, fertilising, aerating the soil or mulching, depending on the types of stress the trees are under.

Protecting trees from pests

Insects attack all stages of growth. Few native trees escape insect attack, but not all insects found on trees cause damage. The insects directly affecting trees are divided into four categories, depending on their mode of feeding:

- leaf-eating
- sap-sucking
- wood or bark feeders
- gall formers.

Trees seldom die following a single bout of insect damage. Repeated damage over a number of seasons or years is more likely to kill.

When deciding if pest control measures are necessary, and what type of control to use, take into account the pests and the seriousness of the problem and use appropriate methods. Remember, pesticides don't just kill pests, they may also kill beneficial creatures, including pest-controlling insects, birds and animals.

Don't blanket spray if only a few small trees are infested. Identify the pest, not necessarily by species, but at least by the major group, for example, sawfly larvae, looper caterpillars, or stem borers.

Consider how damaging the pest is, and whether the end use of the tree justifies the time and expense of treatment. For example, ornamental trees can usually tolerate a few stem borers without a problem, whereas in trees being grown for timber production stem borers may reduce the value of the wood at harvest. In windbreak trees, shrubby growth and chewed leaves are a minor problem but if you are growing flowers and foliage for the export market, these must be unblemished.

Consider the cost benefit of the treatment. Pest management can be expensive in terms of time and money. If trees are attacked repeatedly, consider planting something else.

Some common pests and their control

Hairy caterpillars

These pests are very common in trees such as white cedar *(Melia azedarach var. australasica)*, myall *(Acacia pendula)* and some other wattles. The larvae may completely defoliate trees, usually during the period from January to March.

The adult moth lays its eggs on the bark and foliage. The brown, hairy larvae are 2.5 cm to 4 cm long, and feed during the night sheltering near the base of the tree during the day. In the evening they may be seen, in large numbers, moving up the trunk of the tree. When fully grown they find a sheltered place under bark or in crevices of posts or buildings and construct their pupal cocoons.

When a tree has been completely defoliated, the larvae will leave it and can often be seen moving in procession to another tree. Contact with the hairs on the grubs causes skin irritation to some people.

Control: The larvae may be trapped in a folded bag, placed around the trunk of the tree, and then destroyed. Alternatively a maldison (Malathion®) foliage spray may be used, or the grubs may be sprayed where they shelter on the ground during the day, or when they are moving up the trunk in the evening.

Wood borers

There are a number of different species of borers, but the damage caused by each is treated in a similar way. The injury to the tree usually occurs near a branch fork, or where the bark is cracked or has been broken. The hole made by the borer in the tree may be surrounded by wood dust and sap from the tree and/ or web-like fibres left by the borers.

Kurrajong and bottle trees can fall victim to plagues of grey weevils about the size of a chewing gum pellet (some people call them elephant beetles). These insects bore into bark and do considerable damage to sick or dying trees. They can be a serious pest to these trees.

Control: Many people think that the best way to treat wood borer is to drill holes in the trees and inject systemic pesticides such as Dimethoate (Rogor®). THIS IS RARELY THE SOLUTION. If you intend to inject pesticides, please seek professional advice.

Borers which are active in dead branches or in the hearrwood of a tree are completely unaffected by injecting insecticides. These pests may physically weaken a tree but are otherwise not a threat to the living tree. Damaged branches should be removed if possible. Instructions for removing branches are outlined in the section titled: Preparing for tree surgery later in this publication.

Borers that are active in the sapwood or just under the bark may be affected by Rogor injections, but this should be a last step. Borers can often be controlled by watering and fertilising the tree to encourage sap flow. Lots of sap will gum up borer holes and so naturally kill borers. Borers can also be killed by searching out entry points and feeding in copper wire to skewer the beasts. Such holes can also be filled with methylated spirits using a syringe.

If watering and fertilising is not having an effect then stem injection may be warranted and the increased sap flow should help to carry the insecticide through the tree quickly.

Sap suckers

There are a range if insects which feed on the sap of trees. Many feed on the young foliage, flowers or developing fruits. They may also attack roots and other parts of the plant.

Sap suckers include aphids, scale insects, mealy bugs and vegetable bugs. These insects are very often present in small numbers on healthy plants and can cause cosmetic damage, plants which are stressed or in flushes of new growth may have much larger numbers.

Control: Small numbers of sap suckers should not be considered a problem because this insect group provides an important source of food for predatory and beneficial insects as well as many birds. Where large numbers of sap suckers threaten a plant, it may indicate the plant is not healthy or it is not in a suitable position (often plants in positions which are too shady for them will have high sap sucker loads).

The pesticides used for stem injection are highly toxic to humans, and can also poison the possums, gliders and koalas that use trees for habitat and food.

Sap suckers can be controlled by application of systemic insecticides such as Dimethoate (Rogor®) at recommended rates or simply by addressing stresses such as waterlogging, drought, low nutrients or poor site conditions depending on each plant situation.

Grasshoppers and locusts

Several species occur from time to time and can be very destructive to trees if they are present in plague proportions. The main species is the spur-throated locust although at least four other species may be involved.

Control: Control is difficult unless it is carried out before the grasshoppers reach the flying stage. When flying, grasshoppers invade in large numbers.

Some control can be obtained by using an

insecticide spray such as maldison (Malathion®), fenitrothion (Folithiou® 1000 Insecticide Spray), or diazinon (Diazinon 800®). These are used as a knock down application. It is critical that these pesticides are used strictly in accordance with safety instructions on the label.

Termites (white ants)

These usually eat only dead wood and bark but sometimes infest trees which are weak or damaged. There is a particular termite active in northern Australia which will eat living plant tissue. It has been recorded in central Queensland, but is not common.

Control: Remove all buried timber near trees or buildings since this fuels invasion. Seek out and attack the nest directly with chlorpyrifos (e.g. Deter®, Dursban®).

The amount to apply varies with the size of the colony and judging the correct amount is difficult. Areas around the nest, especially where trails are seen, should also be treated.

Possible treatment for insect problems on trees and shrubs

Table 3. Possible treatment for insect problems on trees and shrubs.

Pest type	Damage	Insects responsible	Chemical control	Non-chemical control
Bud and tip feeders	Distortion and multi-leading of stem; Larvae of small moths; usually do not kill tree	Larval and adult weevils	Usually not needed; a spray with Dimethoate gives control and protection for up to two months	Remove insect and destroy damaged tissue
Flower feeders	Feed on flower parts and seeds	Larvae of moths and butterflies, larval and adult beetles	Not warranted	Not warranted
Leaf chewers Leaf eaters	May cause severe defoliation	Larvae of defoliating sawfly, cup moth, case moths and other moths and butterflies; adult Christmas beetles; adult and larval leaf beetles; grasshoppers, crickets, stick insects, grasshoppers	Carbaryl, Dimethoate sprays; stem injection of older trees with Dimethoate-only in extreme cases	Mechanical removal of stick insects, larvae of processionary caterpillars can be trapped under damp sacks; Dipel (suspension of a bacterial pathogen for some caterpillars)
Leaf miners	Feed and tunnel between leaf surfaces; cause blistering, splitting and cracking leaves	Larvae of some moths, leaf blister sawfly, flies	Systemic insecticides: Dimethoate by spray while crown can be reached; stem injection as last resort-repeated injection causes severe tissue damage	Remove and burn affected leaves
Leaf skeletonisers	Eat tissue between leaf veins	Young larvae of leaf chewers: larvae of gum skeletoniser moth; larvae of some sawflies	As for leaf chewers	As for leaf chewers and miners
Sap suckers	Withered new shoots, distorted leaves and small branches; brown puncture marks on leaves; excretion of 'honey dew' which attracts ants and provides substrate for sooty mould growth; leaf curling with associated small, dark spots	**Mobile:** leaf hoppers, aphids, mealy bugs, cicadas, large bugs **Sedentary:** (often covered with scale) nymphal psyllids (lerps) Scale insects **Leaf curlers:** thrips	Carbaryl, Dimethoate spray. Only use stem injection in extreme cases, and on special trees, Carbaryl and white oil spray, Dimethoate spray or stem injection (only in extreme cases), Dimethoate spray or stem injection (only in extreme cases)	Large bugs can be knocked into a can of soapy water; many large bugs secrete toxins and should not be handled. On small trees, hose or scrape off with small brush, or douse with soapy (pure soap) water; remove and destroy affected tissue
Gall insects	Feed within leaf or stem tissue; secretions stimulate plant cell division to produce malformations often characteristic of pest species, interference with photosynthesis and growth, loss of leaves	Various including wasps, flies, bugs. (Note: some galls are produced by fungal and bacterial infection although insects may also be present)	Damage is seldom severe enough to warrant treatment, but growth of young trees can be affected.	Removal and destruction of affected tissue

Table 3. Possible treatment for insect problems on trees and shrubs. (Continued).

