Growing waratahs for cut flowers

A guide for commercial growers
Growing Waratahs for Cut Flowers
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Foreword

The waratah is an iconic Australian native plant and the state emblem of NSW. It has been grown as a garden plant and a commercial cut flower for many years, and there exists considerable demand. The waratah is very suitable as a cut flower owing to its structure, texture, colour and good vase life. In some instances its commercial cultivation has been spectacularly successful; however, it remains a plant that is considered difficult to grow well in cultivation. It has a reputation of being particularly susceptible to root diseases and fertiliser excesses, and as a short-lived garden plant—although it is known that plants can live and flower well for 50+ years. Indeed, the question has been posed, ‘Will the Waratah Ever Fulfil Its Potential’ (Burnett 1993), owing to the challenges in cultivation.

Confounding the situation is that often the published information is contradictory. For example, the waratah has been reported as both requiring fertiliser for good growth and being particularly sensitive to fertilisers. This guide brings together both published and unpublished information, industry expertise, and the authors’ experience in the industry to assist in resolving this confusion.

The aim of this project was to produce a book that would provide growers, wholesalers, exporters and retailers with practical information about growing, harvesting, postharvest handling and treatment of waratah flowers. This is a practical ‘how to’ guide and covers all aspects from selecting the site to marketing the blooms. Particular attention is paid to ‘critical points’—areas that growers have found problematic in the past. The guide is aimed both at existing growers and potential entrants into the industry.

The guide also has a number of appendices that explore some production aspects in more detail. These include pest control, postharvest handling and economic analysis. The postharvest handling section was produced as part of a project funded by RIRDC Core Funds, which are provided by the Federal Government and supported by the NSW Department of Primary Industries (briefly Industry & Investment NSW), with industry funding contributed by East Coast Wildflowers and Crooby Cottage Wildflowers.

This guide adds to RIRDC’s diverse range of over 2000 research publications, and forms part of RIRDC’s Wildflowers and Native Plants R&D program, which aims to improve the profitability, productivity and sustainability of the Australian industry.

Most of RIRDC’s publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Craig Burns
Managing Director
Rural Industries Research and Development Corporation
About the authors

Dr Ross Worrall recently retired as a Special Research Horticulturist, NSW DPI. Ross was based at the Gosford Horticultural Research Institute, Narara. He worked on the commercial development of Australian native plants for most of his career. He also conducted research in the areas of plant physiology, potting mixes, breeding systems, postharvest management and plant propagation.

Bettina Gollnow provided extension support to the commercial NSW cut flower industry as the Industry Development Officer (Floriculture) for the NSW DPI for over 18 years until her recent retirement. Because the NSW flower industry is so diverse and fragmented, covering a huge range of crops, geographical areas and market niches, Bettina built a strong platform to support to the industry through publications, regular industry events and technical resources.

She recently completed a project for RIRDC to develop the current industry R&D plan and to review the achievements of the previous wildflower and native plants R&D plan.

Acknowledgements

We thank the members of the Waratah Industry Network for their help in the production of this publication. Special thanks are given to Craig Scott, of East Coast Wildflowers, for providing marketing information; Dr Neil Wade for the information on cool room design and layout; and Frank Allatt (waratah grower), Dr Cathy Offord and Faye Cairncross (Mt Annan Botanic Garden) and Neil Kirby (waratah propagator) for their helpful comments. We also thank Dr Geoff Cresswell for providing most of the nutrient imbalance photos.

## Abbreviations

### Units

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<th>Symbol</th>
<th>Description</th>
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<tr>
<td>°C</td>
<td>degrees Celsius</td>
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<tr>
<td>%</td>
<td>per cent</td>
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<td>/</td>
<td>per</td>
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<tr>
<td>µL</td>
<td>microlitre (1 000 000 µL = 1 L)</td>
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<td>cm</td>
<td>centimetre</td>
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<td>g</td>
<td>gram</td>
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<td>grams per litre</td>
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<td>ha</td>
<td>hectare</td>
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<td>kg</td>
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<tr>
<td>mL</td>
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<td>mL/L</td>
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<td>S</td>
<td>sulphur</td>
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<td>Zn</td>
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### Other abbreviations

- **approx.** approximately
- APVMA: Australian Pesticides and Veterinary Medicines Authority
- AQIS: Australian Quarantine and Inspection Service
- av.: average
- CA: controlled-atmosphere (storage)
- DPI: Department of Primary Industries
- EPA: Environment Protection Authority
- FECA: (former) Flower Export Council of Australia
- MA: modified-atmosphere (packaging or storage)
- MB: methyl bromide
- 1-MCP: 1-methylcyclopropene
- MSDS: Material Safety Data Sheet
- No.: number
- OHS: occupational health and safety
- pH: measure of acidity
- QA: quality assurance
- ®: registered trade name
- RH: relative humidity (%)
- STS: silver thiosulphate
- ™: trademark
- Vol.: volume of written publication, journal etc.
- ( ): Plant Breeders’ Rights symbol

### Chemical symbols

<table>
<thead>
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<tr>
<td>B</td>
<td>boron</td>
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<td>Ca</td>
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<td>Cl</td>
<td>chlorine</td>
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<tr>
<td>Na</td>
<td>sodium</td>
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<tr>
<td>P</td>
<td>phosphorus</td>
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Executive summary

What the guide is about
This guide provides advice and information on all aspects of growing, harvesting, postharvest handling and quality management of waratah flowers.

Who is the guide targeted at?
This ‘how to’ guide has been produced for members of the Australian wildflower industry who grow and market waratahs, including growers, wholesalers, retailers, florists, exporters, importers, research, development and extension workers, and students.

Where are the relevant industries located in Australia?
Waratahs are grown mainly in eastern NSW, southern Victoria and south-east Queensland. Flowers are mostly consumed domestically, but there is significant scope to expand exports.

Background
The waratah is an iconic Australia native with great potential as a cut flower. However, despite some notable successes, routine commercial growing for cut flowers and as garden specimens remains elusive. The question ‘Will the Waratah Ever Fulfil Its Potential’ has been asked by Burnett (1993), who outlined some of the key impediments to its success.

Aims
The aim of this work was to produce a guide that includes all the up-to-date literature and grower and researcher data available that will provide the industry with practical information and advice about all aspects of growing and marketing waratahs.

Methods used
This work was done in association with the broader project ‘Quality Specifications for Australian Wildflowers’ and the project ‘Growing Flannel Flowers All Year Round’, for which a production guide was also produced. These projects were conducted by the former Department of Industry & Investment NSW – Primary Industries (RIRDC projects PRJ 000331, PRJ 000498). A guide for the production of Christmas bush was also prepared at the same time. Information was gathered from industry members, including growers, researchers, wholesalers, exporters and importers, and from a review of the research literature, both published and, where available, unpublished. Particular attention was paid to plantations that were successful.

Results
This project produced a guide that provides growers, wholesalers, exporters and retailers with practical information about growing, harvesting, and postharvest handling and treatment of waratah flowers. This is a practical ‘how to’ guide and covers all aspects from selecting the site to marketing the blooms. Particular attention is paid to ‘critical points’—areas that growers have found problematic in the past. A summary of the critical points is provided. The guide also relies on the personal experience of the authors in research on waratah and in advising growers.

The guide covers all aspects of commercial waratah growing, from site selection to marketing the flowers. It includes a number of appendices that explore some production aspects in more detail. These include pest control, postharvest handling and economic analysis.
Implications for relevant stakeholders

This information is now available for people in the industry to use to improve the production and postharvest quality management of waratahs. The information should lead to the benefits of lower costs and improved sales and returns and more efficient production practices.

There is a need for ongoing extension of this information and for ongoing R&D in this area (see Recommendations below).

For students, this can be an extremely valuable resource.

Recommendations

This guide reflects a career-long commitment to research, development and extension in floriculture and has provided an opportunity to capture significant knowledge and shared industry learnings gained over a long period of time.

The availability of this guide needs to be made widely known, by RIRDC, the authors, industry leaders and bodies, and government bodies.

We recommend that industry members adopt production, postharvest and quality management practices outlined in the guide. Individual users can add new information to this guide.

The guide can be updated in the future if there is enough new information, demand, funding and expertise. It is clear, however, that more research is needed on:

- nutrient requirements
- root diseases and their control
- the effect of shading on growth rates and flower quality
- selection of high-yielding clones
- market preferences
- the effect of postharvest solutions on vase life
- extending storage times.

R&D and extension workers need to discover and ensure that new information is made available to the industry in a way that maximises the uptake of those new learnings.
Summary: Producing quality waratahs—a critical-point analysis

General points

- Flowers should not dry out at any stage after harvest. Excessive loss of fresh weight means a shortened vase life. Dry flowers have a ‘blue’ appearance.
- Store flowers either with stems in preservative solution or in a box with a vapour barrier (e.g. plastic wrap—semi-permeable is best to stop condensation).
- Avoid exposing flowers to high temperatures.
- Store at 2 to 4 °C. Waratahs can be cool-stored for about 1 week without a significant (>20%) loss in vase life. May be stored at 1 to 2 °C for better vase life if tight temperature controls are available. Don’t allow flowers to freeze!
- Good-quality flowers store better for extended periods.
- Flowers must be treated with a fungicide to control botrytis if they are to be cool-stored or held under high humidity (for example, in a plastic wrap), especially if individual flowers are open.
- If stored with other flowers, try to hold them at 5 °C or below (without freezing).
- If blooms are to be cool-stored or held under high humidity, use a postharvest solution that does not contain sugar.
- Always use clean containers and clean, low-salt (potable) water.
- If stored correctly, waratahs do not produce significant amounts of ethylene (they are not autocatalytic). However, they can be affected by high levels of externally produced ethylene, which can shorten vase life. Don’t store with fruit and vegetables or with old flowers.
- Keep cool rooms and work areas clean and free from old plant material.
- Always use sharp blades to harvest and trim stems and leaves.
- Rotate stock. Coloured containers indicating date of picking or purchase are helpful.
- Don’t crush stems, leaves or flowers by overcrowding in buckets.

Tips for growers

- Ensure good growing conditions, including correct light, temperature, fertiliser, irrigation and wind protection. Stress—for example, through excessive fertiliser use (or deficiency), wind, insect or disease damage, or insufficient water—can greatly reduce potential vase life.
- Choose your varieties carefully for yield, quality, size, type and vase life.
- Control pests and diseases and non-pest arthropods (for example, spiders), which may become a quarantine problem.
- Harvest when flowers are fully formed, with 0% to 5% of the individual flowers open, for maximum vase life. In fully developed blooms, the more individual flowers that are open, the shorter the vase life is and the higher the risk of insect contamination is, as insects are attracted to the nectar produced by open flowers.
- Use the correct hydrating or pulse (short-term conditioning) solutions.
- Use clean, potable water to make up solutions.
- Cool and hydrate blooms as soon as possible, and pre-cool packed containers by forced-air cooling.
- Disinfest and protect blooms, especially those for export, against botrytis and insects; for example, use a dip containing a fungicide and insecticide.
- Pack to the appropriate standard for the market.
Tips for wholesalers

☑ Stand flowers in a postharvest solution made up with clean, low-salt water.
☑ Maintain good hygiene and keep containers clean.
☑ Store at the correct temperature.
☒ Don’t sell old stock—throw it out!

Tips for retailers

☒ Do not display flowers in areas that are exposed to full sun, drafts, high temperatures or vehicle exhausts, and preferably not near fruit and vegetables. Use refrigerated displays if possible.
☑ Use clean buckets and containers for displays.
☑ Use preservative vase solutions made up with potable (clean, low-salt) water. Also use potable water for arrangements.
☑ Insert the flowers properly into floral foams when making up arrangements, and use enough solution.
☑ If flowers show any signs of wilting or have been stored or transported dry for any length of time, stand them in a postharvest solution until they recover. If they don’t recover, throw them out!
☑ Trimming about 1 cm from the base of the stem daily may help to maintain good water uptake.

☑ Tell the customer how to care for the flowers (for example, give them a care sheet), and emphasise the need for preservative vase solutions.

Tips for consumers

☑ Keep the vase filled with fresh, clean water. Check daily, as waratahs can use a lot of water. Change the water at least every second day. Cleaning the vase will also help. Always use clean vases and potable (clean, low-salt) water.
☑ Remove any leaves that will be below the water line.
☑ Remove about 1 cm from the end of the stem to improve uptake of water, especially if the tip has turned black.
☑ Avoid displaying flowers in areas that are exposed to full sun, drafts or high temperatures. Keep as cool as possible without freezing.
☑ If flowers show any sign of wilting, recut the stem. If they don’t recover, throw them out!
☑ Discard other types of flowers that may be in the same vase when they reach the end of their vase life.
☑ If other flowers in the arrangement require sugar, you may use it in the preservative solution, provided that the flowers are not held under high humidity.
Introduction

The waratah (*Telopea speciosissima* R. Br.) is the NSW floral emblem. The crimson bloom or inflorescence is formed from numerous individual flowers and is surrounded by large bracts (Figure 1).

**Figure 1. Waratah flower in the wild.**

**Figure 2.** The native habitat is woodland on a yellow earth soil more than 1 m deep.

**Figure 3.** Cultivated clones are generally more uniform and provide a wide variety of forms.

(a) Some clones have larger and more numerous bracts.

(b) Red, pink and white flower colours are available.
Figure 4. Waratahs can grow and flower well in the home garden given ‘good’ conditions, especially drainage.

(a) Close up of a plant growing in a home garden with a sandy soil.  
(b) General view of (a).

(c) A plant growing well in a home garden with a well drained clayey soil and a medium level of fertiliser application.

Figure 5. Commercially grown plantation. Crops can be vigorous and high yielding under good growing conditions. Note grass between rows to help to control erosion.

Figure 6. Growing plants under light shade cloth (~30%) can improve of flower quality and growth rates.
The waratah occurs naturally in the Central and South Coast districts and the Blue Mountains region of NSW on poor, deep, sandy soils (over 1.5 m) derived from sandstone. For a fuller description of the history, botany and ecology of the waratah see Nixon (1987) and Wikipedia (2010).

Significant numbers of waratahs are now being grown for commercial cut flower production. These are largely Telopea speciosissima and its hybrids, and this guide refers exclusively to these.

Prices for waratahs on both the domestic and export markets vary greatly, and are related to both flower quality and time of flowering. In the words of one wholesaler, ‘Returns to growers will always depend on quality of flowers sent, presentation, and the volumes in the market on and around the day their flowers arrive.’

In recent years, many growers have planted large numbers of waratahs in a range of sites on the east coast of Australia as well as in inland parts of NSW. Many have planted improved varieties with superior flower colours and shapes, so that for the first time large volumes of high-quality flowers are available. There are also large plantings in Victoria—around Melbourne—that probably exceed those in the whole of NSW, and in southern Queensland.
Flower growing as a business

This publication discusses the basic production and marketing requirements for waratahs. It highlights on-farm management practices that will reduce the risk of planting and marketing poor-quality waratahs. With plants expected to be economically productive for up to 30 years, it is vital for the industry to focus on quality so as to develop local and export markets.

Pay attention to marketing, financial and other factors. Growing waratahs, like growing any other cut flower, should be considered as a business. The key aim of any flower business is to make a profit rather than just to produce flowers. Failure to make a (real) profit means that you either go out of business or have an expensive rural lifestyle. It is important to consider all risks—not just the physical ones. We urge potential growers to develop a business and financial plan to control risks, which may be physical, financial, marketing, legal or business related.

At an industry workshop, experienced growers listed their ‘worst mistakes’ when starting as growers:

- Not treating native flower growing as a business.
- Lack of good-quality research.
- Lack of good-quality marketing: establish the demand for the crop.
- Not getting independent sources of advice.
- Working excessive hours and not allowing for holidays.
- Not controlling customers’ credit.
- Falling foul of regulations and planning requirements.
- Lack of quality control.
- Under- or over-capitalisation.
- Inability to pay for additional labour.
- Exceeding future financial limits.
- Growing the wrong species or varieties.
- Choosing the wrong site.
- Poor basic knowledge.

All these considerations should be addressed in a business plan (in addition to the usual requirements).

Most waratahs are currently produced as open-air crops in the ground, but a significant and increasing number are being grown under shade cloth. The cost of production will vary according to the management system selected by the grower. When comparing systems and examining potential returns, take into account the risk of plant loss. Obviously, if you are certain that a higher-cost production system will reduce the number of plant deaths and yield a greater number of stems, then its use may be economically justified.

For both those starting in the business and established growers, recommended references are listed first in the References section. Other publications can be found on the RIRDC website: www.rirdc.gov.au.
What does the market want?

For waratahs in particular, market appeal is related to the shape of the bloom: the ratio of bracts to the domed mass of individual flowers and the overall appearance of the bloom (Figure 7). This requires attention during the planning phase. Different markets, or even sectors of markets, may have very different requirements. When choosing which varieties to plant, select quality clonal material (cultivars) with the flower shape and size and bract length that your customers want. Some clones have better yields and vase life (up to double) than seedling waratahs. By planting clonal material, you can supply large quantities of uniform blooms, making grading, good product presentation and repeat orders easier to achieve. Another advantage is that clones, being cutting-grown, usually flower within 3 years of planting. Certain varieties establish more successfully in the plantation than other varieties or seedling plants. Some varieties also may be more susceptible to particular pests or diseases; for example, ‘Corroboree’ seems more vulnerable to insect attack.

Figure 7. Structure of the waratah flower (near florets removed).