Pest type	Damage	Insects responsible	Chemical control	Non-chemical control
Bark and sapwood feeders (entry often through scars on weakened trees)	Burrow and feed in bark or sapwood beneath bark; may ringbark branches or stems. Presence indicated by holes and/or coarse sawdust or fine powder, or parallel cuts on branches	Larvae of longicorn beetles, jewel beetles, weevils, powder post beetles, wood moths; adult and larval auger beetles; adult pinhole and shot hole borers	Very difficult: squirt small amounts of methylated spirits in obvious holes; stem injection is ineffective as conductive tissue has been damaged or destroyed	Scrape away damaged tissue, poke wire into borer holes, remove dead branches; attempt to improve tree health and if badly affected, remove tree
Heartwood feeders	Cause piped and hollowed trunks; may build external nests on tree; some species will attack young trees Tunnel up centre of healthy trees	Termites Giant wood moth	For termites control only necessary when they attract young trees; No control possible for Giant wood moth	Remove rotting timber; it is difficult to locate nests which are often in tree trunks or underground No non-chemical controls - exit holes which can be reached should be plugged
Root feeders	Usually feed on small roots; fungal pathogens may enter via wounds	Cicada nymphs, beetle larvae such as curl grubs, scale insects and some termites	Difficult-not normally possible	If trees are young, remove and destroy affected material and dig over soil

An easy guide to chemicals

Table 4. An easy guide to chemicals

WARNING: Always read the directions on the label and follow them! Some of these chemicals must be applied by a registered agent. This list is only a guide - other chemicals may be available.

Pest	Treatment	Trade Name
Insects:		
Ants	Diazinon Chlorpyrifos	Ant Killer Chlorban® Ant, spider & cockroach killer
Aphids	Maldison Pyrethrins Dimethoate	Malathion® Pyrethrum Rogor®
Gall wasp	Pruning and burning	•
Hairy grubs leaf chewers	Maldison	Malathion® or Maldison®
Leaf miners	Dimethoate	Rogor®
Locusts and grasshoppers	Fenthion Fenitrothion Diazinon Carbaryl	Lebaycid® Folithion 1000® Diazinon 800®Gesapon 800®Carbaryl, Bngmaster®Carbene®
Mites	Omethoate Maldison	Folimat® Malathion
Scale insects	Maldison White Oil	Malathion®, Maldison® White oil
Termites	Chlorpyrifos	Deter®, Dursban®
Fungi, mildew or nematodes:		
Downy mildew	Chlorothalonil and fernarimol Furalaxyl	Zero® Multi-pnrpose Fungicide Fongarid®
Nematodes	Fenamiphos	Nemacur® Granular Nematicide

Organic recipes for pest control

Table 5. Organic recipes for pest control

These recipes have been collected from experienced organic gardeners, but they are not guaranteed to work or smell good!

Treatment	Ingredients	Preparation and application	Pests affected
Garlic spray	1 full bulb of garlic 2 tablespoons of parrafin half cake of sunlight soap 1 litre water	Chop garlic and put in blender, add parrafin and soak for 2-3 days. Dissolve soap in water and add to garlic Soak 1-2 days, then strain Dilute half cup to 4 litres water Apply every ten days	Aphids, caterpillars, leaf chewers and sap suckers
Condy's crystals	30 gm Condy's crystals 9 litres water 30 ml white oil	Mix all ingredients together and spray plants once every 10 days when pests are active Do not mix with soap	Aphids, sap suckers,slngs, powdery mildew
Syrnp	2 cnps syrup or treacle 4 litres water	Spray on plants when pests are active	Grasshoppers and locusts (may atttact ants though)
Fish fertiliser	50 ml fish fertiliser to 4 litres water	Apply every seven days when pests are active, acts as a foliage fertiliser as well	Deters leaf chewers
Lettuce or Cabbage	1 head lettuce or cabbage	Boil for 20 minutes, strain and use as one part juice to 4 parts water	Deters leaf chewers and sap snckers
Sngar	2 handfuls sugar per square metre	Apply to soil surface	Repels nematodes

Further Information

Hadlington, P. and Johnston, J. (1988) *Australian Trees, Their Care and Repair.* Sydney, NSW University Press.

Jones, D. and Elliot, R. (1989) *Pest Diseases and Ailments of Australian Plants, with suggestions for their control.* Port Melbourne, Lothian.

Dealing with dieback and its effects on trees

In many cotton growing areas dieback has increased in native trees, particularly in river gums and box trees.

Dieback is the gradual dying off of trees, usually from the young branches back. (Fig. 16). Trees progressively lose growth and vigour as a result of regular defoliation until eventually they run out of reserves and die.

Tree dieback is generally a reaction to change and the stresses associated with it. Trees which have grown in natural conditions can experience significant change following the development of adjoining land for farming. Such trees are exposed to greater extremes of wind, cold, heat and predators. These pressures gradually work to weaken the trees which can result in their death.

Dieback has been studied along the Condamine River and in the Namoi. These studies have identified a number of factors which could be causing the problem, as outlined below.

Drought and floods

Dieback is often much more severe during or following unusually dry or wet seasons. Moisture stress leads to a build up of nitrogen in the leaves which makes them more attractive to insect pests.

When the moisture stress is reduced and seasons return to normal, nitrogen levels drop and the insect populations decline. Severe dry spells limits new growth, and some trees will die from lack of water.

Recent work by CSIRO climatologists has been drawing a link between global climate change and tree dieback. They have mapped the occurrence of severe dieback on the New England Tablelands to climate patterns and have found that the dieback tends to be worse when weather patterns (rainfall, temperature. humidity) are abnormal (Sutherst & Mo, 1997).

Recent work by CSIRO climatologists has been drawing a link between global climate change and tree dieback.

They have also found that the number of abnormal weather patterns has been increasing in recent years as a result of global climate change. The inference this makes is that many of the trees affected by dieback could actually be unsuited to a changing climate.

Old age

Many of the trees remaining in farming areas are having trouble regenerating and as a result the population is progressively getting older. In some areas there is no evidence of successful tree regeneration since European settlement.

Trees develop their root structure, branch arrangement and other physical characteristics based on their immediate environment as they grow.

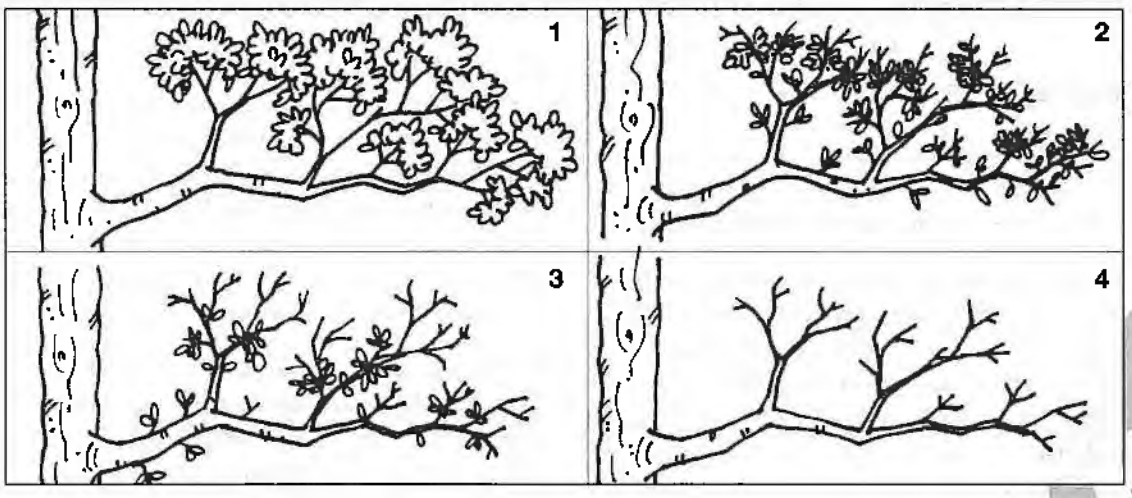

Fig 16. Stages of dieback.

Young trees adapt readily to changes in their environment; older trees take longer (if they can adapt at all). Rapid changes caused by clearing, rising watertables, different climate, new pests, fire or other factors force trees to adapt or suffer significant stress. The older the tree, the slower the response time and so the greater the stress.

One suggestion for reducing insect plagues is to encourage habitat for insect eating birds such as pardalotes,thornbills and honey eaters to help keep insect numbers in check.

As trees age, they also lose some of their tolerance to climatic extremes such as flood and drought. As well, older trees are more likely to provide homes to wildlife which may damage them, such as parrots and leaf eating possums.

In areas where there is a large proportion of old trees the best strategy may be to encourage them to regenerate. Hopefully the new trees will be better able to cope with the new environment.

Loss of diversity

Changes in land use can result in the loss of understorey plants such as grasses, herbs, shrubs and young trees due to fire, grazing or cropping. This removal may result in loss of insect-controlling bird life and other factors which contribute to the stability of the natural system.

Working to restore diversity, including understorey plants, is probably the single most important step in restoring the health and vigour to a native forest area affected by dieback. Natural diversity can be restored by controlled grazing, strategic replanting of natives, careful use of fire and some targeted weed control for weed species and some grasses.

Insect pests

Plagues of insects have been part of the Australian landscape for a long time. When they occur, they do a lot of damage and can cause widespread death of trees.

Loss of plant diversity may also contribute to this plague formation. Many insect-eating birds and other predators need shrubs and small bushes to shelter and nest in and also to supply food at certain times of the year. If there is a lack of ground and mid level vegetation in the area, there is a considerable reduction in bird and insect diversity which in turn affects pest control.

In the Condamine Catchment there have been two major plagues of sap sucking insects in the past five years. The most significant insect threatening eucalypts is the psyllid or lerp. This insect lives on the leaves of trees and builds a sugary shelter which it hides under. These shelters can be seen on affected leaves in a number of different forms, some are lacy, some shaped like cones or covered in waxy thread.

The leaves will turn yellow then brown in patches with this insect. In plague situations the trees look brown all over and quite unhealthy.

Because of the large populations of these insects that develop, chemical control is not practical. The best approach is to try to remove the causes of insect plagues to allow the trees to recover and to resist development of further small plagues.

One suggestion for reducing the cause of the plague is to encourage habitat for insect eating birds such as pardalotes,thornbills and honey eaters which will in turn help to keep insect numbers in check. These types of birds prefer dense understorey vegetation such as bushes and tall grasses.

Other insects which can cause problems include leaf eaters such as grasshoppers and caterpillars; gall formers and borers.

Birds and Possums

Birds, particularly parrots such as corellas, cockatoos and galahs are known to do significant damage to tall trees in forests. The birds, most commonly galahs, chew off twigs and leaves or remove large areas of bark below nesting sites.

In a normal forest this damage is well spread through the area and does not cause a problem. In areas where there are only small remnants of forests left, and bird populations are attracted by food sources such as grain crops, the damage can be really serious. Examples of significant bird damage in native trees can be seen along watercourses on the Darling Downs at Brookstead and other areas.

Possums have also been recorded as causing quite high levels of defoliation and damage to trees in degraded forest on the Darling Downs. Possums prefer to live in areas where there are good numbers of hollows in trees. Possum numbers at one study site consistently

run at about fifty per hectare, compared to normal populations of around two per hectare.

These large possum populations are causing significant damage to the trees by grazing leaves and flowers.

If possums are suspected of causing damage in an area, spotlighting at night will give a quick indication of population levels.

Possums can be excluded from particular trees by placing a galvanised iron band around the trunk. This should be about one metre wide and about one metre above ground level. The band is nailed to the tree, but should not be fastened too tightly.

Spray drift

One of the greatest drawbacks of spray misuse is the effect it can have on the native vegetation. Spray drift is often perceived to be the primary cause of dieback in intensive farming areas. This perception is linked to direct damage to the trees from herbicides and defoliants and also to the effect insecticides can have on numbers of beneficial insects and birds in the native vegetation.

Although the community perception that drift is the major or sole cause of dieback may be faulty, it is clear that inappropriate spraying does have an effect and should not be discounted as a significant factor in tree dieback in intensive farming areas.

Care when applying sprays near areas of native vegetation should be part of best practice.

Fire

Fire presents the greatest risk to native trees that are very young or very old. When they are quite young, fire can burn all the foliage readily; and when they are quite old, trees which may have bark damage or hollows in them can catch alight and burn completely.

Regular, intense fires will remove sick or weak trees, as well as removing fire sensitive understorey plants. Repeated fires also weaken stronger trees that may fall victim to later fires.

Cool burning or regular controlled grazing may help to reduce the risk of fire damage by removing twigs, dry vegetation, and other potential fuel for fires.

Waterlogging and salinity

Rising ground-water levels can have a negative effect on native trees, particularly when salinity is present. Once again, the older trees will be most affected.

Raised water tables have also been linked to the occurrence of insect plagues in eucalypts on the Liverpool Plains.

Mistletoe

Mistletoe has increased in a range of tree species over a wide area of Queensland and NSW. In cotton growing areas, it has become particularly apparent in species such as brigalow (*Acacia harpophylla*), wilga (*Geijera parviflora*), belah (*Casuarina cristata*), box (*Eucalyptus spp*), spotted gum (*Corymbia variegata*) and river gum (*Eucalyptus camaldulensis*).

Research into the causes of the population explosion seems to indicate that clearing forest areas and thinning out of forests is related to increased numbers of these parasitic plants.

Mistletoe is a light sensitive plant that prefers to grow on trees or branches of trees that are exposed to full sunlight. In a natural forest, only trees on the edges of the forest or particularly tall plants provided suitable habitat for mistletoe to prosper.

With clearing and thinning of forests, more light can penetrate the canopy and so mistletoe has a better chance of survival. When the mistletoe survives better, the animals that feed on it and spread seed in turn grow in number. As a result mistletoe spreads even further.

Studies on control of mistletoe have not as yet come up with a simple cost effective means of killing it.

Apart from actually cutting out mistletoe-affected branches, the only other suggestion is to treat the affected trees with a sub-lethal dose of herbicide.

The most desirable way to address dieback is to encourage the present trees to regenerate. This may mean fencing the area, controlling weeds, or managing fire in the area

What can be done?

From many of the studies on dieback across Australia, it seems that the best strategy for severe dieback areas is to start revegetating.

The most desirable way to do this is to encourage the present trees to regenerate. This may mean fencing the area, controlling weeds, managing fire in the area, and/or seeking advice from a tree adviser or Greening Australia officer.

It is also important to regenerate with a wide range of native plants that can provide habitat for beneficial insects and birds. Plants such as river sheoaks, wattles, bottlebrushes, tea trees, mat rushes, native vines, hop bushes as well as eucalypts should be established.

Dieback has the potential to remove some important insect, bird and animal habitat from cotton farming areas. Losing native vegetation through dieback can reduce the availability of refuges for natural pest controllers. Dieback can also reduce tree cover that serves to protect land from salinity or other forms of degradation.

Further Information

Heatwole, H. and Lowman, M. (1986) *Dieback, Death of an Australian Landscape*. Reed Books. Sydney.

Sutherst, R. W. and Mo, J. M. (1997) *Potential impact of defoliating insects in rural tree decline under climate change*. Internal report. Brisbane, CSIRO Entomology Branch.

Preparing for tree surgery

Tree surgery is one means of treating damaged trees and preserving the health of trees on farms. Knowing the appropriate techniques for use in tree surgery can reduce the risk of further damage being done through ineffective lopping or pruning, and encourage prompt action where trees need treatment.

Damage to trees from fire, machinery, wind or other factors can be treated to reduce long term effects. Removing bark from a tree makes it more susceptible to borer or fungal attack, which may weaken it in the future or shorten its life. Simple procedures for cleaning up wound sites and preventing infection need to be done fairly quickly after the damage has occurred if the results are to be good.