Some buyers want large blooms, whereas others prefer the smaller heads. Smaller-headed blooms are perhaps best presented in bunches of five stems, as is done with many proteas. With increasing numbers of cultivated blooms reaching the market, growers need to pay greater attention to grading, sorting blooms for size, shape, colour and stem length, and presenting similar blooms in any given box or bucket sent to market. For the Sydney domestic market, large flowers with long stems are used for corporate arrangements, medium flowers with shorter stems for floristry work, and small flowers with short stems for posies. Flowers with small heads seem to be popular for the export market, especially as greater packing densities can be achieved, reducing freight costs significantly.

Prices for blooms can vary greatly, depending on quality and time of flowering. The best prices for high-quality blooms are generally obtained early in the season. Good-quality blooms late in the season may also achieve higher-than-average prices. Oversupply usually occurs in early October with an influx of large quantities from Victoria. For the export market, the demand varies according to market requirements and includes stem lengths of 60 cm and more.

Consider production, marketing and transport costs when calculating your potential net returns. For example, it is possible for marketing and transport costs to be greater than production costs, especially for exported flowers. Returns, however, could be substantially increased if packing densities could be improved, especially for exported flowers. See the economic analysis in Appendix 2.

What is a good-quality waratah? Local and overseas markets want blooms that:

- are fresh and have a good vase life
- are generally free of bract browning, especially the lighter-coloured flowers (Fig. 8)
- are free of pests and diseases
- show foliage in balance with the bloom, with leaves that have an attractive shape and colour and are free from blemish
- come with the correct documentation.

All of these considerations are affected by how the grower manages the crop, especially during bud set (November to March) and during the 6 to 8 weeks immediately before harvest. Application of adequate fertiliser and water in the 6 weeks after harvest is important to ensure vigorous stem growth to support next season’s flowers.
As a grower you should pick only good-quality flowers for market, and you must provide appropriate postharvest care and treatment to ensure the best vase life for consumers. Useful references are *Postharvest Handling of Australian Flowers* and Quality Specifications for Australian Wildflowers—Waratah (see References and Appendix 1), which include a great deal of general information as well as some information specific to waratahs. The quality of the flower when it is harvested is the best it will ever be: as soon as the stem is cut, the flower begins to die. Your aim should be to slow down the rate of decline to give the retailer and the consumer the longest vase life possible. Avoid or change any activity that speeds up the decline of the stems to minimise effects on flower quality. A concept used by many producers and wholesalers is the Quality Chain or ‘Chain of Life’. This emphasises that all steps in the postharvest chain are important in delivering good-quality flowers to the consumer.

Perhaps 60% or more of the potential vase life of the flower is determined before harvest. For example, some varieties have potentially 2–3 times the vase life of others. Care given to flowers before harvest (for example, by irrigation, fertilising, wind protection, and control of insects and disease) can also greatly influence their postharvest characteristics, especially vase life. The aim is to harvest from healthy plants, which are the most pest and disease resistant.

Harvesting and postharvest processes will influence profitability significantly, as most of the total production costs occur from harvesting onwards. Ask yourself: Is my crop of poor quality or is the market poor? Should I harvest it at all? If you don’t ask these questions, all that you may get for your trouble is a bill.

Common faults recorded in export flowers include ‘blueing’ of flowers (where the red of the florets takes on a bluish tinge), which is caused by drying out or other factors such as application of too little water immediately before harvest; major bract browning; presence of bypass shoots; damaged florets; presence of live and dead insects; and foliage with scale or leaf miner damage. Exporting anything less than the best-quality blooms will only harm our reputation overseas and reduce prices overall.
Flowering season

Waratahs flower mainly from early September to late October, largely depending on the locality. Flowering generally occurs earlier in warmer climates (but not always). For example, flowering begins earlier in northern NSW and southern Queensland than in Victoria. Flowering also generally occurs earlier in coastal NSW than in highland areas. When choosing a site for a new plantation, take care to ensure that the climatic conditions are generally suited to the waratah, or failures may occur. Flowering in a given locality will vary slightly from year to year, depending on seasonal conditions.

Most plants flower between mid September and mid to late October, with a big flush in late September and early October. As flowers tend to have a vase life in excess of 2 weeks, prices tend to fall rather abruptly when peak volumes of flowers reach the market. Work is currently being done to develop varieties and hybrids that flower earlier and later to lengthen the season of availability.

Exceptions include ‘Shady Lady’ (T. speciosissima × T. oreades) and similar cultivars, which flower for much longer. However, their flower heads tend to be much smaller.

Most plants in a commercial plantation tend to flower over a 2- to 4-week period, with most flowers occurring in the second and third weeks. This concentration has implications for harvesting, postharvest treatment and marketing.

Plants will often produce a smaller number of flowers in late summer to early autumn. This off-season flowering appears to be due to an interplay of environmental conditions and pruning time. Such flowers are sometimes similar in size and shape to the main spring blooms, but may be much smaller and often misshapen.
Yields

Very high yields are possible when plants are grown under ideal conditions: for example, up to 60 blooms per plant (Burnett 1993). Some individual plants can produce greater numbers. In a plantation owned by Howard Gay, over 100 saleable flowers were produced by one bush (Nixon 1987; and witnessed by Ross Worrall). Other plants in this plantation also produced exceptional numbers of flowers. One plant in a garden has been observed with over 200 flowers. Yields of commercial plantings can be high. In high-density plantings (where plants grown from cuttings are spaced 1 m to 1.2 m apart in rows, with 2000 plants per ha), 20 000+ blooms per hectare per year can be produced 7 years after planting.

However, often these yields are not realised. High yields will depend on the use of selected clonal material, good growing conditions and cultural practices, and the occurrence of optimum environmental conditions (such as soil and climate) and few natural calamities. Optimal density for flower production will depend especially on the clone used and its vigour under the prevailing growing conditions. Note that at densities much greater than those suggested above, especially for vigorous clones, the number of flowers per bush and per hectare can fall dramatically. Production of flowers on individual stems appears to be strongly related to stem size. Few flowers will be produced on the small stems typically produced in very high-density plantings. This may be partly overcome by appropriate pruning and even perhaps removal of plants as the bushes become larger. Conversely, too low a density will generally increase costs per flower produced and thus lower financial returns. Heavy shading often also dramatically reduces yield. Note also that returns for some varieties are greater than others, often greatly so. This may offset lower yields.

Avoid the trap of extrapolating potential yields from a limited number of plants, as growing conditions, especially shading, the effect of mutual competition and management practices, can be very different.

After establishment, a planting can be expected to remain productive for 30 to 40 years. However, because of the number of failures that have occurred, waratahs must be considered a high-risk crop. In most instances these failures can be attributed to inadequate soil aeration (good aeration and drainage are critical for waratahs) or inadequate attention to plant maintenance.
Propagation

Cuttings (vegetative propagation)

Plants grown from cuttings have many advantages over seedlings. They allow selected varieties that are desirable (mainly in terms of vigour, inflorescence shape, size, colour and vase life) to be established. These plants will usually produce some flowers within 3 years of planting into the field. Selected clonal material will usually outperform seedlings in the field. A wide range of clones with different characteristics are becoming available. The type you select should be suitable for the proposed market: for example, in terms of colour, size, length of bracts and vase life.

Terminal or stem cuttings may be taken. Spring is the best time for taking cuttings, just after growth has begun, or alternatively after the new growth has hardened. Cuttings taken during winter will be slow to strike. Some clones are protected by Plant Breeders’ Rights, and their propagation is legally restricted.

Make the cuttings about 15 cm long, with four or five leaves attached. Dip them in a systemic fungicide to control infections caused by Phyllosticta telopeae and to control latent infections that are not obvious when the cuttings are taken. Failure to do so may result in high percentage losses, especially if the cuttings are taken from plants in a plantation. Treat the basal 5 mm of cuttings for 5 seconds with 2000 ppm IBA (indole butyric acid) (in 50% ethanol solution) or with a semi-hardwood hormone powder (0.3% IBA in talc). Do not use higher rates, as a delayed toxicity may occur.

The use of intermittent mist to strike the cuttings will usually give the best results. Use a coarse, well-drained medium. At Gosford Horticultural Institute, 100% perlite was routinely used with good results. Mt Annan Botanic Garden (now The Australian Botanic Garden, Mt Annan) used a medium of 1 part coir dust : 2 parts coarse sand : 4 parts perlite (by volume). Generally, no fertiliser is added to the striking medium. Fungus gnats (sciaria flies), a common nursery pest, must be controlled, as they can extensively damage the cuttings by stripping the root hairs and by eating the new tender roots and tunnelling into the cut stems. They are also known to spread certain root diseases.

Bottom heat (24 °C) will speed up root formation.

If cuttings are taken at the best time and are in good condition (that is, just after growth has begun in spring) and then are correctly treated, a strike rate of close to 100% should be achieved in 4 to 5 weeks. Strike rates can be poor if cuttings are taken when the plants are dormant or the material is soft. When the plants have struck, transplant them into containers of 1 to 2 litres using a potting mix and fertilisers suitable for established seedlings. A suitable potting mix is made of ⅓ (low-P) composted hardwood sawdust, ½ aged pine bark fines and ½ coarse sand, all adjusted to a pH of about 5.5. Add 0.5 kg slow-release nitrogen fertiliser (commonly known as IBDU) and 4 kg of 4–5-month Nutricote (or 8–9-month Osmocote) per cubic metre. Keep the mix moist and do not allow the roots to dry out. The waratahs will be ready for transplanting into the field after about 6 months in the pots.

Seed

Seedlings take at least 4, and usually 5, years to flower. Large variations in vigour, leaf shape, inflorescence shape, size, colour and possibly disease resistance exist between individuals. This will lead to significant variability in the final product.

Waratah seed germinates readily if it is fresh (under 6 months old if stored at room temperature). Seeds will remain viable for at least 2 years if kept refrigerated at 5 °C. Seed is harvested from about April in the warmer areas to June in the cooler areas. Collect pods when they begin to turn brown, but before they split and release their seeds, and allow them to open in a well ventilated area.

Sow the seeds thinly (about 1.5 cm between seeds) on trays filled with a coarse, well-drained, sterile growing medium such as perlite, and cover with about 5 mm of medium.
Drench the trays with a general-purpose fungicide. Transplant the seedlings as soon as possible after they emerge (after 2½ to 4 weeks) into 5-cm tubes, as the young seedlings are easily damaged. Alternatively, wait until at least six to eight leaves have expanded and the roots are much less readily damaged. A suitable potting mix for the tubes is a mixture of ⅓ peat and ⅔ coarse sand or perlite, sterilised and adjusted to a pH of 5.5 with dolomite. Fertilise weekly with a solution containing 0.2 g/L of a general-purpose soluble fertiliser such as Aquasol or Thrive. Keep moist and don’t over-fertilise.

When seedlings are about 150 mm high, after hardening off they can be transplanted into the field. However, the loss rate can be greatly reduced if they are grown on in larger containers (1 L, 125 mm diameter or bigger). A suitable potting mix for these larger containers is ⅓ (low-P) composted hardwood sawdust, ⅓ aged pine bark fines and ⅓ coarse sand, all adjusted to a pH of about 5.5. Add 0.5 kg of IBDU and 4 kg of 4–5-month Nutricote (or 8–9-month Osmocote) per cubic metre. No additional fertiliser should be necessary before the plants are transplanted into the field. Do not allow plants to become pot-bound by leaving them in the pot for too long (see page 11).

**Watering**

Whether the young potted waratahs have been grown from cuttings or seed, avoid over-watering of pots, as this favours the development of damping-off diseases caused by fungi such as *Pythium*, *Phytophthora* and *Rhizoctonia*. Keeping out diseases by good hygiene is always the best means of control. The spread of these diseases can be restricted by keeping pots on mesh benches or at least above any ground splash. These diseases can be controlled to a certain extent with fungicide drenches. Some fungicides can be phytotoxic (cause plant damage) to the seedlings, so use them with caution. Never exceed the recommended rate and always read the label.

Young waratahs are also very susceptible to drought stress, so pay great attention to watering of the pots. Having an adjustable timing system for watering can be a great help in achieving the optimum water content.

**Where to obtain plants**

Check specialist horticultural magazines such as *Australian Horticulture* and publications such as the annual nursery trade register (published by the Nursery and Garden Industry Association of Australia) to locate specialist propagators. The Internet is also a good source of leads. Suppliers may also provide cultural information and advice on suitable varieties for your area. It is your responsibility to decide what to grow. Do your homework first, and be thorough.

A list of some of the available varieties is shown in the Wikipedia article on waratah: www.en.wikipedia.org/wiki/Telopea_speciosissima (accessed 1st July 2010).
Cultivation

Soil aeration and pH

Adequate soil aeration is perhaps the most critical aspect for successful waratah production. Although waratahs grow naturally in sandy soils over 1.5 m deep, they also thrive in soils with a clay content of 10% to 15% (or even above this) where water drains through at a rate of 100 to 200 mm/h. In cultivation, waratahs will grow in a wide range of soil types, provided the soil is well drained; for example, they thrive on well drained red basaltic clay soil in the Silvan area of Victoria. Soil analysis laboratories can test for these requirements with a Ksat test and a soil particle test. The laboratories should also determine the soil pH and nutrient levels.

Shallow soils, particularly those overlying an impervious subsoil, are not suitable unless provision is made for drainage. Waratah survival and growth rate often dramatically improve when such soils are artificially drained. Poorly structured clay soils (such as those derived from shale in the Sydney basin) are generally unsuitable. Use of a site with a mild slope can often greatly improve drainage. Mounding of beds may also help, providing the mounds do not impede surface water flow. In high-rainfall areas the beds must not dam surface water, otherwise plant death is likely. A solution to this, as practised in the macadamia industry (macadamia is another member of the Proteaceae with similar requirements to the waratah), is to run beds up and down the slope, especially on mild slopes. However, take care to minimise soil erosion: for example, by using techniques such as grassing waterways and maintaining mown vegetation between the rows.

Aim for a soil pH of 5.0 to 6.0. Outside this narrow range, many soil nutrients become unavailable to waratahs.

Aspect

Although they occur naturally in woodland situations, waratahs grow and flower best under light shade or in full sun if in a protected situation. They need protection from strong winds, especially at flowering. A site with a north-easterly aspect is most favourable, especially if protected from the hot afternoon sun.

Protection under light shade cloth can reduce the incidence of bract browning. Plants grown in heavy shade are generally not vigorous and produce few blooms. Plants growing on heavily shaded or southerly slopes can flower 2 to 4 weeks later than those in full sun.

Quality of planting material

Use of high-quality planting material is essential to getting good results, both to minimise losses and to ensure that the plants become established quickly. Poor-quality plants are a bad investment.

When buying good-quality plants, look for (adapted from Wilk 2002):

- plants that are not too large for the pots
- a healthy, well formed root system that is not twisted or spiralled
- a root system that has masses of very fine roots with white tips throughout the potting mix
- healthy, vigorous, well formed growth with dark green foliage
- freedom from insect pests and diseases.

Use a reputable supplier of stock plants. It is a good idea to inspect the stock plants too.

The root system

A well developed root system is important. The root system should evenly fill the pot to the point where the soil is bound together, without being too dense and pot bound (Figure 9). Distortions such as goosenecks and twists, or strangled and crank-handled roots and spirals, usually result in the failure of the plant to grow properly and in weakness at or near ground level, making the plant very susceptible to breaking at ground level.
If the roots do not fill the pot, either it is too soon after transplanting from the previous pot size to plant out into the field or there are serious root problems (for example, disease or waterlogging). Transplanting such plants will generally result in serious damage to the delicate root system.

The young roots in the pot should be white, especially at the tips, indicating that they are in good health.

Waratahs also have specialist roots called cluster roots (Figure 10). These have an important role in plant nutrition, as expanded on later on page 20. Waratahs produce these cluster roots as a means of absorbing more nutrients. Although cluster roots can be formed over a wide range of nutrient levels, the presence of large numbers indicates that only a low level of fertiliser has been used for growing the plants, so take care in applying fertiliser at transplanting: the addition of large amounts of readily available fertiliser may result in toxicity if a large number of cluster roots are present.

The shoot

The shoot should be proportional to the size of the pot and root system. If it is too large, management after transplanting will be more difficult because of greater water usage. The leaves and stems should be healthy and should show no obvious signs of fertiliser excess or deficiencies (see Figures 11a–l). Preferably there also should be signs of new growth on the plants. Once there are serious nutritional imbalances in the young plants and they have stopped growing it is difficult for them to recover.

Inspect the plants for signs of pest infestation or diseases. Aim to avoid introducing new pests or diseases into plantations, as they can stunt growth and increase management costs significantly.

Soil issues in waratah plantations

Waratahs are often grown in high-rainfall areas on relatively shallow soils with relatively steep slopes. This increases the potential for soil erosion and nutrient leaching. Appropriate soil management practices are essential to protect the plantation. Traditionally, a grass sward is left between rows, and a bare soil strip is maintained along the row by the regular use of herbicides or by mulch or plastic weed mat. This practice makes harvesting easier but can contribute to soil loss and degradation unless mulch is used. Additionally, the use of weed mats can make the application of solid fertilisers difficult. Take care that the herbicides you use are not toxic to waratahs.

Factors affecting erosion and soil degradation in waratah plantations are listed below (based on Firth 2003).

Soil physical factors

In waratah plantations, soils are adversely affected by:

- concentrated stem flow (water running
down the stems during heavy rain)
• loss of organic matter
• the impact of raindrops and large water droplets falling through the plant canopy
• the passage of machinery, particularly when the soil is wet
• drying and hardening of the bare soil surface, which can make it water repellent.

These factors:
• erode the soil
• compact the soil
• destroy the surface soil structure
• reduce the soil’s ability to absorb rainfall and withstand erosion
• reduce plant root growth.