Trees have defence mechanisms such as the production of resins with antibiotic properties at wound sites, and callus tissue that grows across the damaged area.

Physical damage includes wounds to branches and trunk, destruction of roots, fire damage, impact injuries causing death of bark and the sapwood beneath and lightning strike. Stress factors include changed soil levels and drainage patterns, drought, waterlogging, increased salinity and massive attack by sap-sucking insects on the leaves.

When a tree is wounded or sick it is susceptible in a number of ways:

- The damage attracts insects such as jewel beetles, ambrosia beetles and auger beetles (collectively called borers). The primary attack is usually on unhealthy or exposed tissue, but can extend into the margins of healthy tissue, causing further breakdown and spreading the damage. Residues of insect chewing stay in the tree and retain moisture, providing ideal conditions for the development of decay fungi as a secondary problem. The fungi may be saprophytic - living on dead or dying tissue, or pathogenic - actively causing tree death.
- Decay fungi can attack trees, particularly through damaged or dead roots. Decay in roots can spread into the main trunk.
- Damp and decaying wood is a preferred food of subterranean termites (white ants). Dead roots can provide underground access to the tree, and alates (winged males and females) can set up new colonies in the decaying wood of old tree wounds above the ground.
- Damaged and weakened trees are less able to recover from attacks by leaf-eating and sap-sucking insects, and so become more stressed and deteriorate further.

Impact injuries

Impact injuries are common on farms and usually involve breaking or ripping off pieces of bark, often with the sapwood beneath, or breaking off branches. Usually a ragged wound or branch stub is left. Such wounds should be repaired quickly. Any broken or damaged bark should be removed with a sharp chisel, leaving a clean smooth area. The wound should be swabbed with methylated spirits and painted with a wound dressing or acrylic paint. Branch stubs should be cut neatly, swabbed and painted.

Although termites feed only on dead wood, their building activities and the high humidity in areas where they are active can increase the size of wounds and hasten the degradation of tree tissue.

Rules for removing a branch

Cut cleanly, using a three-cut method on all but the smallest branches (Fig. 17). It is important to avoid bark injury below a cut as the injury inhibits healthy callusing over the cut surface.

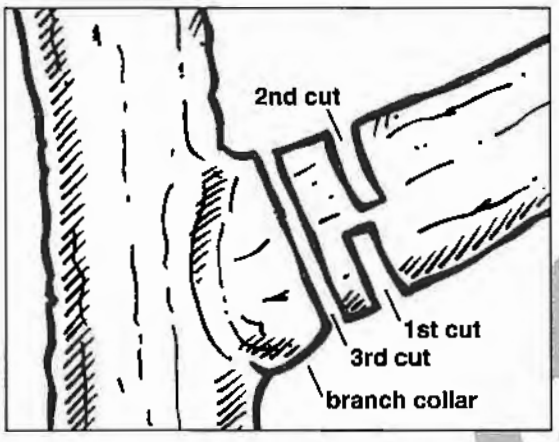

Fig 17. Correct branch removal technique.

Cut close to, but not flush with, the main trunk or limb. To assist the tree in wound closure (callusing) and to provide a protective barrier against decay organisms, it is important to cut on the outside of the branch bark ridge line and not to remove or damage the branch collar region.

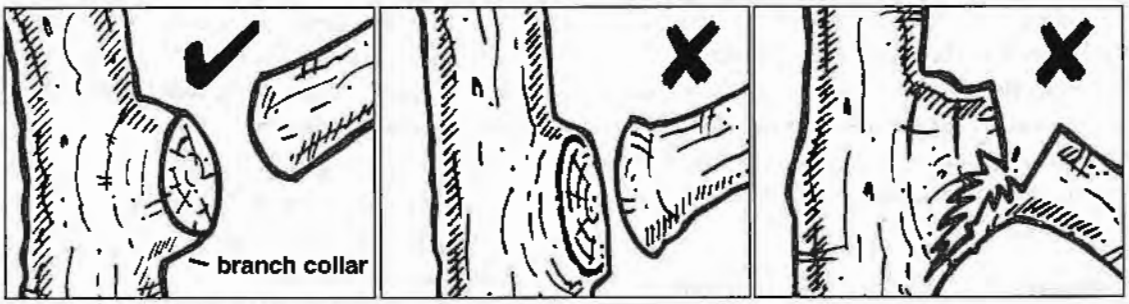

Fig 18. Ideal branch stub condition.

Further Information

Hadlington, P. and Johnston, J. (1988) *Australian Trees, their Care and Repair.* Sydney, University of NSW Press.

Section Three: Learning from other farmers' experience

Seven years of tree planting at Warilea, Narrabri, NSW

Jack and Jacqui, Warnock,

Location: Warilea, Narrabri

Tree planting has been in progress at Jack and Jacqui Warnock's cotton farm at Warilea, just east of Narrabri, since 1992. Jack has planted trees to provide a visual screen for his cotton operations, to improve the look of his property and, as a secondary purpose, to provide some drift capture.

Some 2000 trees have been planted to date with the bulk of these planted in one season in a two row belt on Warilea's northern and eastern boundaries.

Jack paid particular attention to weed control while establishing the trees. This was made easier by the use of a specialised spray unit mounted on a four-wheel motor bike.

The soils where the trees are planted are loamy clays, once covered with bimble box *(Eucalyptus populnea)* woodlands

The Warnocks used quite small planting stock grown at Narromine in vegetable punnet 'speedling' trays. These were mechanically planted using a saltbush planter, which injects 300 ml of water per plant at planting.

Site preparation is crucial for this type of operation to be successful. In this case, the selected site was planted with a cereal crop for green manure, cultivated and left fallow for 18 months. This allowed good soil moisture to build up prior to laser levelling the site and applying a pre-plant spray of Simazine® at two litres per hectare.

The trees were delivered at the end of October 1995, and were planted immediately into a weed free, well cultivated site. Plants were spaced at 3 metres by 3 metres. This density is high, and was chosen with the expectation of some losses. Each tree was covered with a tree guard made up of a milk carton and two small bamboo stakes. No mulch was used.

The trees were planted in 40°C heat, and were given just one follow up watering by hand a week after planting.

Jack paid particular attention to weed control while establishing the trees. This was made easier by the use of a specialised spray unit mounted on a four-wheel motor bike. The unit has a large plastic shroud over a CDA sprayer. It is spring mounted so that it can brush around the trees easily.

One staff member was allocated responsibililty for maintaining the trees. Jack believes this was valuable to the tree's welfare because it became part of that person's routine to check for weeds and any other problems.

The trees were kept weed free for the first 18 months and are now left untended.

This planting has been quite successful. Jack estimates a survival rate of 95%, and the trees were 3 to 4 metres in height at two years of age.

Jack has found the benefits from the planting so far undertaken at Warilea include better bird habitat and improved public relations. Birds are using the trees for nesting sites and for insects and nectar. Improved public relations includes positive support from the local community for the tree planting project and Jack is also finding that spray operators are careful to avoid spraying the trees and they act as a good marker for the boundary of the property.

Table 6 . Tree species planted at Warilea

Species name	Common name
Eucalyptus camaldulensis	River red gum
Eucalyptus cladocalyx	Sugar gum
Eucalyptus sideroxylon	Mugga ironbark
Eucalyptus leucoxylon	Yellow gum
Corymbia torelliana	Cadaghi
Corymbia citriodora	Lemon scented gum
Acacia baileyana	Cootamundra wattle
Casuarina cunninghamiana	River sheoak
Melaleuca armillaris	Honey myrtle
Melaleuca lanceolata	Black tea tree
Callistemon viminalis	Weeping bottlebrush
Callistemon salignus	White bottlebrush

Successful boundary planting and habitat regeneration at Gunnedah

Owen Jones

Location: Gunnedah

Owen Jones, his wife Maree, and son Peter run a 1650 hectare irrigated farm at Mullaley, 40 km west of Gunnedah. Cotton is one of their major crops.

Farming occupies 1200 hectares of the property, 250 hectares is planted with irrigated cotton and a further 50 to 100 hectares is dry land. The property also features some important wildlife habitat areas including a small rocky hill, which provides habitat for some rare butterflies and other wildlife. Some areas of regeneration of box and myall trees in a 15 hectare paddock has been fenced off as a natural habitat area.

Owen started to plant trees on his boundaries about 1992. He is following his father's interest in tree planting as a family tradition. Wide spaced sheoaks *(Casuarina cunninghamiana)* were initially planted along the Oxley Highway on his southern boundary.

This planting is now quite well developed and has added to the visual appeal of a flat landscape.

More recently the Jones family has started larger scale planting of trees to act as a drift buffer for grazier neighbours who are downwind. The first and most recent of these is a 2 km strip planting on the northern boundary. The trees are spaced 5 metres apart in rows 9 metres apart.

Owen believes strongly in good site preparation, which includes bare fallowing through summer before planting in autumn. Trees are hand planted from tubes supplied by NSW Forestry's nursery in Gunnedah. They are watered in well and watered three or four times if required in the first 12 months.

Weed control after planting is done by cultivating between the lines of trees and by using cotton chippers to hand chip around the trees themselves. Owen cultivates between the trees for up to three years and hand chips only as needed.

Owen also uses tree guards to keep birds and hares off the trees while they are young.

Multi-purpose planting at Liverpool Plains, NSW

Jenny and Colin Birchall

Location: 'Tathra', Breeza, NSW

Jenny and her husband Colin have been planting trees on their property on the Liverpool Plains for about 30 years and have gained a great deal of experience in the process.

They grow grains on the fertile plains country, and graze some livestock on the higher country. Their farm is mostly self-mulching black soil plains with a little red soil on the sloping country.

They started planting trees around the house to provide shelter. Their house is on black soil on a slight hill and so is less prone to frosts and floods than other parts of the property. From that early shelter planting they have fanned out with multi-purpose planting throughout the farm, focussing on problem spots like rocky or waterlogged spots.

Jenny emphasises that four factors are vital in contributing to success; good soil preparation, using plants that are native to the site, tending the plants if they get stressed and selecting the most vigorous plants to grow.

Owen believes strongly in good site preparation, which includes bare fallowing through summer before planting in autumn.

Planning for planting occurs at 'Tathra' one year before planting. The site is deep ripped with a rabbit ripper and then cultivated with discs. Cultivation occurs whenever there is weed growth and a strip about one metre wide is kept weed free and consequently, the moisture is stored in the soil. In black cracking clays, ripping can encourage cracks in the soil along the rip line which can kill the tree. Jenny has found this problem is reduced with the cultivation. As well, they successfully used Roundup mixed with Goal one year to reduce weed growth.

Jenny and Colin have found that it is best to plant in autumn, after rain. Their best planting was at the end of February, after 125 mm of rain.

These farmers prefer to plant square tubes of natives with roots that are about 150 mm deep. They do not find the hikos have deep enough roots. Because their soil dries out for the top 50 mm they actually plant the tube about 50 mm

deeper than the soil surface. They avoid overgrown plants, preferring seedlings that are vigorous and actively growing.

Jenny propagates her own seedlings from seeds she collects herself from the surrounding district. She sows directly into the pots in which the trees are to grow. She aims to sow about 10 seeds per tube and gradually thins the seedlings down to the seedling which is most vigorous. Early vigour in a seedling translates to vigour in the growing plant, so her method of selecting to the top 10 per cent of any seed batch is a good one. Direct sowing into pots and thinning also avoids J-rooting.

Jenny makes her own potting mix from four parts red loam collected from the property plus two parts sand, one part peat moss and a sprinkle of gypsum. She sows at the end of October with the aim of having plants ready to plant at the end of February.

Jenny propagates her own seedlings from seeds she collects herself from the surrounding district. She sows directly into the pots in which the trees are to grow.

When they plant their trees Jenny and Colin have used Hamilton Tree Planter hand implements, shovels, trowels and a home built tree planting machine all successfully. Their machine injects two litres of water into the trench, places the plant, then backfills the trench using discs and then presses the plant in with two press wheels. Someone walks behind the machine and indents the soil to hold the mulch and further water.

Jenny and Colin always protect the tree with a tree guard and have used both milk cartons and plastic guards successfully. They have had problems with unguarded trees being damaged by kangaroos, galahs, cockatoos, cattle, pigs and even mice. They also mulch each plant with pine wood chips, or on occasions, sheets of newspaper punched to let water get into the plant.

After planting, Jenny waters trees when they look like needing it (perhaps three times over the first year). She doesn't believe in letting trees suffer. She generally tries to avoid insecticides, but has used them to control some insect pests (e.g. spitfires).

If weeds threaten to overwhelm the trees, Colin sprays around each tree for a diameter of about 2 metres around each tree.

One of the most important factors in achieving success (and Jenny and Colin achieve close to a 100% success rate in their planting) is species, selection and using local species. Trees that have stood out include river red gums, yellow box, mugga ironbark, Western grey box, cooba and river cooba. They conducted a forestry trial on the black soil, results of which are included in the table below.

They plant their trees along existing fences, up to three rows wide, or in clumps. If a tree doesn't thrive, it's pulled out. Over the years they have planted over 5000 trees and have inspired many others to do so as well.

Table 7. Tree species planted on black soil at Tathra

Species name	Common name
Acacia pendula	Weeping myall
Acacia salicina	Cooba / Doolan
Acacia stenophylla	River cooba
Angophora floribunda	Rough-barked apple
Casuarina cristata	Belah
Casuarina cunninghamiana	River oak
Casuarina glauca	Swamp oak
Casuarina stricta	Drooping sheoak
Callistemon paludosus	River bottle brush
Eucalyptus amplifolia	Cabbage gum
Eucalyptus argophloia	Western white gum
Eucalyptus astringens	Brown mallet
Eucalyptus brockwayii	Brockway's gum
Eucalyptus camaldulensis	River red gum
Eucalyptus camaldulensis var. obtusa	Blunt budded river red gum
Eucalyptus camaldulensis var. subcinerea	Silverton gum
Eucalyptus camaldulensis var. albacuya	Albacutya river red gum
Eucalyptus camaldulensis var. Finke River	Finke River red gum
Eucalyptus camaldulensis var. Mooki River	Mooki River red gum
Eucalyptus crebra	Narrow-leaved ironbark
Eucalyptus dealbata	Tumbledown gum
Eucalyptus gardneri	Blue mallet
Eucalyptus lansdowneana	Crimson mallee
Eucalyptus largiflorens	Flooded box / black box
Eucalyptus leucoxylon	White ironbark
Eucalyptus laxophleba	York gum
Eucalyptus melliodora	Yellow box
Eucalyptus microcarpa	Grey box
Eucalyptus microtheca	Coolabah
Eucalyptus moluccana	Grey box
Eucalyptus occidentalis	Swamp yate

Table 7. Tree species planted on black soil at Tathra (continued)

Species name	Common name	Species name	Common name
Eucalyptus ochrophloia	Yapunyah or Napunyah	*Eucalyptus spathulata*	Swamp mallet
Eucalyptus orgadophila	Hilltop coolibah	*Eucalyptus tereticornis*	Forest red gum
Eucalyptus platypus	Round leafed moort	*Melaleuca alternifolia*	Paperbark
Eucalyptus populnea	Bimble box	*Melaleuca bracteata*	White cloud tree
Eucalyptus raveretiana	*Black iron box*	*Melaleuca decussata*	Cross leaf honey myrtle
Eucalyptus salmonophloia	Salmon gum	*Melaleuca ericifolia*	Swamp melalueca
Eucalyptus salubris	Gimlet	*Melaleuca halmaturorum*	Salt paperbark
Eucalyptus sargentii	Sargent's or salt river mallet	*Melaleuca lanceolata*	Moonah
Eucalyptus sideroxylon	Mugga ironbark	*Melaleuca linariifolia*	Narrow leaf paperbark
Eucalyptus scoparia	Wallangarra white gum		