Signs of soil erosion are often not as obvious as those of gully erosion. On sloping sites, exposed lateral roots and fine fibrous roots of trees indicate topsoil loss. Another indicator is erosion along the edge of the bare strip of newly planted rows after prolonged heavy rain. Note that in plantations over 15 years old, exposed roots are common, even on fairly level land where erosion is not controlled.

Soil chemical factors

A major problem in bare soil strips or under plastic mulches is that soils tend to become more acidic. Increased acidity reduces the soil cation exchange capacity (its ability to hold certain nutrients), which may lead to deficiencies, especially of calcium and magnesium.

Problems related to acidity appear to be worse on sites previously cultivated for other crops. These sites have already lost topsoil and been nutritionally depleted before the waratahs are planted.

Soil ecological factors

Waratahs probably have an optimum soil environment when decaying plant litter is retained under plants. In macadamias, which are in the same plant family as the waratah and have a similar root system, a mulch trial conducted by the former NSW Agriculture found a good as-

sociation between healthy trees, increased numbers of fibrous roots, and mulch in the form of nut husks.

Exposure of bare soil to high summer temperatures can decrease numbers of soil improvers such as microorganisms and earthworms. Earthworm activity also declines with increasing acidity and declining organic matter levels. The depletion of soil microorganisms and the decrease in earthworm activity may contribute to soil degradation in waratah plantations.

How to reduce soil erosion and other degradation

Three main ways are used to reduce soil erosion and degradation: controlling runoff, using mulches and growing groundcovers.

Controlling runoff

Experience shows that the traditional method of planting without mounding, combined with bare soil along the row, causes erosion problems, even on relatively flat land. Water runs down the stems and along the tree row, removing soil and exposing roots. As soil is removed, the row acts more and more as a drainage channel, increasing the rate of erosion.

To control erosion in waratah plantations, especially those on light sandy soil in high-rainfall areas, runoff must be controlled. The runoff problem is aggravated in mature plantations, where larger plants increasingly restrict the growth of groundcover by shading, making the bare soil more susceptible to erosion. Much of the land on which waratahs are grown in coastal NSW is unsuitable for the traditional runoff control measures of contour or diversion banks. Contour banks do not work in high-rainfall areas because they can be breached by heavy falls of rain. They can also pond water, which often leads to root rot. Contour banks make it difficult, if not impossible, to carry out routine harvesting and other mechanical operations, because working across the slope is dangerous.

The runoff control system that is easiest to build and that works most efficiently is to run mounded rows and associated drains directly downhill. An essential proviso is good ground-
cover in the inter-rows and drains to prevent erosion. The other important component of runoff control is the retention of grassed watercourses of sufficient capacity. Plants should not be planted in or immediately next to these. Runoff from the rest of the plantation can then be directed into these watercourses, and from there into dams for storage and later reuse.

In established plantations, remove plants already growing in natural watercourses and thus acting as erosion points, and grass the watercourse. The best time to do this work is September or October—after harvest—when kikuyu or other preferred species are about to resume growth and the risk of heavy, erosive rainfall is lower than at other times of the year. Suitable low-growing legumes or grasses adapted to shade can also be planted.

Build mounded rows to control runoff before planting. The best time is before the plantation is planted: it is easier and less expensive, and the drainage network can be planned and properly located. Also, permanent groundcovers are easier to establish over the entire plantation.

If you have not yet planted and have decided to build mounded rows, use the following technique:

- When making rip lines for planting, leave a 2-m gap every 15 to 20 m. This will help prevent erosion along the rip line.
- Excavate the cultivated soil in the centre of the inter-row area to a depth of 15 cm and place this soil in the proposed bush row, making a mound 30 cm above the low point in the middle of the inter-row.
- Sow the whole area immediately to an annual cover crop (such as ryegrass, which establishes quickly) or with species that will provide a permanent grass–legume sward. Only the spot where you are actually going to plant each waratah should be left clear of vegetation. If this area has revegetated before you plant your waratahs, spray the planting sites (0.5–1 m diameter) with herbicide. It is safer to use only contact herbicides (not residual herbicides) in this situation.

### Mulching

The practice of maintaining a continuous bare soil strip is undesirable. More growers are now using mulch or groundcovers to protect the soil, especially in young plantations. The general practice is to let inter-row swards bulk up before slashing and then to direct slashed material into the row. In older plantations you can mulch leaf litter and prunings in place each year and apply them to the beds.

Trial results with macadamia indicate that mulching can improve yield and tree health by helping to maintain or improve soil fertility levels, the activity of soil microorganisms, and the retention of soil moisture. Another benefit of mulching is that herbicide usage is reduced or is virtually eliminated.

Disease suppression also has been noted with the use of eucalyptus bark incorporated into the soil.

### Growing groundcovers

Low-growing perennial groundcovers such as kikuyu stabilise the plantation floor and reduce soil erosion. Trial results indicate that growing groundcovers between the rows is the most effective means of reducing runoff and erosion in mature plantations. Nutrient losses in runoff water are also reduced. During the harvest season, mow groundcovers to keep them short—this makes it easier to harvest flowers. Try to prevent groundcovers from flowering, as the flowers can harbour insect pests.

### Planting waratahs

Plant waratahs in early spring or early autumn. Waratah growth slows down in peak summer, especially where flower buds are forming, and again in midwinter. Space the plants at least 1.5 m apart; plant cultivars with proven high vigour 2 m or more apart. Close spacing results in weak plants, and few flowers will be produced. As plantations mature, effective pest and disease management becomes more difficult if plants are too close together. The spacing between beds will vary with the cultural methods and equipment to be used (for example, with the width of mowers or slashers).
Dig in 100 g of blood and bone or the equivalent of other slow-release organic fertiliser around each planting hole, but do not place the fertiliser in direct contact with the root system. Take care when applying fertilisers to young seedlings, as they are particularly sensitive, especially if their potting medium is low in nutrients.

Keep the original pot level at the same level as the surrounding soil. Water new plants thoroughly straight after planting and make sure they are kept moist (but not waterlogged) until the root system becomes well established. This usually takes 2 months when the plant is actively growing, but may take all summer and into autumn for a waratah planted in late spring or early summer.

One of the most common causes of the death of transplanted container plants or of failure to thrive is the grower’s failure to recognise when the root ball becomes dry. This can occur even when the surrounding soil appears moist, as moisture does not generally flow freely into the restricted root zone from the surrounding soil. Thus, check the root zone itself to determine when irrigation is required.

Unless soil drainage is excellent and good soil aeration can be maintained, it may be advisable to use a soil fungicide drench, at least initially, to minimise losses due to Phytophthora and Rhi zoboctonia. Most losses will occur in the first 3 months.

Good weed control is essential, especially while plants are young. Mulches, weed mats and (as the plants become larger) contact herbicides may be used. Take care with using glyphosate near waratahs, especially in very sandy soils. Also, do not use glyphosate to spray weeds whose roots intermingle with the waratah roots, especially on very sandy soils.

**Irrigation**

Although waratahs can be grown in the higher-rainfall areas without irrigation after establishment, additional watering may be required to produce high-quality blooms in dry springs and to minimise bract browning. You must check the quality of your water source (if it is river, dam or bore water) before planting. A testing laboratory can determine its suitability for irrigation, ensuring, for example, that it does not have high levels of salts. A plant health laboratory can test the water source for the presence of pathogens such as Phytophthora. If pathogens are found, a system of water disinfection (for example, by chlorination) may be needed.

Micro-jet irrigation with one nozzle per plant (or per two or three plants if rows are offset) has proven to be both satisfactory and reasonably economical, especially on sandy soils. In high-rainfall areas the roots will grow over the entire area, and trickle irrigation may be unsatisfactory, especially on sandy soils, where only part of the root zone may be wetted. In low-rainfall areas where roots tend to grow around the trickle outlet, a single outlet will be more satisfactory. On clay soils the water from the outlet is more widely distributed, but drainage may be impeded. This distribution problem may be at least partly overcome by using multiple trickle outlets per plant.

The amount and frequency of irrigation required will vary widely through the year. They will be influenced by factors such as location, stage of growth, rainfall and evaporation. Exact requirements can be difficult to estimate, and the amount of water applied will vary throughout the year. The crop will need to be monitored to determine exact requirements, but allow for 4 to 5 L/day/plant, especially in hot dry periods. On the Central Coast of NSW the most critical time of year tends to be before flowering in the spring, which is also usually the driest time of the year. A well drained soil will provide some protection against waterlogging and anaerobic conditions due to overwatering and heavy rainfall.

**Fertilisers**

Fertilisers must be used to achieve maximum growth rates and flower production, especially early flowering. It is important to supply a balanced range of nutrients at the appropriate rates (Table 1). However, waratahs also have a reputation of being sensitive to fertilisers in general, and especially those containing phosphorus (P).

**Leaf nutrient levels**

Table 1 shows a range of leaf analyses for waratah of different ages and growing in different
environmental conditions. It is clear that concentrations can vary widely, and actual leaf levels provide a poor guide to the actual nutrient status of the leaf. This is particularly evident for P. For example, Grose (1989) found that plants could have up to 4.7% P in their leaves and be showing symptoms of toxicity, yet they remained alive. In contrast, Cresswell and Weir (1997) suggested that 0.23% was excessive. Environment can have a significant effect. Clearly, more experimentation is needed before leaf analysis becomes a reliable guide to plant nutrient status.

Table 1. Waratah nutrition standards.

<table>
<thead>
<tr>
<th>Element</th>
<th>Youngest mature leaf blade below flower bud during dormancy of 2-year-old plants (Aug) (from Reuter and Robinson 1986)</th>
<th>Young plants (6 months old in pots) (from Cresswell and Weir 1997)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>1.3–1.6 excessive, 3.0+ (young shoots)1</td>
<td>2.0–2.75 low, &lt;1.2; normal, 1.2–2.83 (young shoots)1</td>
</tr>
<tr>
<td>P (%)</td>
<td>0.07–0.10; excessive, 0.83 (0.4 [high] to 4.7 [toxic] in field-grown plants 2)</td>
<td>0.09–0.23; high, &gt;0.23</td>
</tr>
<tr>
<td>K (%)</td>
<td>low, &lt;0.17; normal, 0.45–0.53</td>
<td>1.00–1.75</td>
</tr>
<tr>
<td>S (%)</td>
<td>0.20–0.26</td>
<td>0.23–0.35</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>0.39–0.53</td>
<td>0.53–1.10</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>0.12–0.15</td>
<td>0.20–0.34</td>
</tr>
<tr>
<td>Na (%)</td>
<td>0.013–0.058</td>
<td>0.02–0.07</td>
</tr>
<tr>
<td>Cl (%)</td>
<td>0.07–0.15</td>
<td>0.48–0.78</td>
</tr>
<tr>
<td>Cu (mg/kg)</td>
<td>2–3</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Zn (mg/kg)</td>
<td>8–9</td>
<td>20–30</td>
</tr>
<tr>
<td>Mn (mg/kg)</td>
<td>220–318</td>
<td>180–275</td>
</tr>
<tr>
<td>Fe (mg/kg)</td>
<td>50–90</td>
<td>30–40</td>
</tr>
<tr>
<td>Al (mg/kg)</td>
<td>175–380</td>
<td></td>
</tr>
<tr>
<td>B (mg/kg)</td>
<td>15–21</td>
<td></td>
</tr>
</tbody>
</table>

2. Grose (1989) found that optimal growth occurred at 0.4% P in the youngest fully expanded leaf, and toxicity symptoms (chlorosis) occurred at 4.7% P.
Visual symptoms of deficiencies or toxicities

The following figures show nutrient deficiencies and excesses (from Cresswell and Weir 1997, except Figures 11c, j, k and l).

Figure 11a. Nitrogen (N) deficiency—leaves pale and small (healthy leaf at top). A few leaves at the base of the stem senesce early, developing a brilliant red before falling.

Figure 11b. Sulphur (S) deficiency—S-deficient young leaves on right are pale green compared with oldest leaves (left). Light brown scorch can develop as the disorder progresses.

Figure 11c. Phosphorus (P) deficiency—purpling of leaves in severe cases.

Figure 11d. Manganese (Mn) toxicity—young, mature and old leaves from a plant receiving excess Mn: uniform, yellow-green chlorosis of the youngest leaves and marginal burning of the oldest leaves.
Figure 11e. Phosphorus (P) toxicity (mild)—the first indication of P toxicity is a lime green ‘iron’ chlorosis of the youngest leaves (two leaves at the left). As the condition progresses, the tip and margins of the oldest leaves lighten and then develop a red-brown necrosis (leaf on far right).

Figure 11f. Phosphorus toxicity (severe)—leaves from a plant at an advanced stage of P toxicity have burned and yellowed from the margins.

Figure 11g. Potassium (K) deficiency (severe)—K deficiency produces a reddish-brown necrosis of the tip, and margins of the oldest leaves become pale green.

Figure 11h. Boron (B) deficiency—light brown necrotic lesions develop between the veins of recently matured leaves, which remain dark green.
Figure 11i. Zinc (Zn) deficiency—Zn-deficient leaves (right) compared with healthy leaf (far left). Younger leaves of Zn-deficient plants are small and distorted. The region near the leaf tip becomes chlorotic, contrasting strongly with the dark green of the remainder of the blade.

Figure 11j. Leaf miner (this may be confused with toxicity symptoms).

Figure 11k. Effect of root dysfunction. Leaf chlorosis (yellowing) is common in waratahs. Although the result is an iron deficiency, it may be caused by a wide range of conditions in the soil besides a soil deficiency, which is rare. A wide range of conditions, such as high pH, high soil P, anaerobic conditions (which may lead to an excess of Mn ions) and root rots due to disease may restrict the uptake of iron. Leaf analysis is not always a reliable guide to an iron deficiency: the iron may be present in the leaf but immobile, and the outside of leaves is often contaminated by iron in dust or soil splash.
Phosphorus and the waratah

Phosphorus has been implicated in the deaths of many plants, often without justification. However, a plant’s response to applied P is a complex situation. There is little doubt that waratahs can respond well to applied P in terms of both growth and flowering. Relatively high rates of P fertilisers are usually necessary for good growth of nursery and plantation waratahs (for example, Goodwin 1983, Nichols and Beardsell 1981, Nixon 1987, Worrall 1983). Such levels of P are within the range considered to cause toxicity problems in many P-sensitive plants.

Waratahs are also reputed to be sensitive to applied P, which in some circumstances can kill plants even at relatively low levels (for example, Goodwin 1973, Grose 1989) This is especially true if the P is applied immediately after transplanting into the field (Burnett 1993).

To understand this apparent contradiction, and to manage P application at levels necessary to support healthy plant growth without the risk of toxicity, it is necessary to understand the mechanism of uptake of P by the plant and the factors that influence the availability of P in the soil.

Cluster roots and mycorrhizae

The waratah evolved in soils very deficient in P by world standards, and it has developed a particularly effective mechanism for extracting P from the soil, namely cluster roots (Figure 10). Cluster roots are dense clusters of fine roots whose function appears to be to help the plant absorb nutrients from the decaying organic matter in its natural environment. They were first discovered in the family Proteaceae (of which the waratah is a member), and thus were originally called proteoid roots. Since then they have been found in other families, including, for example, lupins and flannel flowers, so they are now generally called cluster roots. No particular microorganism appears to be associated with their formation. The practice by some growers of adding organic matter or soil taken from around other Proteaceae to waratahs is not necessary for their formation, either in pots or in the field. This practice may instead reduce plant growth (Lamont 2003) and spread soil diseases.

Cluster roots are thought to have a particularly important role in the P nutrition of the Proteaceae, as these plants generally occur in soils with low levels of available P. Organic com-
pounds released from the cluster roots increase the availability of cations (especially cations of Fe and Mn) and phosphates to the plant (Lambers et al. 2009). If phosphate ions are available to the plant in the growing medium at high levels, then the formation of cluster roots will be partially suppressed. This is presumably a feedback mechanism to help prevent excessive uptake of P by the plant. Take care in applying fertilisers to plants grown at low levels of nutrients. These plants will often have extensive networks of cluster roots that are primed to take up nutrients, especially P. Gradually increasing nutrient levels will reduce the production of cluster roots (which have an effective life of about 2 weeks), thus helping to avoid toxicities.

High levels of N, especially in combination with P, can inhibit cluster root formation. Thus, available N can reduce the toxicity of P in the soil by inhibiting cluster root formation. Added potassium (K), however, does not have this effect. If there are few cluster roots present, or if they are very small, then excessive N or P has probably been added to the soil.

Cluster roots are very susceptible to attack by Phytophthora and perhaps other fungi that cause root diseases, such as Rhizoctonia. Addition of high levels of N to the soil, but not P or K, makes waratahs very susceptible to root diseases (Worrall 1986).

Mycorrhizae are fungi associated with the root systems of many plant species that can improve the uptake of P and other nutrients, especially in deficient soils. In general, members of the Proteaceae do not have mycorrhizae, but there are conflicting reports for waratah (e.g. Bellgard 1991, Boulet and Lambers 2005, Wenzel et al. 1994). Certainly they have occasional colonisation of roots in the wild, but the importance of this colonisation is unknown. The addition of mycorrhizae to roots does not appear to improve growth and may actually reduce it.

The interaction of cluster roots (and possibly mycorrhizae) with the roots of the waratah is complex and requires more investigation because of the cluster roots’ important role in plant nutrition and possibly root disease.

**Soil availability of P**

The form of phosphate is important in determining its availability to the plant. Generally, the more available it is, the more toxic it can be. Toxicity can be reduced by building up P soil levels with small, frequent applications of the more readily available fertilisers, for example, through fertigation (application of nutrients through the watering system). The availabilities of some commonly used forms of P fertiliser are given below.