Table 8. List of failures on black soil at Tathra

Species name	Common name	Cause of death (where known)
Acacia melanoxylon	Blackwood wattle	Drought
Callistemon salignus	White bottlebrush	Frost
Eucalyptus botryoides	Mahogany gum	•
Eucalyptus blakelyi	Blakely's red gum	•
Eucalyptus bakeri	Bakers mallee	•
Eucalyptus cinerea	Argyle apple	Drought
Eucalyptus cornuta	Yate	•
Eucalyptus cladocalyx	Sugar gum	•
Eucalyptus dunnii	Dunns white gum	•
Eucalyptus erythrocorys	Illyarie	Frost
Eucalyptus forrestiana	Fuschia gum	•
Eucalyptus fibrosa	Broad leaf ironbark	Flood
Eucalyptus ficifolia	Scarlet flowered gum	•
Eucalyptus globulus	Tasmanian blue gum	Drought
Eucalyptus kondininensis	Kondinin gum	•
Eucalyptus le souefii	Goldfields blackbutt	•
Eucalyptus nicholii	Narrow leaved black peppermint	•
Eucalyptus nitens	Shining gum	•
Eucalyptus occidentalis	Swamp yate	Drought, bnt has resuckered
Eucalyptus papuana	Ghost gum	Frost
Eucalyptus robusta	Swamp mahogany	Drought, frost
Eucalyptus rossii	Scribbly gum	•
Eucalyptus stellulata	Black sally	•
Eucalyptus scoparia	Wallangarra white gum	Drought, but resuckering
Eucalyptus stricklandii	Strickland's gum	•
Eucalyptus steedmanii	Steedman's mallee	•
Eucalyptus tessellaris	Carbeen	Frost
Eucalyptus torquata	Coral gum	•
Eucalyptus woodwardii	Lemon flowered gum	•
Grevillea robusta	Silky oak	•
Melaleuca armillaris	Bracelet honey myrtle	Storm damage, generally unthrifty
Melaleuca styphelioides	Prickly leaf tea tree	•
Melaleuca quinquenervia	Paper bark	Frost
Pinus radiata	Radiata pine	•

Table 9. Forestry trial results

Species name	Common name	Survival rate %
Acacia melanoxylon	Blackwood wattle	0
Acacia stenophylla	River cooba	87
Casuarina cristata	Belah	60
Casuarina cunninghamiana	River oak	29
Eucalyptus camaldulensis v. lake albacutya	River red gum	97
Eucalyptus melliodora	Yellow box	94
Eucalyptus sideroxylon	Mugga ironbark	91
Eucalyptus microcarpa	Grey box	91
Eucalyptus stenophylla	River cooba	87
Eucalyptus camaldulensis v. obtusa	Blunt budded river red gum	85
Eucalyptus camaldulensis v. subcinerea	Silverton gum	70
Eucalyptus tereticornis	Forest red gum	59
Eucalyptus salmonophloia	Salmon gum	59
Eucalyptus moluccana	Grey box	50
Eucalyptus leucoxylon	Yellow gum	39
Eucalyptus brockwayii	Dnndas mahogany	36
Eucalyptus crebra	Narrow-leaved ironbark	34
Eucalyptus gardneri	Blue mallet - not a timber tree	24
Eucalyptus botryoides	Mahogany gum	0
Eucalyptus robusta	Swamp mahogany	0
Grevillea robusta	Silky oak	0

Table 10. Buffer survival rates

Species name	Common name	Survival rate %
Acacia pendula	Weeping myall	49
Acacia salicina	Cooba	85
Casuarina obesa	Swamp sheoak	0
Casuarina cunninghamiana	River oak	29
Casuarina glauca	Swamp oak	95
Eucalyptus sargentii	Salt river gum or sargent's mallet	78
Eucalyptus astringens	Brown mallet	38
Eucalyptus occidentalis	Swamp yate	17
Eucalyptus cladocalyx	Sugar gum	0
Eucalyptus steedmanii	Steedman's mallee	0
Eucalyptus stricklandii	Yellow flowering box	0
Melaleuca styphelioides	Prickly paper bark	0

The Birchalls have had 99.9% success rates with trees they grew from seed.

Shelter, buffer and habitat planting at Narrabri, NSW

Rachel Thomas is the enthusiastic Environmental Officer for Oakville Pastoral Company near Narrabri, NSW. She has commenced a tree planting program of about one kilometre per year to provide shelter, a spray buffer, and to improve habitat values and aesthetics on the farm. They have planted almost 10, 000 seedlings between 1996 and 1998, plus 25 hectares of saltbush.

The property is flat and has mainly black cracking clay soil with a small hill on clay ridges.

Site preparation consists of deep ripping four to six months before planting, and cultivating a couple of times within that period. The residual herbicide Simazine is applied four to six weeks before planting. A knockdown herbicide is applied about a week before planting if necessary.

They have planted in autumn (April-May) and spring (August-September). Autumn seems to be better as there are fewer weeds, better soil moisture and more time available on the farm, although frosts can be a problem. Spring planting can run into soil moisture and weed control problems.

They have planted 23 species of native trees and shrubs, which are listed at the end of this case study. Most of these species are indigenous to Narrabri, and virtually all are indigenous to north-west NSW. The species that had done exceptionally well after two years are indicated in the table.

After experiments with machine and hand planting, they now favour hiko seedlings propagated by a local farm tree nursery and the potti putki hand planting implement. Each tree is guarded with a milk carton guard and two bamboo stakes. They have found that it is very important that the tree guard has a good seal with the soil as wind can get in under the guard and dry out the plant.

In their first year of planting, they used speedlings planted by machine, but had difficulties. The ground preparation was not good, and the soil had many large clods. Soil moisture was a problem, and they lacked species suitable to the site. Consequently, many plants died.

The shelter belts are usually 25 metres wide and about one kilometre long. Shrubs and trees are mixed, about 4 metres apart along rows that are five to six metre apart. Each shelter belt has three-four rows, depending on how many can be fitted in. They have also established a small wood lot nine rows wide, that is 100 metres by 350 metres.

Trees planted two years ago are up to and exceeding 2 metres high and some birds have moved into the planting. Their plantiug has created considerable interest among other farmers in the district.

Table 11. Trees and shrubs planted at Oakville

Species name	Common name
Eucalyptus camaldulensis	River red gum
Eucalyptus microcarpa	Grey box
Eucalyptus melliodora	Yellow box
Eucalyptus populnea	Bimble box
Angophora floribunda	Rough-barked apple
Eucalyptus sideroxylon	Mugga ironbark
Eucalyptus blakelyi	Blakely's red gum
Acacia salicina	Cooba
Eucalyptus melanophloia	Silver-leaved ironbark
Brachychiton populneum	Kurrajong
Callistemon salignus	Weeping bottlebrush
Eucalyptus albens	White box
Acacia harpophylla	Brigalow
Pittosporum phyllireoides	Butterbush
Eucalyptus tessellaris	Carbeen/Moreton Bay ash

Table 12. Species planted April 1996

Species name	Common name
Acacia stenophylla	River cooba
Acacia decora	Western golden wattle
Melaleuca bracteata	White cloud tree
Allocasuarina leuhmanii	Bull oak
Casuarina cristata	Belah
Casuarina glauca	Swamp oak
Eucalyptus largiflorens	Black box
Eucalyptus coolabah	Coolibah
Eucalyptus gardenii	Blue mallee
Rhagodia spinescens	Berry saltbush
Callistemon viminalis	Red bottlebrush
Hakea leucoptera	•
Atalaya hemiglauca	Whitewood
Atriplex nummularia	Old man saltbush

Spray drift control planting at the Emerald Natureline, Qld

The Emerald Natureline project began after concerned citizens raised queries about health risks caused by spray drift. The Queensland Health Department suggested that the planting of a belt of trees around the town would have some effect in reducing drift, and in 1990, a tree planting project funded by the state government was started.

The project was originally designed to provide a belt of trees around the perimeter of the town, but as more information on spray drift became available, planting on farms was seen to provide greater drift capture opportunities.

In all 50, 000 trees were supplied by Department of Primary Industries Forestry and planted over a two year period. Further planting has been done, but on a much smaller scale. About two thirds of the trees planted in the Natureline were planted on farms, with most of the planting on about 19 farms.

About two thirds of the trees planted in the Natureline were planted on farms, with most of the planting on about 19 farms.

Much of the planting was established on light to medium clays, on former brigalow country

The success of the Natureline planting was mixed; in some cases virtually all the trees died. Causes for this varied from drought stress and insect attack to simple neglect.

Trees planted on some farms were not well looked after. The reasons could have been that the trees were free, they required more maintenance than was expected, or landholder priorities changed and the trees were no longer part of the property plan.

Plants which did succeed have done exceptionally well. These have benefited from good management from the start and from the use of some simple rules which were developed during the life of the Natureline project.

The Natureline 'rules'

- Plant any time of the year, as long as there is at least 70 cm soil moisture.
- Trees should be watered in at planting with a few litres of water to settle them in.
- Total weed control is essential for the first six to twelve months. Plant into bare soil and use mulch if possible.
- Plant in wide strips, at least 30 metres wide with trees in rows about 5 metres apart.

Table 13. Best species to plant around Emerald

Species name	Common name
Acacia pendula	Myall
Acacia stenophylla	River cooba
Acacia salicina	Doolan
Melaleuca bracteata	Black tea tree
Callistemon viminalis	Weeping bottlebrush
Casuarina cunninghamiana	River sheoak
Casuarina cristata	Belah
Eucalyptus camaldulensis	River gum
Eucalyptus sideroxylon	Mugga ironbark
Eucalyptus argophloia	White gum
Eucalyptus tereticornis	Forest red gum
Eucalyptus microtheca	Coolibah
Eucalyptus ochrophloia	Yapunyah
Eucalyptus raveretiana	Black iron box
Albizia lebbeck	Indian siris

Roadside and boundary planting by the Balonne Chemical Liaison Group

The Balonne Chemical Liaison Group, started by a group of cotton farmers, began establishing trees on property boundaries and road reserves in the St George Irrigation Area in 1994. They planned to capture spray drift and at the same time improve the landscape by greening the edges of the major road that runs through the township.

In 1994 they applied for funding and were granted 5000 trees per year for three years through the Queensland government's Trees for Landcare scheme. This allowed planting to be established along roadsides and properties. The group learned from some early failures that time had to be allocated to looking after the trees after planting. Watering was critical to allow the tree time to get established.

They are now planning further planting in the area, much of which is intended to capture spray drift from local cotton fields.

Nick Bligh, St George

The first planting was on Nick Bligh's property where 1000 trees were planted in 1994. Two rows went in between his dam sump and the main road to Goondiwindi. The soil was prepared well by cultivating and fallowing for a season. The site was laser levelled just prior to planting and furrows were cut for flood irrigation of the trees.

The site was flood irrigated just before planting and the trees were hand planted into moist soil. Plastic Sure Gro tree guards were used and weed control was maintained while the trees were less than 18 months old. Half the trees were mulched with cotton trash, which proved to be a good mulch option.

There was no real difference in the growth of the trees with or without mulch, but thorough watering and controlling weeds aided the trees greatly. The trees were flood irrigated a couple of times in the following years, but this was only needed because of drought conditions. Trees were planted at a spacing of 4 metres by 5 metres and had reached heights of up to 6 metres in three years.

The trees are highly visible from the road and have had very positive responses from the local community. A wide range of trees were planted, some of which proved more successful than others.

Table 14. Best performing species around St George

Species name	Common name
Acacia pendula	Myall
Acacia stenophylla	River cooba
Casuarina cunninghamiana	River sheoak
Eucalyptus argophloia	Western white gum
Eucalyptus camaldulensis	River red gum
Eucalyptus largiflorens	Black box
Eucalyptus leucoxylon rosea	Red flowered yellow gum
Eucalyptus coolabah	Coolibah
Eucalyptus moluccana	Grey box
Eucalyptus raveretiana	Black iron box
Eucalyptus spathulata	Swamp mallett
Melaleuca bracteata	Black tea tree
Melaleuca stypheloides	Prickly leaf tea tree
Tipuana tipu	Racehorse tree

Failures included

Species name	Common name
Callistemon	Bottlebrushes
Eucalyptus papuana	Ghost gum

Tree planting by machine at St George

For later plantings, the Balonne Chemical Liaison Group used a tree planting machine, which suited the flat soils and good site preparation. The use of the tree planter changed the work of planting from hard work with mattocks to a fast and effective system which has seen up to 1200 trees planted in a day.

The machine used was a modified Shelterbelter planter from Western Australia. The planter was converted to a drawn machine with electric hydraulics controlled by the planting machine operator.

Lessons from half a century of tree planting on the Downs

Trees planted 50 years ago at Mike and Peter Thomas's property, Tyunga, a cotton, grain and broccoli farm on the road between Brookstead and Cecil Plains in western Queensland, remain a good source of knowledge for tree growers with heavy clay soils, in the Downs or in similar districts. The large planting greets visitors at the front gate of the property.

The trial involved the planting of 91 species from 1948 to 1960. Some species have survived the test of time well; others performed well initially but later failed.

In 1948 Mike and Peter's father, Frank Thomas, formed an alliance with the then Queensland Forestry Department to establish species trials for trees on the heavy clays of the Darling Downs.

The trial involved the planting of 91 species from 1948 to 1960. Some species have survived the test of time well, others performed well initially but later failed.

Trees were spaced at 3 metres by 3 metres and established as lines of different species in a multi-row windbreak. The trees were kept weed free by cultivating between them. Trees were watered from a nearby irrigation channel during dry times only.

Since the trees have grown, they have had minimal attention.

Table 15. Best surviving species 49 years after planting

Species name	Common name
Casuarina glauca	Swamp sheoak
Eucalyptus camaldulensis	River gum
Eucalyptus moluccana	Grey box
Acacia pendula	Myall
Eucalyptus sideroxylon	Mugga ironbark
Tamarix aphylla	Athel pine
Eucalyptus ochrophloia	Yapunyah
Pinus halepensis	Aleppo pine
Acacia harpophylla	Brigalow
Brachychiton populneus	Kurrajong
Celtis sinensis	Celtis
Acacia stenophylla	Fragrant myall
Eucalyptus pilligaensis	Molly box
Eucalyptus salubris	Gimlet

The arboretum was measured regularly by the Forestry Department until the early 1970s, and reading these old reports is interesting. These recorded which trees were the best performers at the time. Some species named in the mid-60s as the best trees have since died out or gone on to become serious weeds. Others which went unnoticed are now surviving and growing well.

Planting for rising water tables and salinity at St George, Queensland

Ian Thomas, St George

When Ian Thomas took up a block in the St George Irrigation area he found that he was starting to have problems with rising watertables and salinity in association with a leaky channel. The channel in question runs along his northern boundary and is built largely above the ground. The hydraulic pressure created when the channel was full was causing waterlogging and saline conditions for some 70 metres into Ian's cotton fields.

Ian has a long association with tree planting, having inherited an interest from his father, Frank Thomas of Tyunga, Brookstead. [See earlier case study on Frank Thomas's 20 years of planting at Tyunga].

In 1988 Ian decided to plant 500 trees in two rows adjacent to the channel to try to control the waterlogging. Within three years the previously spreading wet patch had disappeared. Crop production returned to normal and the land has remained quite stable.

By using available resources on the farm and a conple of spare days he successfully established a vigorous and functional tree plot. Planting cost approximately $3.00 per tree and saved several hectares of valuable land from becoming useless.

For the first year Ian irrigated the trees from the leaky channel and ensured success by controlling weeds regularly.

Now that the plot is well established, Ian is finding that as well as achieving his original plan to stop the waterlogging problem, the trees serve as a wind break shelter, improving the general look of his property, and provide the pleasure of regular visits of koalas and other wildlife.

Table 16. Trees planted for salinity

Species name	Common name
Eucalyptus melliodora	Yellow Box
Eucalyptus rudis	WA flooded gum
Eucalyptus sideroxylon	Mugga ironbark
Eucalyptus moluccana	Grey box
Casuarina cristata	Belah

Ian has gone on to plant more areas of his property for other purposes, including drift capture and wildlife habitat.