- **Readily available P:** liquids used in fertigation; for example, phosphoric acid, monoammonium phosphate, dipotassium phosphate; triple superphosphate.
- **Less readily available P:** single superphosphate—a mixture of readily available and slow-release P. Finer material is more readily available than coarser material.
- **Slow release P:** manufactured slow-release fertilisers; for example, Osmocote, Nutricote (release rate depends on formulation; low-P formulations are also available); rock phosphate (slow release over an extended period); blood and bone meal (slow release); P in composted organic materials (usually slowly available, although there can be exceptions, such as mushroom compost, with which care should be taken if large amounts are used).

Clay and some forms of iron and aluminium may also reduce the availability of P by fixing it in the soil, and may thus reduce toxicity. The rate of leaching of the soil can also have a large effect in P removal, especially if the P is not fixed. However, as P is usually less readily leached than N or K, it can accumulate in soils to high levels. In short, the probability of P toxicity is highest when the P level is suddenly increased from a low concentration by applying P in a readily available form, especially for waratahs growing in P-deficient sands containing little clay. This usually also applies to pot-grown plants, as most modern potting mixes have little capacity to fix P.

**How much P fertiliser to apply?**

For field application, Nixon (1987) recommends adding 2 to 5 g per m² of root zone per year (20–50 kg/ha/year) of P in a slow-release form, split over several applications when the plants are actively growing. The actual rate will depend on the soil type and losses through
leaching, erosion, pruning of stems and removal of flowers, and uptake by cover crops. P is generally more resistant to losses than N or K, and so it will more readily accumulate in the soil. Use leaf analysis as a guide to the availability of P in the soil. Suggested levels are given in Table 1. The ratio of nutrients is often more important than the absolute levels. This is discussed in more detail in the next two pages. A soil level of about 30 ppm available P appears to be satisfactory.

Summary
To minimise the chance of P toxicity and allow sufficient P for good growth:

- Increase the level of available P slowly, especially if the plants are initially deficient in P and have developed an extensive cluster root system.
- Use slow-release P sources, or apply readily available forms in small doses over an extended time or throughout the growing season, for example by fertigation.
- Ensure that excessive P does not accumulate in the soil: soil analysis is a good idea, especially before planting a crop.
- Use leaf analysis to determine whether plants are taking up excessive P.
- Ensure that adequate amounts of other nutrients are present in the soil. If there is a deficiency of another element, growth may slow, leading to excessive P levels in the leaf, as the rate of P uptake does not slow down. In actively growing plants, leaf P concentration will be reduced by dilution. Leaf analysis can be a good guide to what is happening in the plant.
- Learn to recognise symptoms of P toxicity and deficiency in your plants. However, remember that when visual symptoms are apparent, growth will already have been severely reduced.

Overall, especially when compared with other Australian native plants, the waratah must be classified as not particularly sensitive to P. It responds favourably to the addition of P fertilisers, although care must be taken in the method of application.

Nitrogen and the waratah
Nitrogen (N) is an important component of waratah leaves (Table 1). Waratahs require about 15 times as much N as P. This is within the range found within most ‘normal’ plants. As with P, additional N is normally required for optimal growth and flowering in waratahs. In practice, N fertilisers do not seem to be implicated as often in the sudden death of waratahs as are P fertilisers. However, trials have shown that excessive N fertiliser can make waratahs much more sensitive to root diseases, although the effect on leaf N levels is minimal (Worrall 1986). In one trial, where waratahs were grown in their native soil, additional N fertiliser applied at a relatively low level caused high mortality, whereas gradual addition of P fertiliser, even to very high levels, did not. This was despite no significant accumulation of N in the soil, whereas the final available P level was 130 ppm. In another pot trial, excessive N also made the plant roots more susceptible to Phytophthora.

Nitrogenous fertilisers can reduce P phytotoxicity by:

- suppressing the production of cluster roots, hence reducing the uptake of P (the effect of high levels of N and P in suppressing the formation of cluster roots is synergistic: that is, both act together to suppress their formation more than either alone)
- diluting the P in the plant through increased growth; note that other nutrients will also have to be supplied at adequate levels.

Form of nitrogen
Ammonium-N is much more readily taken up by the waratah than nitrate-N. It is also far more effective at suppressing cluster root formation than nitrate-N. Thus, for effective N fertilisation, the N should be supplied in a form that either contains ammonium or breaks down to form ammonium (e.g. organic matter or urea). Take care that the pH of the soil or growing medium is not greatly reduced, as ammonium fertilisers used by themselves can significantly lower soil pH (making them acidic).
How much N fertiliser to apply?

Nixon (1987) recommends 15 to 20 g/m²/year (15–20 kg/ha/year) of N applied in a slow-release form, split between the growth flushes in spring and autumn. A range of fertilisers are suitable; for example, coated fertilisers or organic materials. If immediately available fertilisers such as urea or ammonium nitrate are used, apply only small amounts at any one time; for example, through fertigation. It is essential to monitor soil pH and compensate for any large decrease by adding liming materials.

The above is only a recommended starting point. Leaf analysis is one of the few ways of accurately determining whether sufficient—or excessive—N fertiliser has been applied. Soil analysis is usually not a good indicator, as N is usually readily lost from the soil, especially in high-rainfall areas.

Other fertilisers

Waratahs contain K at the same P/K and N/K ratios as most ‘normal’ plants if supplied with adequate K fertiliser. However, K (unlike N and P) appears to have little effect on the production of cluster roots or the prevalence of root disease. In experiments with potted waratahs there was also little response to applied K fertiliser when plants were grown in their native soil over an 18-month period (Worrall 1986). In the long term, however, application of K fertilisers is advisable, especially if the root zone is restricted, for example in potted plants. Leaf standards (Table 1) can be used for monitoring whether leaf levels of K are adequate. Nixon (1987) suggests applying 5 to 10 g/m²/year (5 to 10 kg/ha/year) of K fertiliser.

Other nutrients (for example, calcium, magnesium, iron) are also essential for maintaining healthy growth in waratahs, although specific requirements have yet to be identified. Complete fertilisers with added trace elements or organic fertilisers will help to maintain soil levels of the other essential elements. See the leaf standards in Table 1 to determine whether leaf levels are in the normal range. Seek advice about corrective action from professionals if levels are outside this range.

To maintain adequate uptake of nutrients by the plant, the pH of the soil or growing medium should be 5.0 to 6.0 (although waratahs can tolerate a pH ranging from 4.5 to 6.5). Add liming materials if the pH falls too low. Poor root health may also result in deficiencies of nutrients, especially iron. Iron deficiency will commonly occur where the soil is waterlogged or the roots have been damaged by disease. The symptoms of iron deficiency are a distinctive yellowing of the leaf (see Figure 11k).

When to apply fertilisers

Apply fertilisers when plants are actively growing, especially those readily lost from the soil (for example, N and K). Waratahs generally have two major growth flushes per year. These usually start just after flowering in the spring and at the end of summer. In some instances, however, such as in young plants being propagated in greenhouses or on the North Coast of NSW, growth may occur for much of the year, requiring a continuous supply of nutrients. In any case, if plants are being grown for cut flowers, avoid fertilising—especially with N—immediately before flowering, as it may increase the incidence of grow-through, where shoots grow past the flowers and make the stems unmarketable.

Using mixed fertilisers

Normally, mixed fertilisers are used because of convenience. Nichols and Beardsell (1981) recommends applying a total of 100 g/m²/year (1000 kg/ha/year) of a general mixed fertiliser with an N content of 15% to 20%, a P content of 2% to 5%, and a K content of 5% to 10%. Exact ratios are not important, as most plants can tolerate a wide range of ratios. Usually, however, P will accumulate in the soil more than N or K. Thus, as time passes, the P proportion will almost certainly need to be reduced. The only way of determining by how much is to perform leaf and soil analyses.

How to apply fertilisers

Fertilisers need to be applied to the active root zone to be effective. In higher-rainfall areas the root zone will be spread out. In lower-rainfall areas, in contrast, the root zone will be concentrated around irrigation outlets. In the worst
case situations—such as the use of single drip-pers on a light sandy soil in a low-rainfall ar-ea—the root zone may be restricted to a small area around the dripper. In this instance, ferti-gation may be the best method of applying fer-tiliser.

In higher-rainfall areas solid fertilisers can be applied directly to the soil surface if weed mat-ting has not been used. Physical incorporation is usually not necessary if there is no signifi-cant surface erosion, but the fertiliser should be well watered in. However, take care with slow-release fertilisers such as Osmocote and Nu-tricote applied directly to the soil surface: their release rate is controlled by temperature, and the soil surface may become very hot (up to 60 °C) in direct sunlight, causing rapid release. The effect is greater when the fertiliser has been freshly applied. These fertilisers need to be incorporated into the soil.

Also take care where wood-based mulches (such as wood chip) or other materials with a high C/N (carbon to nitrogen) ratio (such as wheat straw) have been used. Fresh material can take up a lot of N when it breaks down. Additional fertiliser—especially N—may have to be applied.

Weed matting presents special problems. The only satisfactory method of fertilisation when weed mats cover the soil is by liquid fertiliser or fertigation. Solid, insoluble fertiliser will sit on the surface and not be available to plants. Fertiliser may be placed in a band at the edge of the weed mat, but it will be more readily avail-able to inter-row plants (grass and weeds). As a compromise, some growers use a band of mulch along the centre of the bed where the plants are growing, which allows direct place-ment of solid fertiliser between narrow weed mat strips on either side to control weeds.

**Mulches**

Besides controlling weeds and soil erosion and helping to preserve soil moisture, organic mulches can contribute a range of nutrients to the soil, depending on their composition. Through the action of soil organisms that feed on them (for example, fungi, bacteria and earthworms), they can greatly improve the soil structure and its ability to hold soil nutrients. In addition, the increased biological activity may help to control some soil pathogens.
Pruning

Regular pruning of the plants is essential. Nixon (1987) defines three forms, and discusses them in greater detail than we do here:

Initial pruning

Plants should be tip-pruned 2 weeks before or 2 weeks after planting and need to be pruned in the first year or two of growth to establish a multi-branched shape. This may delay flowering, but it will greatly increase subsequent yields. Nixon (1987) recommends autumn pruning for the first 2 years.

Annual pruning

During or immediately after harvesting, prune off excessive growth and weak stems. The aim is to produce flowers with stems at least 80 cm long for the next flowering season. If a large number of shoots are left on the plant, flowers will be of poor quality and have short stems. Thin, weak stems also produce few flowers. Some may actually produce duds with red bracts which then revert to the vegetative form without producing flowers. However, avoid pruning too heavily, as this will weaken the plant. Do not remove more than about ⅓ of the plant, unless you are rejuvenating. Pruning later in the season, especially after January, may remove next year’s flowers.

Rejuvenation

Every 10 years the plants should be severely pruned, mainly to reduce the overall height for easier picking and to encourage longer stems. As this will reduce the flower yield for the next 2 or 3 years, carry out severe pruning on a rotational basis in the plantation. Cutting-grown plants and seedlings are generally pruned differently. Seedlings have a lignotuber just below ground level. This is a disc-shaped structure from which multiple shoots can arise. Its function in the wild is to help waratahs to survive bushfires, when all the above-ground part of the plant is destroyed. Therefore, for rejuvenation, plants grown from seedlings can be cut back to ground level, as the plant will regenerate from the lignotuber. Cuttings do not have lignotubers (although some do produce lignotuber-like structures), so enough of the above-ground stem must be left for dormant buds to grow if the lignotuber-like structures are not present.
Pests, diseases and disorders

Pests

Flowers and foliage are often damaged by insect pests, which, besides greatly reducing the value of the bloom, may also cause problems in export shipments. One of the most serious and difficult-to-control pests is the macadamia bud borer. It damages flowers by burrowing into them at the bud stage. The insect appears to be most active in the spring and then again in late summer to autumn as buds are developing. Therefore, protective spraying of the plants needs to take place in late spring and early summer to protect the newly emerging vegetative shoots and again in later summer to early autumn as the flower buds begin their development.

Bud borer and scale insects, two of the most serious pests in waratah, are discussed in detail in Appendix 3.

Diseases

The main diseases affecting waratahs are caused by Phytophthora and related species such as Pythium and Rhizoctonia. Phytophthora is a fungal disease that causes root and collar rots. It is extremely difficult to eradicate from infested soil or plants, so prevention is better than cure.

In eastern Australia, Phytophthora is endemic to many areas. Good soil aeration is essential to reduce losses through root diseases. To reduce losses, choose a site with well drained soil. To further improve drainage, plant in raised beds. Ensure that you buy disease-free plants. Phytophthora is also favoured by temporary waterlogging, which can occur during periods of high rainfall. It is spread by moving water and splashing of soil. Contaminated footwear, water, vehicles and tools can also spread it. Don’t allow potted plants to touch contaminated soil: keep pots on raised benches.

Various laboratories will test soil and water samples for the presence of Phytophthora. If your plantation site seems to be free of Phytophthora, take care not to introduce it via unsterilised soil or potting mix, in contaminated equipment, or in later plantings. Phytophthora can be introduced via nursery stock and irrigation water, especially if you source your water supply from creeks, rivers or dams. You may need to disinfect the water before use, for example by chlorination.

Plants that are stressed by poor nutrition, weed competition or lack of water are more susceptible to diseases like Phytophthora. Do not use plants with root systems that are pot-bound. Over-watering of seedlings and young plants can make them more susceptible to root rot diseases.

Take care not to introduce Phytophthora in later plantings. It is a good practice to wash a few plants from their pots and check the roots for signs of disease. Whenever you introduce new plants to your plantation, drench them with a suitable fungicide and observe them for a few days before planting out.

Waratahs also suffer from leaf spots caused by a range of fungi, especially Phyllosticta teleoae (apparent as greyish brown leaf spots). Management practices to reduce their severity include reducing humidity in the canopy, removing old leaves, and spraying with appropriate fungicides.

Botrytis or grey mould (caused by the fungus Botrytis cinerea) can be a serious problem near and after harvest. The fungus can lie dormant in leaves and flowers and become a problem under conditions of free moisture and cool temperatures. You may need to dip flowers in an appropriate fungicide before packing, to lessen risk of losses due to grey mould. This is especially critical with export shipments.

Bract browning

A common defect of waratah blooms is browning of the bracts, especially the tips. This is also called bract burn. Severity varies between years and with variety grown. Bract browning can be a major factor in reducing market quality, in terms of both visual appeal and potential vase life. Flowers with significant damage can be unmarketable, especially in export markets.
Bract browning is usually far more obvious, and therefore more serious, on light-coloured flowers, especially whites. Whites and pinks are far more susceptible and the browning is far more obvious on the light-coloured background. Deep red bracts tend to mask the browning. Some varieties, regardless of colour, also appear to be far more susceptible. Obviously, varieties with smaller or no bracts will be less affected, although the individual flowers within the flower head itself may also suffer from browning, especially the whites and pinks.

Both the protective bracts enclosing the flower buds before opening and the large floral bracts surrounding the inflorescence can suffer from browning. Browning of the protective bracts is more common but less serious, as they are partly or fully obscured by the inflorescence when it opens. The very tips of the larger floral bracts may also be damaged before opening, but the more obvious and thus more serious damage generally occurs after the inflorescence opens. In extreme situations the inner individual flowers may also become brown.

The basic cause of bract browning is not known, but its incidence appears to be related to environmental conditions, especially water stress. To minimise browning, avoid water stress during bud development and especially just before bud opening. Wind and sun also contribute to bract browning, so windbreaks for protection from strong winds may be advisable in some locations. It has long been recognised that light shading (for example, by trees in their natural habitat) will improve the quality of the flowers. A few growers have invested in shade houses (15% to 30% shade) to protect their waratahs from both sun and windburn. The increased prices for the flowers, especially the whites, can make this a viable economic proposition. Take care, however, not to provide too much shade, as the number of flowers will be severely reduced. Nutrition may also play a role in bract burn, but the detailed interactions are yet to be defined. Bract browning occurs towards the end of flower development (from August onwards), rather than at bud set (December–February) (Martyn et al. 2007).

Condensation on the bloom in the early morning may also predispose the bracts to browning, especially on the side first exposed to the sun. Growers have observed that bract browning tends to be more apparent on the northern side of the bloom. Protection from the early morning sun may help to reduce this effect. Also avoid overhead irrigation at this time of day.

Stockings placed over mature buds until they open have been reported to greatly reduce bract browning, as well as insect and bird damage. This, however, may result in a slightly lighter flower colour, which may be desirable in the case of pinks and whites, but not reds.

To minimise bract browning:
- grow less susceptible varieties or colours
- protect flowers from the wind
- grow under light shade, or cover the developing flowers with a light fabric (e.g. stockings)
- maintain adequate soil moisture levels, especially after buds have opened
- maintain an adequate and balanced supply of nutrients.
Harvesting

Waratah flowers need to be treated with the same care that other cut flowers generally require. Poor handling will reduce both quality and postharvest life. Drying out of flower stems is a major cause of losses after picking and of reductions in vase life.

Stage of harvest

Best storage and subsequent vase life will be obtained if blooms are cut when the central flowers are fully formed and up to 5% of the individual flowers on the head have opened (Figure 8). For most *T. speciosissima* selections in which the flowers open on the outer rim of the head first, no more than the outer ring of flowers should be open, and preferably less. When harvested at this stage the flowers have a vase life of about 13 days at 20 °C, although some may have a vase life significantly shorter than this, and others have a vase life of up to 17 days. If more of the individual flowers making up the inflorescence are open, the subsequent vase life will be proportionally reduced. Blooms picked at a more immature stage will not develop properly. Bracts should be fully open (reflexed) at harvest, and many buyers prefer that they cup the flower head (Figure 12).