Section Four: Selecting the right tree

Species suitable for cotton farms

Shrubs and small trees

Scientific name	Common name	Height in metres	Years to reach 3m	Frost tolerance	Preferred Climate	Soils	Uses
Native species							
Acacia pendula	Myall or Boree	6	5	high	any	clays-but not wet	wildlife, aesthetic drift.
Acacia salicina	Cooba, Doolan, Sally wattle	8	3	high	any	clays	drift, salinity, windbreak, timber. creek banks, suckers readily from roots.
Acacia stenophylla	River myall, River cooba	8	3	high	southern	clays	creek banks, drift, wildlife, salinity, spreads from seed.
Callistemon citrinus	Red bottlebrush	3	7	high	any	clays-but not wet	wildlife, aesthetic, slow growing.
Callistemon paludosus	River bottlebrush	2	*	high	southern	clays	wildlife, creek banks.
Callistemon salignus	White bottlebrush	2	*	low	any	lighter clays	wildlife, creek banks.
Callistemon rigidus	Stiff leaf bottlebrush	2	*	high	northern	adaptable	wildlife, drift, great habitat for small birds to nest in.
Callistemon viminalis	Weeping bottlebrush	6	4	high	any	clays	windbreaks, drift, wildlife, creek banks
Eucalyptus dadocalyx 'nana'	Dwarf sugar gum	8	3	moderate	southern	adaptable	windbreaks.
Eucalyptus leucoxylon rosea	Red flowering yellow gum	8	3	high	any	adaptable	windbreak, drift, aesthetic.
Eucalyptus platypus	Moort, platypus gum	5	3	moderate	northern	lighter clays	windbreak, drift.
Eucalyptus sargentii	Sargent's mallee	8	3	low	southern	adaptable	windbreak, drift, salinity.
Eucalyptus spathulata	Swamp mallet	8	3	moderate	southern	adaptable	windbreak, drift, aesthetic, salinity.
Eucalyptus steedmanii	Steedman's mallee	8	3	high	southern	adaptable	windbreak, drift, aesthetic.
Eucalyptus stricklandii	Yellow flowered gum	8	3	moderate	southern	light clays	windbreak, drift, aesthetic.
Eucalyptus viridus	Green mallee	6	3	high	southern	light clays	windbreak, drift, aesthetic.
Melaleuca bracteata	White cloud tree	6	3	moderate	any	adaptable	windbreak, salinity, creek banks, wildlife,drift.
Melaleuca halmaturorum	Salt land paperbark	3	6	high	southern	clays	salinity, windbreak.
Melaleuca linariifolia	Snow in summer	4	7	moderate	any	lighter clays	creek banks, windbreaks, wildlife, salinity, melaleuca oil.
Melaleuca nesophila	Mauve paperbark	4	6	moderate	northern	lighter clays	aesthetic, windbreak.
Melaleuca styphelioides	Prickly paperbark	7	4	high	northern	adaptable	windbreak, drift, wildlife, good habitat for small birds.
Exotics							
Albizia julibrissin	Silk tree	4	3	moderate	southern	adaptable	aesthetic.
Ceratonia siliqua	Carob bean	7	5	moderate	any	clays	aesthetic, slow growing.
Fraxinus griffithsii	Evergreen ash	5	3	high	southern	adaptable	windbreaks, drift.

Taller trees

Scientific name	Common name	Height in metres	Years to reach 3m	Frost tolerance	Preferred Climate	Soils	Uses
Brachychiton populneus	Kurrajong	12	5	high	any	adaptable	wildlife, aesthetic
Cassia brewsteri	Leichhardt bean	10	5	moderate	northern	lighter clays	wildlife, windbreak, aesthetic ,semi deciduous
Casuarina cristata	Belah, black oak	12	2	heavy	any	adaptable	drift, windbreak, wildlife, some leaf bugs in very heavy soils
Casuarina cunninghamiana	River sheoak	14	2	high	any	lighter clays	drift, windbreak, wildlife, (some leaf bugs in very heavy soils)
Casuarina glauca	Swamp oak	12	3	moderate	northern	adaptable	salinity, drift, windbreak, wildlife, ideal single or two row buffer species as it suckers and will keep a canopy to the ground
Eucalyptus albens	White box	15	2	high	southern	adaptable	windbreak, drift, firewood
Eucalyptus argophloia	Western white gum	20	2	high	any	adaptable	timber, drift, windbreak
Eucalyptus blakelyi	Blakely's red gum	16	2	high	southern	adaptable	windbreak, firewood
Eucalyptus brockwayi	Dundas mahogany	12	3	high	southern	adaptable	windbreak, drift
Eucalyptus camaldulensis	River red gum	16	2	high	any	adaptable	windbreak, wildlife, creekbanks, salinity, drift
Eucalyptus camaldulensis var cinerea	Silverton gum	16	2	high	southern	adaptable	windbreak, salinity, drift
Eucalyptus cambageana	Dawson gum	14	2	high	northern	adaptable	windbreak, wildlife, drift, very competitive with crops
Eucalyptus largiflorens	Black box	12	3	high	any	clays	salinity, windbreak, drift
Eucalyptus melanophloia	Silver leaf ironbark	10	3	high	northern	lighter clays	windbreak, wildlife, drift
Eucalyptus melliodora	Yellow box	12	3	high	southern	lighter clays	windbreak, wildlife, drift, good honey tree
Eucalyptus microcarpa	Western grey box	12	3	high	southern	adaptable	windbreak, wildlife, drift
Eucalyptus coolabah	Coolibah	12	3	high	any	clays	windbreak, wildlife, drift
Eucalyptus moluccana	Gum topped box	14	3	high	any	adaptable	windbreak, salinity, wildlife, drift
Eucalyptus ochrophloia	Yapunyah	14	3	high	any	adaptable	windbreak, wildlife, drift, generally multi stemmed, good honey tree
Eucalyptus orgadophila	Mountain coolibah	12	3	moderate	northern	lighter clays	windbreak, wildlife, drift
Eucalyptus pilligaensis	Molly box	12	3	high	southern	lighter clays	windbreak, wildlife, drift
Eucalyptus polyanthemos	Red box	12	3	high	southern	lighter clays	windbreak, wildlife, drift
Eucalyptus populnea	Bimble box Poplar box	12	3	high	any	lighter clays	windbreak, wildlife, drift, key koala food tree in western areas
Eucalyptus raveretiana	Black iron box	12	3	moderate	northern	adaptable	windbreak, wildlife, drift
Eucalyptus sideroxylon	Mugga ironbark	12	3	high	any	adaptable	windbreak, wildlife, drift, firewood
Eucalyptus tereticornis	Forest red gum, Qld blue gum	18	3	moderate	northern	adaptable	windbreak, wildlife, drift, firewood, salinity
Eucalyptus thozetiana	Mountain lapunyah	10	3	moderate	northern	lighter clays	windbreak, wildlife, drift
Flindersia australis	Crows ash, Teak	10	5	moderate	northern	lighter clays	windbreak, wildlife, drift
Grevillea robusta	Silky oak	14	3	moderate	any	lighter clays	windbreak, wildlife, drift, craft wood, good for honey eaters
Lysiphyllum hookeri	Native bauhinia	10	4	moderate	northern	lighter clays	windbreak, wildlife, drift, craft wood

Taller trees continued

Scientific name	Common name	Height in metres	Years to reach 3m	Frost tolerance	Preferred Climate	Soils	Uses
Melia azederach	White cedar	10	2	moderate	any	adaptable	windbreak, wildlife, drift salinity, craftwood, attracts hairy caterpillars, deciduous
Pleiogynium timorense	Burdekin plum	8	5	moderate	northern	lighter clays	windbreak, wildlife, drift craftwood, edible fruit

Exotic trees

Scientific name	Common name	Height in metres	Years to reach 3m	Frost tolerance	Preferred Climate	Soils	Uses
Celtis sinensis	Chinese celtis	10	4	moderate	southern	adaptable	windbreaks, drift, deciduous, a major weed in creeks on the coast
Koelreutaria paniculata	Golden rain tree	10	3	moderate	any	lighter clays	windbreaks, aesthetic, deciduous, some weed potential
Pinus halepensis	Aleppo pine, Galipoli pine	10	4	high	southern	lighter clays	windbreaks, drift
Schotia brachypetala	Parrot tree	8	5	moderate	northern	lighter clays	wildlife, aesthetics, good for nectar feeders
Tamarindus indicus	Tamarind	12	5	moderate	northern	adaptable	windbreaks,drift, fruits
Tamarix aphylla	Athel pine	12	5	high	any	adaptable	windbreaks, drift, salinity, very invasive root system
Tipuana tipu	Racehorse tree	10	2	high	any	adaptable	windbreak, drift, craft wood
Schinus molle	Pepperina	12	4	high	any	lighter clays	windbreak, driftbrittle branches, fly repellent, craft wood, edible fruit

Further Information

Department of Natural Resources: *Queensland Tree Selector* (http://www.dpi.qld.gov.au/fiqweb/welcome.htm)

Department of Natural Resources, (1995) *Trees and Shrubs*, DNR, Brisbane.