Figure 12. Waratah flower at the optimum stage for harvest.

In contrast, hybrids express characteristics of both parents. Florets of *Telopea oreades*, *T. truncata* and *T. mongaensis* tend to open from the top or middle of the inflorescence, unlike *T. speciosissima*, which always opens in successive rows from the bottom. The hybrid flower behaviour can be like either species parent, meaning that some hybrids behave like *T. speciosissima*, with florets opening from the bottom, but others will open from middle to apex, especially on the side towards the sun. The latter rule applies to the hybrids *T. ‘Golden Glow’* (syn. ‘Shady Lady Yellow’) and *T. ‘Champagne’*.

*Telopea* hybrids and *T. speciosissima* show other common differences too:

- The total number of florets is usually less in hybrids, but the overall inflorescence diameter may be the same as in many smaller *T. speciosissima* selections. Hence, they should probably be marketed as individual stems rather than bunched.

- Perianth behaviour is different. *Telopea oreades*, *T. truncata* and *T. mongaensis* all have perianths that split and later break and shatter as the flower ages, tending to fall off and leaving an open spidery appearance similar to a leucospermum flower head. In contrast, *T. speciosissima* perianths tend to remain attached and wither.

For these hybrids, best storage and subsequent vase life will be achieved if flower stems are picked when approximately 40% of the total florets are open, or if there is no perianth shatter (that is, no flower parts fall off when the stem is given a light shake). Growers are advised to check the vase life of individual selections before planting large numbers of hybrid waratahs.

More information can be found in Gollnow and Worrall (2010).

Besides a shorter vase life, other problems will become more serious if a large number of individual flowers have opened. The opened flowers produce significant amounts of sugary nectar, which accumulates on the stigma surface. Insects find these opened flowers very attractive, and their numbers inside and around the heads will greatly increase. The exudates also encourage the development of botrytis.

For heads with a large number of opened flowers, swinging and flicking the head downwards
will remove most of the nectar and many of the insects. Dipping in water or a registered fungicide/insecticide solution and then allowing to dry, preferably in a cool room, may be necessary to remove copious nectar. It will also remove a portion of the insects.

For more complete disinfestation, especially for export, use the fungicidal and insecticidal dip described on page 31. Remember, however, that the dip does not guarantee a 100% kill of insects, so it is important that insect numbers be as low as possible before treatment to minimise the possibility of any surviving.

Figure 13. Typical effect of initial score (% of open flowers on the head) on the subsequent vase life of inflorescences of seedling-grown *T. speciosissima* (Worrall 1986).

(a) System for scoring the maturity of waratah blooms by the percentage of individual flowers that are open.

<table>
<thead>
<tr>
<th>Score</th>
<th>Stage of development (% styles reflexed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0–5</td>
</tr>
<tr>
<td>1</td>
<td>6–25</td>
</tr>
<tr>
<td>2</td>
<td>26–50</td>
</tr>
<tr>
<td>3</td>
<td>51–75</td>
</tr>
<tr>
<td>4</td>
<td>76–94</td>
</tr>
<tr>
<td>5</td>
<td>95–100</td>
</tr>
</tbody>
</table>

(b) Relationship between vase life and initial score at 20 °C for seedling-grown waratah: the higher the initial score (i.e. the greater percentage of open flowers), the shorter the vase life.

Stems

Use sharp blades to cut stems; do not snap them. Normally waratahs are picked with minimum stem lengths of 50, 60, 80 or 120 cm. The market price of waratahs is strongly related to stem length. For the best market returns, pick blooms with stems at least 80 cm long. However, cut the stems with future yields in mind. It is also usually more efficient to prune plants when harvesting flowers and cut off excessive stem length when grading than to return to the plant a second time to prune. There is a market for smaller flowers for use in bouquets, usually at a much reduced price. See your wholesaler for the current state of the market.

Stems should be relatively straight with no more than a 15° bend. Thickness should be proportional to the flower. Normally the stem should be 12 mm or less in diameter, except with some very large varieties.

Leaves

Leaves should be blemish free. Remove leaves from the bottom ⅔ of the stem and any damaged leaves or bracts. Take care when removing leaves. A sharp snap downwards holding the thumbnail at the base of the leaf stalk will usually work. However, if they do not come away freely when pulled, cut them to avoid excessive damage to the bark and stem.
Faults

There should be no regrowth (called bypass shoots) from the flower head (Figure 14). Cut off any small shoots. Deformed and asymmetrical flower heads and multiple flower heads are also considered defects. Other factors affecting price are flower shape and size, freedom from blemish, and the numbers of waratahs on the market, particularly early and late in the season.

For fully developed blooms, the more individual flowers that are open, the shorter the vase life. Flowers and leaves should also be free of visible spray residues and pests and diseases. They must also be free of non-pest species such as spiders.

Water stress

One of the most common causes of poor post-harvest life is drying out of the blooms. Drying out causes ‘blueing’ and wilting of the flower head. To avoid this the crop should not be stressed when the flowers are cut. If necessary, irrigate before picking. Picking in the early morning is usually the best, and it is usually cooler as well. Placing immediately into water (at least 5 cm deep) after cutting is recommended. Pick stems straight into clean buckets filled with clean, high-quality water (for example, rainwater) and protect from direct sun. Transport the flowers to the packing shed as soon as possible, and cool them quickly.
Postharvest handling

Storage

Hold waratahs at about 2 to 4 °C until you are ready to grade and pack. A lower temperature (1 to 2 °C) is better for long-term storage, but storage at close to 0 °C requires very accurate control of the cool room temperature to ensure that flowers do not freeze.

Take care that the flowers do not dry out, as this will reduce both quality and vase life. Cover them with plastic, or use humidifiers to keep the relative humidity (RH) as close to 100% as possible. Cooling coils in cool rooms will naturally reduce the RH as they must be below room temperature, so water condenses on them, drying out the air. If waratahs have a large number of large leaves on a marketable stem they will be vulnerable to drying out. For export product, reducing the number of leaves on the stem may help. If you are storing or shipping flowers, use a plastic liner in the box to prevent drying out, but take care not to block the vents used for forced-air cooling.

Good-quality flowers can be stored for about 1 week with an acceptably low (<20%) loss of vase life (Figure 15). Lill and Dennis (1986) found that storage at 2 °C for 4 days actually increased the subsequent vase life of waratah blooms from 7 to 15 days (at 18 °C). The vase life after storage was comparable to that of fresh blooms tested by Worrall (1986). The reason for the increase in vase life after storage is not known, but the cold storage may correct some physiological stress experienced by the flowers before storage. Further trials at low storage temperatures to further examine this effect seem warranted.

Faragher (1986a) found that storage at 2 °C and 100% RH for 2 weeks did not reduce vase life, yet storage for 4 weeks reduced it from about 8 to 4 days. Again, the vase life after 2 weeks was comparable to that found by Worrall (1986). However, while the fresh blooms assessed by Worrall (1986) had a vase life of about 12 days, those assessed under almost identical conditions by Faragher had a vase life of about 8 days. The latter had between ¼ and ⅓ of the individual florets opened and were placed directly into water.

Managing postharvest diseases and insects

The most common cause of fungal decay in storage is the grey mould fungus (*Botrytis*). This especially grows on nectar produced by the individual flowers, but can also infect the leaves later, leading to complete loss in storage. *Botrytis* reduces flower quality and vase life. This is especially critical for export, where *botrytis* may develop in transit. *Botrytis* can be present as a latent infection—that is, with no apparent symptoms. Under favourable conditions such as high humidity (which is common when flowers are wrapped in plastic, especially if refrigerated storage is not continuous), the disease can develop rapidly. It is strongly recommended that any flowers that are to be packaged and stored for any significant length of time (for example, for export) be dipped in an appropriate fungicide.

To reduce the chance of live insects being present in flowers after harvest, aim to control them in the field before harvest. This also reduces the numbers of unsightly dead insects—especially scale insects on marketed stems. Disinfesting the large and complex waratah flower heads to remove insects and spiders deep inside can be difficult. However, it is especially important to ensure that flowers to be exported are thoroughly disinfested; you may need to consider a postharvest insecticide dip.
An APVMA minor use permit (PER 12785, expires 30 June 2016) allows the use of insecticide and fungicide postharvest dips for wildflowers. The permitted insecticides are Cislin Residual Insecticide, Barmac Delta Force Insecticide and Insectigone Insecticide, which contain 10 g/L deltamethrin as the only active ingredient. The permitted fungicides are Rovral Aquaflo Fungicide and Farmoz Civet Aquaflo Fungicide, which contain 500 g/L iprodione as the only active constituent. The permit and labels give the rates to be used and the duration of dipping. You can download a copy of the permit from www.apvma.gov.au.

Do your own disinfection trials to see whether the products work in your situation. Check to see that the insecticide kills the insects and that there is no damage to the flowers.

Some growers also use fumigants as an added insurance against live insects. To date, only the fumigant methyl bromide is close to 100% effective against insects. However, it may damage the flowers, and its use is being phased out worldwide.

**Ethylene**

Waratahs do not normally produce high levels of ethylene. However, they are sensitive to very high levels of external ethylene, but unlike the case with many other ethylene-sensitive flowers, anti-ethylene treatments do not appear to extend their vase life. Do not store waratahs with strong sources of ethylene, such as other flowers and fruit, especially if these are ageing.

**Postharvest solutions**

Biocides can be added to postharvest to solutions to help prevent stem plugging and to maintain water uptake by the flowers. However, these may or may not actually extend vase life, depending on the conditions. Under conditions of low evapotranspiration (e.g. high RH, low wind speed), the amount of water lost does not shorten vase life. But under conditions of high evapotranspiration, vase life may be shortened appreciably. A wide range of floral preservatives has been tested on waratahs, but to date none has greatly improved vase life when high-quality water has been used to make up the solutions. Avoid using sugar in pulsing solutions, as it has little effect on vase life but will greatly increase susceptibility to stem blocking and botrytis because of greater nectar production from the individual flowers as they open.

Given the tendency for woody stems to become blocked after cutting, using reputable commercial postharvest solutions that reduce stem plugging by acidifying the water and reducing microbial growth may enhance vase life under adverse conditions. Trimming 1 cm from the base of the stem daily may help to maintain water uptake.

**Packaging**

Flowers of similar length and quality should generally be boxed together.Normally the price will be determined by the poorest-quality flower in the box, so accurate grading is important. Transport is a very significant part of the cost of marketing waratahs overseas. It is important to pack the flowers as densely as possible without damaging them. This will increase the returns per flower for small-headed and small-stemmed flowers compared with larger flowers. There may be a market for stems of mixed length because of the greater packing densities possible, but check with your marketer first.

Keep the loss of water to a minimum. If boxes do not have a vapour barrier (plastic coating or waxing), then line them with plastic. However, the boxes should have holes at the end to allow forced ventilation and fumigation. Do not block the holes with the liner.

Forced-air cooling after packing is important. Large boxes or stacked boxes will take many hours to naturally cool to the temperature of the cool room, significantly reducing possible storage times and subsequent vase life.

**Labelling**

Label each box or unit on the end with stem length, count, variety (especially colour), grower (identification code) and shipping details. Tag the boxes as appropriate (for details of National Parks and Wildlife Service tagging regulations see ‘Legislative requirements’ over.)

More detailed information on labelling can be found in Faragher et al. (2010).
Wildflower Industry Network (WIN)

The Waratah Industry Network (WIN) was established in July 1995. Its goal was to provide a forum for waratah growers, wholesalers, exporters, florists, breeders, propagators and researchers to develop and implement a strategic plan for the development of waratah as a commercial crop. WIN linked waratah growers together through a newsletter and farm walks. In 2011 the network changed its name to Wildflower Industry Network NSW Inc. to reflect the broader interests of its members.

WIN is also involved in supporting key events to promote waratahs. The annual Waratah Festival (held at Mount Tomah Botanic Garden) promotes cultivated waratahs to the general public. It also includes a competition open to growers, and WIN funds an annual award for the champion waratah bloom. Already the Festival has influenced local florists to seek out cultivated blooms for their shops.

WIN may be contacted through Frank Allatt (fallatt@bigpond.net.au).

Legislative requirements

Some Australian native species, including waratahs, are protected in the interests of protecting rare and endangered species and of protecting species diversity and ecological sustainability. Various state and territory authorities administer legislation that restricts the commercial use of these species, and a number of legislative requirements apply to the production, sale and export of waratahs. These may change from time to time. It is your responsibility to check current requirements.

Protected Native Plant licences

The waratah is a protected native plant, and a licence is required to grow it for commercial purposes. In NSW, the Protected and Threatened Plants in the Cut Flower Industry management plan includes details of licensing affecting waratah growers. To ensure a sustainable and viable population of Telopea species, no licences are being issued for wild-harvested or bush-picked waratahs. Licences are available from the Wildlife Licensing and Management Unit of the National Parks and Wildlife Service (NSW Office of Environment and Heritage): for current details see www.environment.nsw.gov.au and search for 'plant licensing FAQs'. Apply to your local NPWS district office.

In addition, the Australian Government requires that growers and exporters have permits to export certain native flower products, including waratahs, and insists that state regulations be complied with. Export permits may be required by the Australian Department of Sustainability, Environment, Water, Population and Communities (DSEWPC; see www.environment.gov.au), AQIS and the Australian Customs and Border Protection Service.

Export permits are required in order to export flowers derived from native species not included in an exempt list. This requirement is designed to protect and manage nationally and internationally important flora, including endangered species. Permits need to be obtained by the grower or exporter, and a fee applies. Some growers report that freight forwarders can assist them with export permits.

Some flowers may be exempt from this requirement, including those protected in the Plant Breeder’s Rights Act 1994 (except those in the threatened species list); an artificially propagated hybrid of Australian native species that do not naturally hybridise; and commercial cultivars that do not occur in the wild. Check the requirements for your flowers with DSEWPC or your exporter.

For more information about export permits

- Contact the Director, Wildlife Trade Regulation Section, Department of Sustainability, Environment, Water, Population and Communities, GPO Box 787, Canberra ACT 2601, 02 6274 1900, wildlifetrade@environment.gov.au.
- Ask your exporter.
References and further reading

Recommended references are highlighted in **bold**.


Lamont B. 1982. *Export Market Requirements and the Horticulture Potential of Australi-


Worrall RJ. 1986. Biology and Cultivation of
the Waratah (*Telopea speciosissima* R. Br.). Dissertation submitted for the degree of Master of Science in Agriculture, University of Sydney.


Appendix 1. Waratah quality specifications
Product: Waratah
Botanical name: *Telopea speciosissima*
Variety: Seedlings and named cultivars

Quality specifications for Australian wildflowers
The distinctive and spectacular New South Wales waratah is also the NSW floral emblem.

Waratah blooms are harvested commercially from many distinct cultivars and seedlings, some of which have improved yields and vase life. The market is increasingly demanding the uniformity offered by the cultivars, and flowers of the same cultivar presented together.

The range of head sizes, forms and colours is increasing, and includes the traditional red, in addition to pink and white. Most are forms or hybrids of *Telopea speciosissima*, which occurs naturally in the Central and South Coast districts and the Blue Mountains region.

Each waratah bloom is composed of a central mass of individual flowers or florets surrounded by a ring of leaf-like bracts. The florets open (visible as the style or ‘pin’ sticking out) from the outer rim inwards. Blooms are fully open when the florets at the tip of the dome are open. The arrangement and size of bracts differs between cultivars, ranging from very large and showy to small and compact.

Market appeal is related to the shape of the bloom: the ratio of bracts to the domed mass of individual flowers and the overall appearance. For commercial growers, this requires attention during the planning phase. Different markets, and even sectors of markets, may have very different requirements.

Hybrid waratahs are available in a range of colours (including yellow) and forms. The bracts may be small or missing.

Maximum vase life is achieved if blooms are cut when the central flowers are fully formed and <5% of the individual florets have opened. Once open, florets produce significant amounts of nectar, which attracts insects and encourages the development of botrytis (grey mould fungus). Don’t add sugar to postharvest solutions, because it stimulates nectar production.

One of the most common causes of poor vase life is drying out of the blooms. Another is that the more individual flowers that are open, the shorter the vase life.

This specification describes a red *T. speciosissima* bloom of the best quality that can be produced by most commercial growers (traded as ‘A’ grade). Waratahs grown under shade protection may achieve a higher quality.

Small-headed blooms are a lower grade than described here and should be marketed in bunches of 3 or 5, depending on the cultivar and customer preference.

Irrigate before harvest if necessary to avoid water stress at picking.

**Flowering season:**
Late August to late October, depending on cultivar, locality and season.

**Typical vase life:**
7–14 days (some hybrids have a much shorter vase life). Export can reduce the vase life, especially if the transport conditions are not cold, the product dries out, or transport takes too long.

**Other products to which this specification can be generally applied:**

Other waratah selections include white and pink.
Product: Waratah ‘Songlines’

STAGES OF OPENING

Stage 1
Immature stage, unacceptable to markets

Stage 2
Prime stage for export and domestic markets – 0-5% of florets open (equivalent to no more than 1 ring of florets open)

Stage 3
Acceptable stage for domestic markets – 6-25% of florets open (equivalent to 2 rings of florets open)

COMMON DEFECTS

Common defects to be avoided at market entry:
- Bract browning
- Overmature blooms
- Shoot grow through
- Deformed or off type blooms
- Blooms damaged by insects, e.g. bud borer
- Poor quality foliage due to insect or mechanical damage or poor crop nutrition

Deformed bloom – do not harvest

 Shoot grow through

Bract browning (note that this is more prominent in white varieties)

Scale insects – disinfest before harvest
The stages shown apply to the product at market entry. The climate, season, mode and duration of transport must be considered because the flowers will continue to open during transport. You must consult with your target market to ensure the flowers arrive there at the desired stage.

**Stage 4**
Latest stage for domestic markets – 26-50% of florets open (equivalent to 3 or more rings of florets open)

**Stage 5**
Overmature stage – 51-75% of florets open: unaccepted by many markets

**Stage 6**
Overmature stage – 76-100% of florets open: unaccepted by most markets

- Thick stem, no bracts and shoot grow through – do not harvest
- Curved stem – do not harvest
- Leaf damage – mechanical injury
- Overmature (wilted) – do not market
- Bud borer – discard
- Leaf miner insect damage
- Insect chewed bracts and poor quality foliage – do not market
- Nutrient deficiency spoiling leaf quality – discard

The stages shown apply to the product at market entry. The climate, season, mode and duration of transport must be considered because the flowers will continue to open during transport. You must consult with your target market to ensure the flowers arrive there at the desired stage.
FLOWERS

**Appearance**
- Flower head fully formed, bracts fully opened (for that cultivar), and flower head opening evenly to reveal the central dome.
- Flower size proportional to stem length and diameter – market smaller heads on shorter stems.
- Flower head follows in a straight line from the stem (and is not offset from the stem at >15°).
- Flower head not hidden by leaves.
- No secondary blooms or shoots growing through the head.

**When to harvest**
- Flower mass (dome) firm and fully swollen, and <5% of florets open (when the first or outer ring of florets is open). Immature buds will not open properly.
- Flower head well coloured and typical for the selection.
- Take care when harvesting flowers if they are wet.

**Damage**
- No damaged bracts, or asymmetrical, deformed or damaged blooms.
- Minimum blemishes such as bract browning.
- No folding, creasing or damage to bracts.
- No ‘blueing’ of flower.
- No wilting.
- Discard any poor-quality product with insects or fungal infections.

**Contamination**
- Ensure the flowers are free of grit and soil, weed seeds or weeds, and signs of insects or spiders, such as webbing.

**Pests and diseases**
- No apparent pest or disease damage.

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LEAVES

**Appearance**
- Bright green; crisp appearance.
- Not dull or wilted.
- Minimum discoloration (<10% by area and affecting <10% of leaves).

**At harvest**
- Avoid harvesting or storing when foliage is wet.
- Strip leaves from lower third to half of the stem, being careful not to damage the stem (a sharp snap downwards holding the thumbnail at the base of the leaf stalk usually works).

**Damage**
- Minimum evidence of pests, diseases or other blemishes such as mechanical damage. Leaves entire (no insect feeding damage).
- No scale insects, earwigs or spiders. No spider webs.
- Free of visible chemical residues.

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STEMS

**Appearance**
- Rigid and strong enough to support blooms, without being too heavy and bulky.
- Bend <15°.
- Free of disfiguring trim marks or other blemishes.
- Neatly cut end.

**Length**
- According to market demand, typically as recommended in ‘Grading and bunching’ below.

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RECOMMENDED HANDLING AT HARVEST

- Minimise drying out and exposure to heat – pick when it is cool, preferably straight into buckets of clean potable water, ideally with added registered biocide, and hold in the shade.
- Move cut stems promptly to a cool, shaded packing area and cool to 2–4 °C as soon as possible to remove field heat and to stop the bloom from continuing to open.

---

GRADING AND BUNCHING

**Grading**
- Flowers are generally marketed as single stems.
- Grade quickly to minimise time stems are out of water.
- Reject any contaminated stems.
- Sort stems according to flower maturity, length and thickness: flower head proportional to stem length (typically 20%–25% of the total stem length for larger blooms).

**Bunching**
- Waratahs meeting this specification are generally marketed as single stems, unless the buyer requests otherwise. There is a greater risk of flower damage if waratahs are packed as bunches.

**Stem length**

<table>
<thead>
<tr>
<th>Stem length* (cm)</th>
<th>Diameter of flower head excluding bracts (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 cm</td>
<td>9 cm</td>
</tr>
<tr>
<td>80 cm</td>
<td>8 cm</td>
</tr>
<tr>
<td>60 cm</td>
<td>7 cm</td>
</tr>
</tbody>
</table>

* Measured from the top of the dome to the base of the stem. Because of the great variability in flower size and shape, it is not possible to give exact stem lengths required by markets.

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**Sleeves**
- Especially for export and for forms with long, delicate bracts, use perforated sleeves. A tight sleeve holds the bloom together and makes flowers easier to pack.
**HOLDING AND STORAGE**

### Cooling

Effective cooling soon after harvest is important to retaining quality and maximising vase life. There are two options:

- **Cool, process, cool** – for example, remove field heat by cooling flowers immediately on entry into shed to 10 °C in buckets of solution, process flowers (bunch, grade), and then cool to 2–4 °C by either forced-air cooling (if boxed) or holding overnight in a cool room.

- **Process within 1 hour of cutting, and then cool** to 2–4 °C by either forced-air cooling for 20–30 minutes (if boxed) or holding overnight in a cool room (if in buckets).

Forced-air cooling of packed flowers is ideal for large volumes of product.

### Temperature and humidity

- **Hold in a high-humidity cool room (95%) at 2–4 °C.**
  - Another way of achieving high humidity is to cover the flowers with plastic sleeves or plastic sheeting, as long as there is no condensation on the flowers, which can favour botrytis.

### Postharvest solutions

- **Postharvest solution:** Hold in high-quality potable water with an added biocide registered for postharvest use in cut flowers. Do **not** add sugar, as this stimulates nectar production, which promotes botrytis.
  - **Holding solution:** Same as the postharvest solution.
  - **Recutting stems at this stage appears to be beneficial in maintaining water uptake.**

- **To increase water uptake and improve hydration it may be worth holding the stems in deep water (e.g. 20 cm) or in special hydrating solution (see Postharvest Manual* for details).**

### Longer-term storage

- **For longer storage seek professional advice and test in the market before committing product.**

**PACKAGING**

Pack only dry, cold flowers.

Especially for export, stems in each box should be approximately the same diameter and length, and flower head size should be consistent.

Pack with flower heads at each end of the box and stems in the middle to avoid damaging blooms.

Pack stems firmly in boxes or use export hooks or stem breaks so the product will not move and be damaged. Use shredded paper to protect flower heads, unless forced-air cooling is to be used (as the paper slows cooling). Avoid packing too many stems per box.

Use boxes with holes to allow forced-air cooling.

Minimise water loss. For long-distance shipping consider lining boxes with plastic if they do not have a plastic or wax vapour barrier.

Cool flowers to 2–4 °C before transport.

**LABELLING AND DOCUMENTATION**

Label boxes and buckets as recommended in Postharvest Manual* or as required by customer.

Ensure box contents are exactly the same as specified in the documentation and on the end of the box.

**TRANSPORT**

Refrigerated vehicle at 2–4 °C.

**COMMON POSTHARVEST PROBLEMS**

Refer to Postharvest Manual* for general advice.

- **Fungal decay in storage due to botrytis (grey mould)**
  - Use preharvest fungicide sprays during wet weather, which favours botrytis.
  - Use preharvest insecticide sprays to reduce the pest population at harvest.
  - Dip flowers that are to be packaged and held for any significant length of time (export product) in a registered fungicide and insecticide solution with added wetting agent for not less than 1 minute, then dry naturally for 2 hours to ensure thorough disinfection. Florets produce a lot of nectar (which favours botrytis) as they open, so protection against botrytis is important.
  - Or: Fumigate flowers before dispatch to kill insects. Shake out any dead insects after fumigating and before packing.

- **Ethylene sensitivity**
  - Waratahs are sensitive to high levels of external ethylene. Do not store waratahs with strong sources of ethylene such as ageing or botrytis-infected flowers and ripening fruit.
  - Note: Anti-ethylene treatments do not normally appear to significantly extend vase life.

**Messages for importers and wholesalers**

- Recut stems and place into fresh water containing a registered biocide and avoid adding sugar. Cool product before marketing or sending on and keep it cool (2–4 °C).
- Maintain good hygiene and keep containers clean.

**Messages for retailers**

- Recut stems and place into fresh water containing a registered biocide.
- Use clean buckets and containers for displays.
- Do not display flowers in areas that are exposed to full sun, draughts, high temperatures or vehicle exhausts, and preferably do not display near fruit and vegetables. Use refrigerated displays if possible.
- Tell the customer how to care for the flowers and emphasise the need for fresh clean water and clean vases.

**Messages for consumers**

- Keep vase filled with the clean water. Check daily, as flowers can use a lot of water.
- Change the water at least every second day. Always use clean vases and clean water.
- Do not display in areas that are exposed to full sun, draughts or high temperatures. Keep as cool as possible without freezing.
- Discard other flower types in the same vase when they reach the end of their vase life.

**Postharvest Manual**

Refer to Postharvest Manual* for general advice.

- **Recut stems and place into fresh water containing a registered biocide.**
- **Use clean buckets and containers for displays.**
- **Do not display flowers in areas that are exposed to full sun, draughts, high temperatures or vehicle exhausts, and preferably do not display near fruit and vegetables. Use refrigerated displays if possible.**
- **Tell the customer how to care for the flowers and emphasise the need for fresh clean water and clean vases.**

- **Keep vase filled with the clean water. Check daily, as flowers can use a lot of water.**
- **Change the water at least every second day. Always use clean vases and clean water.**
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- **Discard other flower types in the same vase when they reach the end of their vase life.**


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Appendix 2. Economic analysis

R.J. Worrall

Note

All data included in this economic analysis are estimates only. Do not rely on them without checking for current values. It is almost inevitable that some data will vary greatly in your situation—for example, prices are very time dependent and yields can vary greatly with growing conditions and clone. Also, the list of input parameters is not exhaustive for every situation. For example, a range of flower qualities may be produced, commanding a range of prices. The accuracy of predictions is only as good as the quality of the input values.

Introduction

An Excel spreadsheet specifically for waratahs has been adapted from a spreadsheet for proteas originally published by RIRDC (Hassall & Associates 2000). Use this in conjunction with this guide, which describes some of the inputs in greater detail. The spreadsheet is very comprehensive, giving forward estimates for many years, cash flows, risk analysis etc. It includes most inputs, including those listed below, and more inputs can be added relatively easily.

Business plans and economic analysis are essential to the financial success of any commercial cut flower venture. This is especially so for waratahs, which can take years to come into production and can then stay in production for many years: up to 40 years in one instance. If it seems unlikely that the plantation will make a profit, it may become a very expensive hobby. It is important to recognise that the accuracy of an economic analysis depends on the accuracy of the inputs. The saying ‘garbage in, garbage out’ has particular relevance in this case. The costs of some inputs, such as land and installation of irrigation, are accurately known. However, some factors of critical importance, such as the price received for flowers 10 years in the future, can only be guessed at—although a well considered (educated) guess is far better than none at all. Yield can also be difficult to estimate. For example, Nixon (1987) gives the range of yield for plantation waratahs as between 5 and 50 blooms per plant, with occasional individuals having up to 100. My own observations support this statement.

One of the strengths of the following analysis is that the effect on profitability of variations in some important parameters, such as price and yield, can be estimated. That is, you can estimate how far both can fall before the enterprise becomes unprofitable. The analysis can also be re-run with different values for variables as many times as you wish, to determine their effect on profitability.

Notes on the individual inputs: physical parameters

These notes are included for guidance only and should not be taken as exhaustive, as in most circumstances they will not be. You must determine whether they, or other factors, are applicable to your particular circumstances.

Number of plants per hectare

This will vary with the planting scheme and the expected vigour of the plants. Higher densities will give greater returns per hectare in earlier years, but planting costs will be greater. Larger transplants may also produce significant numbers of flowers earlier, partly offsetting the greater costs. This effect would disappear by year 5. Normal densities will be between 1000 and 2000 plants/ha, or higher (>3000/ha) if expensive environmental protection such as shade cloth is used.

Flowers per plant

Yields in commercial plantings are very variable. Nixon (1987) estimates yields of between 5 and 50 flowers per plant, with some individuals producing up to 100. Although yields can be high, use caution in yield estimates. One commercial grower, for example, averages 8 flowers per plant. Stem length and variety, as well as quality, are important factors in determining
price. Larger plants may flower earlier. Smaller plants, however, will usually catch up by year 5 and may perform better than large plants.

Yield in stems per hectare = flowers per plant $\times$ plants per hectare.

Total hectares

This is the planted area. Experience suggests that one person can manage a total of 2 ha of waratah flowers. Since at any one site waratahs have a restricted flowering time, additional labour may be required at harvesting. Growing other Proteaeae or Australian native cut flowers to spread harvest times will reduce the need for additional labour at harvesting and the need for extra packing facilities.

Field investigations

Include such factors as surveys, soil analysis, agronomic investigations and farm planning.

Land cost

This may or may not be included in your analysis. What is the opportunity cost of your land? If you already own the land, what else can it be used for? For example, a small acreage with a dwelling may have little value, or even a negative value, if there are few alternative uses, perhaps because of planning restrictions. If land is to be bought or leased, then the cost should be included. It is important that the land be suitable for growing waratahs, otherwise plant losses may occur, and the cost of preparing the land for planting may make the enterprise uneconomic. In costs associated with land, remember to include access and facilities such as electricity, water supply, fencing and windbreaks.

Buildings

You will need facilities such as machinery storage sheds. Access to storage (such as a cool room) and packing facilities may also be required, depending on the marketing strategy to be followed. If these are not available on farm or nearby (for example, at a neighbour’s or a joint packing facility), then their cost will have to be included.

Plants

Only clonal material is commercially acceptable because of the variability of seedlings. The price for flowers of seedlings will be heavily discounted. At the time of writing, typical costs per plant from specialist suppliers were about $6 for 75-mm tubestock and $8 to $10 for 140-mm (check for latest prices!). Smaller sizes and large quantities can be difficult to get, creating a need for forward orders. Some varieties have Plant Breeders’ Rights protection.

Replanting

Losses can be anticipated for a number of reasons, necessitating replanting. For example, there may be large losses through root disease if soil drainage is suboptimal. Use of a good site with good management and adequate bed preparation can minimise these losses. Wind may blow plants over. Adequate shelter can help prevent this. Changes in fashion and the release of new varieties may also necessitate replanting of the site.

Establishment costs

Establishment costs include all the materials and labour required to establish the crop, such as the costs of irrigation, soil preparation, weed mats or mulch and their installation, or planting costs. Irrigation costs will include supply and installation of equipment in the actual area of the crop and supply of water to the site if not already available. For example, a dam or bore and pump and a filtering and delivery system may have to be allowed for if they are not already in place.

The use of shade cloth to protect the crop is a major input and will have to be included. Its high cost may make higher-density planting more economic.

Permits

Include the cost of a NSW DECCW licence. See your local office. Other licences or permits may also be required, for example from local councils for dams.
Recurrent inputs

**Plants.** As required for losses and new varieties.

**Irrigation/water.** Running costs and cost of water if purchased.

**Fertilisers.** Both cost of fertiliser and cost of application. Both may vary widely. Also cost of leaf and soil analysis to manage rate of application.

**Chemicals.** In addition to that needed for crop protection, include costs of chemicals used in postharvest treatments.

**Crop protection.** Include costs of weeding, slashing, spraying, identifying pests and diseases, analysing leaf and soil nutrition, and replacing weed matting and mulch.

**Harvesting.** Estimates in the literature and actual grower figures range from 10¢ to 50¢ per bloom, depending on the operation. This is a significant cost that needs to be carefully considered. Costs will generally be higher for small operations and for poor-quality material. In one case a grower halved his costs by reorganising his operations.

**Maintenance.** For example, fencing, banks and structures. Also include pruning costs. Actual and published figures range from $0.50 to $1.00 per plant.

**Packaging.** Costs will depend on the number of flowers per box and therefore on flower size and box size. Different markets will also have different needs.

**Transport.** Costs will depend on location and market. Sydney is currently the biggest market for waratahs in Australia. Domestically, transport costs vary greatly with location. For example, freight from Brisbane or the North Coast of NSW to Sydney is relatively cheap because of competition. Freight from remote locations can be many times this cost. Export costs for waratahs have not been considered here, as the FOB return can be used for prices received. However, be aware that the greatest cost in exporting waratahs is freight, and relatively small differences in freight rates (or exchange rates) can mean the difference between profit and loss.

**Other.** Other costs include casual labour, fuel, electricity, containers and rates. They may be included if the analysis goes beyond a simple gross margin analysis. All costs need to be included, such as motor vehicle expenses and depreciation, fuel, telephone, rates, stationery, marketing, displays, professional and association memberships, insurance, education, government charges, bank fees, protective clothing and accountancy fees. See your accountant for advice.

Returns

Harvest time has the greatest effect on local prices. At the beginning of the season, prices for high-quality blooms on the local market can exceed $6 a flower. However, at the peak of the season, prices may be as low as $2. Quality, especially stem length and variety (for example, good whites sell for more), can also have a large effect on price. Also, do not ignore agents’ fees and commissions (usually about 20% to 25%). A commission of 20% translates to a return to growers of a high of $4.80 and a low of $1.60. Ask local agents and exporters about their fees and charges.
# Economic analysis 2011

**Key assumptions**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise scale</td>
<td>1 ha</td>
</tr>
<tr>
<td>Initial investment</td>
<td>$77,501</td>
</tr>
<tr>
<td>Typical recurrent input costs</td>
<td>$27,376</td>
</tr>
<tr>
<td>Farm gate (or other) prices</td>
<td>$2.50 / flower</td>
</tr>
<tr>
<td>Discount rate</td>
<td>7%</td>
</tr>
<tr>
<td>Inflation rate (if any)</td>
<td>n/a</td>
</tr>
<tr>
<td>Analysis period</td>
<td>20 years</td>
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**Present value @ 7% over 20 years:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment inputs</td>
<td>$104,703 (incl. working capital)</td>
</tr>
<tr>
<td>Recurrent inputs</td>
<td>$225,368</td>
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<tr>
<td>Revenues</td>
<td>$545,883</td>
</tr>
<tr>
<td>Residual values</td>
<td>$8,496</td>
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</table>

**Net present value of enterprise @ 7% over 20 years:** $224,308

**Financial analysis results:**

- Breakeven on cumulative discounted basis after 7 years

**Threshold analysis results:**

Net present value of enterprise = 0 when:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield / prices decreased by</td>
<td>41%</td>
</tr>
<tr>
<td>Investment expenditure increased by</td>
<td>21%</td>
</tr>
<tr>
<td>Recurrent inputs increased by</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Major risks to financial viability:**

- Price
- Distance to export markets
- Cost of freight (international only)
- Disease, pests
- Bract browning
- Drought, flood, wind, hail, temperature
Stage Two (Cash Flow) Analysis
Crop Enterprise
Waratahs growing in NSW - guide only (please input your own values)

1. Decide on an appropriate unit of production (eg. hectare of growing area) – may be different from unit used in Stage One Analysis.

   Unit of production used: 1 hectare

2. Estimate all costs and revenues for this unit of production, on an annual cash flow basis.

3. Use the "physical parameters" workspace if required.

4. All costs are negative values, and all revenues are positive values.

5. All costs and revenues are to be estimated in real terms; that is, with no allowance for inflation.

6. Decide on an appropriate analysis period that matches the expected life of the enterprise, if applicable, but not longer than 20 years.

7. For investment assets with useful lives less than the analysis period, estimate cyclical renewal costs under "Investment".

8. Estimate the residual value of each investment asset at the end of the analysis period.

9. Decide on an appropriate real interest rate or required annual rate of return, and enter here: 7% pa

### Physical Parameter Workspace:

| Units | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Flowers per plant | 0 | 2 | 4 | 10 | 15 | 15 | 15 | 15 | 15 | 15 | 0 | 5 | 15.0 | 15.0 | 15 | 15 | 15 | 15 | 15 |
| Yield - bunches per ha | 4000 | 8000 | 20000 | 30000 | 30000 | 30000 | 30000 | 30000 | 30000 | 30000 | 0 | 10000 | 30000 | 30000 | 30000 | 30000 | 30000 | 30000 |
| Total ha | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

### Investment Inputs

<table>
<thead>
<tr>
<th>Units</th>
<th>Number</th>
<th>Price</th>
<th>Cost</th>
<th>Useful Life</th>
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<td>Field Investigations</td>
<td>1</td>
<td>$2,000</td>
<td>2,000</td>
<td>20</td>
</tr>
<tr>
<td>Land</td>
<td>1</td>
<td>$0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Buildings</td>
<td>1</td>
<td>$15,000</td>
<td>15,000</td>
<td>30</td>
</tr>
<tr>
<td>Plants</td>
<td>2,000</td>
<td>$8.00</td>
<td>16,000</td>
<td>10</td>
</tr>
<tr>
<td>Machinery</td>
<td>1</td>
<td>$20,000</td>
<td>20,000</td>
<td>10</td>
</tr>
<tr>
<td>Establishment (incl. soil/woodvil or mulch)</td>
<td>1</td>
<td>$9,150</td>
<td>9,150</td>
<td>20</td>
</tr>
<tr>
<td>(not inc. shade)</td>
<td>1</td>
<td>$6,500</td>
<td>6,500</td>
<td>20</td>
</tr>
<tr>
<td>planting costs</td>
<td>1</td>
<td>$400</td>
<td>400</td>
<td>10</td>
</tr>
<tr>
<td>Shade structure</td>
<td>1</td>
<td>$75</td>
<td>75</td>
<td>3</td>
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<tr>
<td>Other contingencies</td>
<td>1</td>
<td>$200</td>
<td>500</td>
<td>50</td>
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### Recurrent Inputs

<table>
<thead>
<tr>
<th>Units</th>
<th>Amount</th>
<th>Price/Unit</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Irrigation / water</td>
<td>100</td>
<td>$6</td>
<td>600</td>
</tr>
<tr>
<td>Shade maintenance</td>
<td>1</td>
<td>$709</td>
<td>709 per ha</td>
</tr>
<tr>
<td>Rent etc.</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Fertilisers</td>
<td>1</td>
<td>$300</td>
<td>300 per ha</td>
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<tr>
<td>Chemicals</td>
<td>1</td>
<td>$1,417</td>
<td>1,417 per ha</td>
</tr>
<tr>
<td>Crop management weed/slash/spray</td>
<td>1</td>
<td>$1,250</td>
<td>1,250 per ha</td>
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<tr>
<td>Harvesting / grading / packing</td>
<td>1</td>
<td>$0.30</td>
<td>0.30 per flower Plus $0.10 tag fee per flower/bunch/box if required</td>
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<tr>
<td>Maintenance</td>
<td>1</td>
<td>$1.00</td>
<td>1.00 per plant</td>
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<tr>
<td>Packaging boxes</td>
<td>1</td>
<td>$3.00</td>
<td>3.00 per 20 boxes</td>
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<tr>
<td>Transport (domestic)</td>
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<td>$4.00</td>
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<td>Other</td>
<td>1</td>
<td>$1,600</td>
<td>1,600 per ha</td>
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</table>

### Revenue

<table>
<thead>
<tr>
<th>Units</th>
<th>Yield</th>
<th>Price per flower</th>
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<tbody>
<tr>
<td>Crop</td>
<td>Unit Yield</td>
<td>$2.50 per flower</td>
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By-product #1
By-product #2
## CASH FLOW ANALYSIS

... for enterprise of 1 hectare

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<thead>
<tr>
<th>Investment Inputs</th>
<th>Present Value @ 7%</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
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<th>Year 14</th>
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<th>Year 16</th>
<th>Year 17</th>
<th>Year 18</th>
<th>Year 19</th>
<th>Year 20</th>
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</thead>
<tbody>
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<td>Buildings</td>
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<tr>
<td>Other</td>
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<td>-$604</td>
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<tr>
<td>Permits, etc.</td>
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<td>$70</td>
<td>75</td>
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<td>SUB-TOTAL</td>
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<tr>
<td>Recurrent inputs</td>
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<tr>
<td>Irrigation / water</td>
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<tr>
<td>Rent etc.</td>
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<td>Fertilisers</td>
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<tr>
<td>Crop management</td>
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<td>-$19,243</td>
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<td>10%</td>
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<tr>
<td>Maintenance</td>
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<tr>
<td>Packaging</td>
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<tr>
<td>Transport</td>
<td>-$2,400</td>
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<tr>
<td>Other (eg electrical)</td>
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<td>SUB-TOTAL</td>
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<td>4,224</td>
<td>21,324</td>
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### FINANCIAL ANALYSIS RESULTS

#### Cash Flow Analysis:
- Net Present Value @ 7%: $24,708
- Internal Rate of Return: 26.1%
- Benefit Cost Ratio @ 7%: 1.97

#### Sensitivity Analysis:
- Net Present Value with:
  - % decrease of discount rate: 5% / 9%: $24,708 / $17,851
  - % decrease of interest rate: 30%
  - % decrease of yield / price value: 10% / 10%: $24,708 / $17,851

#### Threshold Analysis:
- Net Present Value equals ZERO with:
  - yield / price value: 10%
  - investment expenditure value: 10%

### Breakdown Analysis:
- The Enterprise breaks even on a cumulative discounted basis in Year 7
Appendix 3. Management of scale insects in waratahs

Dr Victor Rajakulendran and Lowan Turton

One of the common pests that commercial waratah growers have to manage is scale. Scale insects can be divided into hard scales and soft scales. Hard scales have an oyster-like armour and are therefore difficult to control, because the insect is protected beneath the armour; for example, red citrus scale. Soft scales have no armour, so they are easier to control; for example, soft brown scale. Effective management of these pests requires some understanding of their lifecycle.

No extensive surveys of scale insects have been carried out in waratahs. So far we have come across only one species, the white palm scale (*Pseudaulacaspis eugeniae* (Maskell)), which is the common scale found in waratahs in and around Sydney. This scale is also called oleander scale and waratah scale. It is a hard scale.

This article relates to scales in waratahs, but much of the information is useful for managing other types of hard scale.

Waratah bush infested with white palm scale.

General life cycle of scale insects

Mature females lay in excess of 100 eggs. Eggs are laid under the female’s body and are protected by the mother. Eggs hatch to crawlers (the dispersal stage) in 8 to 12 days. Crawlers are the only mobile stage in the life cycle of scale insects. Crawlers migrate to various sites on the plant, insert their needle-like mouthparts and begin to feed on the sap. They remain in the same spot for the rest of their life. Females pass through three stages (instars) and reach maturity in about 28 days. Males pass through four stages and emerge with legs and a pair of wings. The adult males do not feed; their sole purpose is to mate with the females. As the female matures, she becomes an oval, bright yellow, feeding and egg-laying body hidden under a white, pear-shaped armour.
An adult female covered with white protective armour.

White protective armour opened to show the adult female.

White protective armour opened to show crawlers protected under the armour.

A young female just settled in its position on a leaf.

A young female beginning to secrete the white armour over her body.

Late stage of white armour formation.

An adult female with her progeny around her.
How to detect the presence of scales in a bush

When chlorotic spots (pale yellowish patches) appear on the upper surface of leaves, check the lower surface for scales. The scales can be seen as white powdery patches on the undersurface of the leaves. Under the microscope or with the aid of a magnifying glass, one can see the adult females with a colony of young ones around them.

Discoloured patches on the upper surface of the leaves.

Scales appearing as white powdery patches to the naked eye.

Another indicator of scales is the presence of ants on the bush, particularly when the flowers are infested. The ants feed on the honeydew excreted by the scales, and they tend to congregate around the scales. Sometimes they even try to protect the scales from enemies such as predators and parasites.

Ants and scales on the bracts of a flower.
How to manage scales on waratahs

Cultural management

If the bushes are free of scales, take care not to create any opportunity for scales to come onto the farm. They can move in on new nursery stock. Therefore, carefully examine any new plants brought in from other sites. Also provide adequate plant spacing, as scales seldom spread from one plant to another. This way it is easier to quarantine a plant if and when it gets infested, and you can prevent the scale insects from spreading throughout the plantation.

Biological management

Predators, such as lady beetles, attack and feed on young and adult scales.

Some species of tiny wasps parasitise scale insects. They pierce the white armour of the adult females and lay an egg into the fleshy body of the scale. The egg hatches, and the wasp larva feeds on the scale’s body from inside, eventually killing it. When the larva reaches maturity, it pupates under the white armour of the dead scale. When the new wasp is ready to emerge, it chews a round exit hole through the white armour.

White armour of an adult female chewed by a predator.

The round hole chewed by a parasite on the white armour to allow the adult insect to emerge.

Growers can promote the activity of parasites and predators by minimising the use of insecticides and using ‘soft’ insecticides as much as possible.

Mechanical control

If only few bushes are infested, scrubbing and scraping the leaves will dislodge the scales. Once dislodged, they will starve and die as they dry out on exposure to the air.

Chemical control

Contact insecticides can kill only crawlers and emerged adult males. Systemic insecticides have to be used to kill adult females and feeding nymphs. However, spraying for scales could increase other pests by killing the natural enemies of those pests. Therefore, if you find scales on your plants, use insecticides only after exhausting all other means of control.

When scales are detected, direct sprays at hot spots rather than spraying everything. Choose soft insecticides as much as possible to let the predators and parasites do their work on the scales. Unfortunately at this time, few low-impact insecticides are registered for use against scale insects on ornamental plants—see Table 1.
Table 1 Insecticides registered in 2012 for use against scale insects on ornamental plants.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Example of trade name</th>
<th>Mode of action</th>
<th>Registration details</th>
<th>Effects on beneficial insects (if known)</th>
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<tbody>
<tr>
<td>petroleum oils</td>
<td>BioCover® Horticultural Oil</td>
<td>Note that only some products have an ornamental crop use pattern</td>
<td>Registered for use on ornamental plants against immature scales in NSW, Vic, SA, WA and Tas</td>
<td>Considered a ‘soft’ insecticide</td>
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<tr>
<td>acetamiprid</td>
<td>Crown® 225 SL</td>
<td>systemic and contact</td>
<td>Registered for scales on ornamentals in all states</td>
<td>Harmful</td>
</tr>
<tr>
<td>dimethoate</td>
<td>Dimethoate</td>
<td>systemic</td>
<td>Registered for scales on ornamentals in all states</td>
<td>Harmful</td>
</tr>
<tr>
<td>malathion</td>
<td>Maldison</td>
<td>contact</td>
<td>Registered for managing scale insects in flowers and ornamentals in NSW, SA, Vic, Tas and WA only</td>
<td>Harmful</td>
</tr>
</tbody>
</table>

For an up-to-date list of registered insecticides, visit the Australian Pesticides and Veterinary Medicines Authority at [www.apvma.gov.au](http://www.apvma.gov.au); click on ‘Search registered chemical products (PUBCRIS)’; against ‘Product type’ select ‘Insecticide’, against ‘Host animal/crop’ type ‘ornamentals’, and click on ‘Search’. At the time of publication, registered insecticides included petroleum oils, dimethoate and maldison. As registrations can and do change, before using any pesticides, you must check the label to ensure that the product is registered in your state for use against scale insects on ornamental plants. Then do a test spray on a small area first to ensure that there are no adverse effects from using the product on your crop.

This Appendix was prepared from information presented to the November 2008 meeting of the Waratah Industry Network. The photographs were taken by Lowan Turton. Dr Victor Rajakulendran is an entomologist based at the Elizabeth Macarthur Agricultural Institute, Menangle.
Appendix 4. Improved on-farm management of waratah bud and stem borer
Improved on-farm management of Waratah bud and stem borer

Victor Rajakulendran  
Entomologist, Science and Research, Menangle

Bettina Gollnow  
District Horticulturist, Natural Resource Advisory Services, Menangle

The problem
Waratah bud and stem borer causes serious damage to commercially cultivated Waratah bushes (Telopea speciosissima). The larval stage of the insect generally bores into the buds and stems of the plant. Eggs are laid at the axillary region where the bracts are found when the new growth flush appears in early spring.

After hatching, the first instar (stage) larva bores into the stem in this region while the stem is still tender. The larva remains in the tunnel and feeds from the inside, making the stem in this area hollow and weak. As a result, the shoot can break at this point and a potential flower is lost.

Later in the season when the flower buds start to appear at the tip of the new growth, moths lay their eggs at the base of the flower buds where the bracts are. Hatching larvae bore into the bud and destroy the bud by feeding from the inside.

Therefore to achieve effective chemical control of this insect, growers need to know the life cycle and habit of the insect so that insecticide applications can target the vulnerable stages of the insect. This is when the young larvae are found exposed on the surface of the plant tissue before they bore into the tissue. Any spraying outside these ‘windows’ will be useless and a waste of resources.

The pest
Waratah bud and stem borer (Xylorycta luteotactella – Lepidoptera: Oecophoridae) is also known as macadamia twig girdler because it is also a pest on macadamia trees. In macadamias it only feeds on young foliage and the larvae are always exposed and therefore easy to control by spraying.

The adult is a white moth with golden wing margins and legs. When the moth is at rest the wings are folded like a roof on its back.

A waratah bud and stem borer moth

In Waratahs, females lay tiny amber coloured eggs singly on the surface of the plant tissue and these are very difficult to see without the help of a magnifying glass. The egg shell is ornamented and appears like a corn cob.
A freshly laid egg

As the larva develops inside the egg, the egg assumes a reddish-pink colour, probably to camouflage it so it blends with the colour of the bracts.

An egg with developing larva inside

The tiny neonate (just hatched) larva is reddish-pink with a black head.

A young larva feeding on the surface covered by webbing and frass

Once inside, the larva feeds and moult several times to reach 1.5 – 2 cm in length.

A neonate larva

The young larva first feeds on the surface of the plant tissue, protected under the webbing spun by the larva and the frass that becomes entrapped in the webbing, then bores through the tissue and enters the stem or the bud.

A fully matured larva

When fully matured, the larva goes into a resting pre-pupal stage.

A pre-pupa inside the stem

The pupa is brown and found in a silken cocoon. The moth emerges from this cocoon.
A number of insecticides, including widely used broad-spectrum insecticides, have shown good efficacy against this pest. It appears that application timing is more critical than what is being sprayed. However, as there are naturally occurring predatory and parasitic insects in most plantations, it is preferable to avoid using broad-spectrum insecticides, which will also kill these beneficial insects. Of the insecticides tested, Bacillus thuringiensis (commonly known as Bt) and spinosad are currently registered for ornamentals and can be used to control Waratah bud and stem borer. These two are less harmful to beneficial insects than broad-spectrum products.

A pupa inside the silken cocoon

The life cycle of this insect takes from 62 to 84 days to complete, depending on the environmental temperature.

Egg-laying

Based on our investigation during 2003/2004 in Oakdale, in New South Wales, larvae appeared when the temperature was above 10°C. There were two peaks of egg laying activity by the moth. The first peak was in mid December when the plants put out the new flushes, and the eggs were laid in the bract area of the new growth flush at this time. The second peak was in February. This was more spread out as flower buds were produced over a longer period than the new growth flushes. Therefore any insecticide spraying outside these two windows will not have any effect on the tunnelling larvae, because they are well protected inside the plant tissue.

Fluctuation in neonate larval numbers

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Check for updates of this Primefact at:

Disclaimer: The information contained in this publication is based on knowledge and understanding at the time of writing (June 2009). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of New South Wales Department of Primary Industries or the user’s independent adviser.

Job number 9494
Appendix 5. Cool room design and layout

Equipment

Your cool room should be of the right size for your particular business, so it should be planned to suit both the current and intended handling procedures. Before you build a room, give particular thought to how your business might expand, and how handling efficiency might be improved. For example, allow for access and manipulation in planning the room. Provide a facility for pressure cooling if the room will be used to cool stacks of cartons before dispatch or storage. Design the room to operate reliably with a uniform temperature of 2 °C at high (90%) relative humidity when fully loaded. The room must have an adequate refrigeration capacity for the duty required of it, and be well insulated.

Draw rough sketch plans until you are happy with the result. It costs nothing to plan on paper.

The following sections examine cool room design and procedures in more detail. A checklist at the end of this section will help in your cool room design.

Storage and access

Tiered racks can be used to stack flower buckets several high. Straight racks of open mesh can be used to lay out packed cartons to assist cooling. Mobile racks that can be moved between the packing area and cool room are efficient. Alternatively, trolleys or carts may be used to move flowers in and out of the room. Another option is to install in the cool room wall a small hatchway through which buckets or cartons are moved on a roller conveyor. Allow adequate aisle space to give free access inside the room, and clear space to manipulate trolleys and carts. Provide air gaps to allow free circulation of air around the room. At least 25% of the floor area will be taken up with aisles and air gaps.

Room height

The height of the room must be adequate for people to move about and to allow buckets or cartons to be stacked. Allow room for the cooling unit to be hung beneath the ceiling and so that nothing need be stacked higher than the bottom of the cooling unit. A room in which handling is done by hand should be at least 3 m in height.

Gaps for air circulation

Allocate space to allow unimpeded circulation of air around the room and between stored objects. Circulating air is the vehicle by which heat is carried to the cooling unit. Heat that leaks into the room is best removed by air that flows over the entire inner sides of the ceiling, walls and floor. Similarly, ensure that air can circulate freely around each stored object in the room. A guide to the appropriate size of air spaces is given in Table 2.

Insulation

Adequate insulation is essential if the room is to maintain a uniform temperature and high humidity and to use electricity efficiently. Select insulation to suit each application and location. A minimum specification for a cool room built inside a shed is for the walls and ceiling to contain 100 mm and the floor 50 mm of expanded polystyrene or equivalent. The common provision of 75 mm polystyrene for the walls is usually inadequate. All new floors should be insulated. Where an existing floor is being used, the cost of insulation may not be justified, especially if the room is not used for storage. Be aware, however, that problems are likely if flowers are stored in rooms without floor insulation.
Table 2. Recommended clearances for good air circulation

<table>
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<tr>
<th>Position</th>
<th>Space to allow</th>
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<tr>
<td>Space in front of cooling unit</td>
<td>at least 2 m</td>
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<tr>
<td>Space between buckets or cartons (which must be stood off the floor, on pallets or racks) and floor</td>
<td>50–100 mm (100 mm if the floor is not insulated)</td>
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<tr>
<td>Space between buckets or cartons and outer walls</td>
<td>75 mm, or 125 mm if the wall is unshaded and faces north to north-west</td>
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<tr>
<td>Clearance between top of flowers and ceiling</td>
<td>at least 300 mm; preferably &gt;450 mm</td>
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<tr>
<td>Space between individual buckets or stacks of cartons</td>
<td>50 mm</td>
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**Vapour barrier**

Protect the insulation in a cool room used for flower storage from moisture by a high-grade vapour barrier. The vapour barrier is formed by the outer skin of a sandwich panel room. All joints in, and penetrations of, this skin must be sealed with an approved high-quality sealant. A suitable specification in the contract might be ‘The room shall be constructed so that a continuous, impervious vapour barrier is established. Only installers with extensive experience in the construction of vapour-proof cool rooms shall be employed.’ Never allow holes to be cut or drilled in the outer skin of a cool room by anyone other than an experienced installer.

**Cooling unit**

The unit cooler hung from the ceiling consists of the refrigeration evaporator and the fans that circulate room air over the evaporator coils. The correct selection of the unit cooler is a job for an experienced refrigeration engineer. Keep in mind the following important considerations:

- The unit must have sufficient surface area and airflow to provide high humidity. The optimum humidity will depend on how flowers are held and how long they may be stored. For most purposes a target humidity of 90% should be satisfactory and can be achieved with a coil diffusion temperature of 3.0 °C.
- The airflow from the unit should give at least 60 room air changes per hour when hot material is first placed in the room. The air change rate should be reduced to between 30 and 15 per hour when already cooled flowers are being stored. This reduction can be achieved with a two-way switch on the unit fans. The fans run continuously during temperature pull-down but cycle with the cooling unit afterwards. Note that if electric defrosting is not installed as recommended below, then the fans must be left to run continuously.
- A room operating at 2 °C and used for the storage of flowers must have electric defrosting. The daily defrosting cycle should be turned on by a clock and off by a refrigeration pressure switch.
- Take care in selecting the size of the unit and the velocity of air it discharges. Low-profile units are essential in small rooms so that storage space is not wasted. Most units discharge air too fast for contact with flowers exposed in buckets. The air velocity also makes working conditions uncomfortable. Low-profile, low-velocity units that still provide adequate air circulation and humidity are preferable. Such units typically have a discharge velocity of about 0.7–1.0 m/s. The velocity of air over exposed (unpacked) cut flowers once they have cooled down should not exceed about 0.3 m/s. Even with low-velocity units it may still be necessary to hang plastic sheets in the room to act as windbreaks.

**Refrigeration capacity**

Ensure that the refrigeration machinery installed to cool the room has adequate capacity to properly cool the largest, hottest load that will ever be put into the room under the worst
probable heatwave conditions. Estimating the refrigerator capacity is a job for an experienced engineer. A reliable estimate can be made only if you provide reasonable and realistic information:

- What is the largest quantity of flowers that will be harvested and placed in the room on the same day at the peak of the season?
- How hot is this load of flowers likely to be?
- Will a similar quantity be harvested the next day, or the day after that?
- What is the largest amount of flowers that will be held in storage (after cooling) at any one time?

**Thermostats**

Because flowers are easily frozen, the room temperature must be controlled by a sensitive and accurate thermostat. It is often desirable in cool storage for the thermostat to control the refrigeration cycle through a liquid line solenoid valve. An electronic thermostat is recommended, set to a differential of 1 °C. The temperature read by the thermostat appears on a digital display outside the room. Some models have an under-temperature warning alarm. The sensing element should be located in the return air stream to the cooling unit, and kept at least 300 mm away from the walls, ceiling and lights. The best location may have to be determined by trial and error. Never assume that by setting the thermostat to 2 °C the room will necessarily operate at 2 °C. The operation of any cool room below about 5 °C always carries a very real risk of freezing. Considerable care must be taken in setting up the room in the first place and in maintaining safe operating conditions. Independent thermometers must be used to set up and maintain the correct conditions.

**Thermometers**

Thermometers are used to check that the air temperatures in different parts of the room are uniform, and that the flowers are being held at the correct storage temperature. Such thermometers must be of good quality. Glass or electronic types are suitable, although the latter are specifically recommended for use in cool rooms. The scale should be readable to at least 0.5 °C. Thermometers used to gauge air temperature should have the bulb or sensing element immersed in a small (20–100 mL) vial or jar of water that remains in the room. The water smooths out short-term fluctuations in the air temperature. Test thermometers after you buy them and at least once each season. In addition, test them if they have been damaged in any way. Test by inserting the thermometer into a slurry of crushed ice and water and noting the temperature registered. The temperature of melting ice is 0 °C.

**Checklist of cool room design information**

This checklist summarises many of the items that need to be considered, and information that needs to be gathered, in order to design a satisfactory cool room.

**Capacity of room**

- What is the maximum weight of flowers that will be picked and placed in the room on any one day?
- What is the maximum weight of flowers that might be stored in the room (that is, not dispatched before flowers from the next harvest start coming into the room)?
- What is the weight of each water-filled bucket without flowers?

**Desired cooling time**

- How quickly do you wish to cool the flowers?

**Handling method**

- Are flowers handled entirely in buckets, or is some or all of the harvest packed into cartons?
- Are buckets and cartons handled manually, or are handling aids such as mobile racks, pallet trucks or roller conveyors used?
- Are forklift trucks used?
- Are changes in handling anticipated in future?
Handling flow

☐ How will flowers be handled when picked?
☐ Will they be accumulated in the cool room until graded or will they be stood outside?
☐ Will they be graded and packed, or graded, cooled and packed?
☐ Which conditioning treatment will be used?

Commodities to be cooled

☐ Are waratahs the only produce that will be cooled, or will other produce be cooled? (See table below.)
☐ Will only your produce be stored in the room, or might the room be shared with another grower?
☐ If the room will be used for storing other produce, will there be times when waratahs and other produce might be put into the room together?

Commodity roster for multi-purpose cool room

<table>
<thead>
<tr>
<th>Commodities to be cooled</th>
<th>Months of year when cooling will be used</th>
<th>Maximum expected commodity temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>5</td>
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</tbody>
</table>
Telopea-speciosissima

Telopea speciosissima, commonly known as the New South Wales waratah or simply waratah, is a large shrub in the Proteaceae family. It is endemic to New South Wales in Australia and is the floral emblem of that state. No subspecies are recognised, but the closely related Telopea aspera was only recently classified as a separate species. *T. speciosissima* grows as a shrub to 3 or 4 m (10–13 ft) high and 2 m (7 ft) wide, with dark green leaves and several stems rising from a pronounced woody base known as a lignotuber. It is most renowned for its striking large red inflorescences (flowerheads) in spring, each made up of hundreds of individual flowers. These are visited by the eastern pygmy possum (*Cercartetus nanus*), birds such as honeyeaters (*Meliphagidae*), and insects.

The floral emblem for its home state of New South Wales, *Telopea speciosissima* has featured prominently in art, architecture and advertising, particularly since federation. Commercially grown in several countries as a cut flower, it is also cultivated in the home garden, although it requires good drainage, yet adequate moisture, and is vulnerable to fungal disease and pests. A number of cultivars with various shades of red, pink and even white flowers are available. Plantsmen have also developed hybrids with *T. oreades* and *T. mongaensis*, which are more tolerant of cold, shade and heavier soils.

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- 2 Taxonomy
- 3 Distribution and habitat
- 4 Ecology
- 5 Cultivation
  - 5.1 Cultivars
- 6 Symbolic and artistic references
- 7 See also
- 8 References
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### Description
The New South Wales waratah is a large erect shrub up to 3 or 4 metres (10–13 ft) in height with one or more stems.\(^1\)[2] Arising vertically or near vertically from a large woody base, or lignotuber, the stems are little branched. There is a spurt of new growth after flowering in late spring, with new shoots often arising from old flowerheads.\(^3\) The dark green leaves are alternate and usually coarsely-toothed and range from 13 to 25 cm (5–10 in) in length.\(^1\)[1] Enveloped in leafy bracts, the flowerheads develop over the winter and begin to swell in early spring,\(^1\)[4] before opening to reveal the striking inflorescences. The exact timing varies across New South Wales, but flowering can begin as early as August in the northern parts of its range, and finish in November in the southern, more elevated areas.\(^3\) Spot flowering may also occur around March in autumn.\(^5\) Containing up to 250 individual flowers, the domed flowerheads are crimson in colour and measure 7–10 cm (3–4 in) in diameter. They are cupped in a whorl of leafy bracts which are 5 to 7 cm (2–3 in) long and also red.\(^1\)[3] Variations are not uncommon. Some flowerheads may be more globular or cone-shaped than dome-shaped, and the bracts may be whitish or dark red. The tips of the stigmas of some inflorescences may be whitish, contrasting with the red colour of the rest of the flowerhead.\(^6\)

An individual flowerhead reaches full size around two weeks after first emerging from the bracts, and lasts another two weeks before the flowers fade and fall. In the first phase, the individual small flowers, known as florets, remain unopened—and the flowerhead retains a compact shape—before they mature and split open, revealing the style, stigma and anther. The outermost florets open first, anthesis progressing towards the centre of the flowerhead, which becomes darker and more open in appearance, and begins attracting birds and insects.\(^5\) The anther is sessile (that is, it lacks a filament) and lies next to the stigma at the end of the style. The ovary lies at the base of the style and atop a stalk known as the gynophore, and it is from here that the seed pods then develop. Meanwhile, a crescent-shaped nectary lies at the base of the gynophore.\(^7\) The seed pods grow to 8–15 cm (3–6 in) long.\(^8\) The pods eventually turn brown and leathery, splitting open to reveal the winged seeds inside;\(^1\) this generally occurs in early winter.\(^5\) In the wild, only 2 or 3 seed pods develop per flowerhead, but there may be anywhere from 5 to 50 in cultivated plants.\(^5\)

**Taxonomy**

The New South Wales waratah was first described by botanist James Edward Smith in his 1793 *A Specimen of the Botany of New Holland*, from "very fine dried specimens sent by Mr. White".\(^9\) He gave the species its original binomial name of *Embothrium speciosissimum*.\(^9\) The specific epithet is derived from the superlative of the Latin word *speciosus* "beautiful" or "handsome", hence "very-" or "most beautiful".\(^1\) *Embothrium* had been a wastebasket taxon at the time, and Robert Brown suggested the genus *Telopea* in 1809, which was published in 1810.\(^10\) Richard Salisbury published the name *Hylogyne speciosa* in 1809, but Brown’s name was conserved.\(^11\)

*Telopea speciosissima* is one of five species from southeastern Australia which make up the genus *Telopea*. Its closest relative is the very similar Gibraltar Range waratah (*T. aspera*) from northern New South Wales, which was only recognised as a separate species in 1995—it had previously been considered an unusual northern population of *T. speciosissima*.\(^12\) The genus lies in the subtribe Embothrininae, along with the tree waratahs (*Alloxylon*) from eastern Australia and New Caledonia, and *Oreocallis* and Chilean firetree (*Embothrium coccineum*) from South America.\(^13\)[14] Almost all these species have red terminal flowers, and hence the subtribe's origin and floral appearance must predate the splitting of Gondwana into...
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Distribution of Telopea speciosissima within Australia highlighted in red

Although no subspecies are recognised within Telopea speciosissima itself, geographical variations within its range have been noted. Forms toward the northern limits of its range have more prominently lobed leaves. Botanist Cathy Offord of the Royal Botanic Gardens annex at Mount Annan noted a population from Waterfall had darker red, wider inflorescences, and that a population at West Head in Ku-ring-gai Chase National Park had paler inflorescences, and that leaf shape varied widely.

The common name of waratah was first applied to this species before being generalised to other members of the genus Telopea and, to a lesser extent, Alloxylon. It is derived from the Eora Aboriginal people, the original inhabitants of the Sydney area. The Dharawal people of the Illawarra region knew it as mooloone, and mewah is another aboriginal name. A former common name is "native tulip", from around 1900, possibly derived from Telopea.

Distribution and habitat

The species is found from the Watagan Mountains southward to Ulladulla, with a relatively widespread distribution in the Central Coast region. It usually occurs as an understory shrub in open forest on sandy soils in areas with moderately high rainfall, receiving on average around 1200 mm (50 in) a year. Dappled shade from eucalyptus trees reduces sunlight by around 30%. Much of its range occurs in the Sydney Basin, an area with one of the highest human populations and development in Australia. The impact of habitat fragmentation and decreased fire interval (time between bushfires) on the gene pool of Telopea speciosissima, which relies on outcrossing, is unclear. Although largely protected within National Parks and conservation reserves in the Sydney area, most populations are small, numbering under 200 plants, and are often located near urban developments.

Ecology

Telopea speciosissima is a pyrogenic flowering species, relying on post-fire flowering followed by production and dispersal of non-dormant seeds to take advantage of favourable growing conditions in the altered environment. Of the woody resprouter species of southeastern Australia, it is one of the slowest to produce seedlings after fire, taking at least two years. The species resprouts from a lignotuber, a swollen woody base which is largely under the soil. Storing energy and nutrients, it is the source of rapid new shoots after bushfire. Waratahs dominate the understorey around two years after a fire, but are later overtaken by the slower-growing banksias and wattles. Fire also serves to strip away diseases and pests. Flowering may be prolific at this time.
The prominent position and striking colour of *Telopea speciosissima* and many of its relatives within the subtribe Embothriinae both in Australia and South America strongly suggest it is adapted to pollination by birds, and has been for over 60 million years.[15] Honeyeaters, in particular the New Holland honeyeater (*Phylidonyris novaehollandiae*)[22] and crescent honeyeater (*P. pyrrhopterus*),[23] are frequent visitors. However, a field study conducted at Barren Grounds showed New Holland Honeyeaters to carry relatively little pollen. The eastern pygmy possum (*Cercartetus nanus*) also forages among the flowerheads.[22]

The New South Wales waratah was initially considered to be protandrous (that is, male parts concluding sexual activity before female parts become receptive on the one plant),[7] but analysis of the timing of pollen viability and stigma receptivity by Cathy Offord showed they overlapped significantly.[24] It has been shown to be self-incompatible, and requires cross-pollination with other plants to reproduce successfully.[25]

### Cultivation

The New South Wales waratah was a popular garden plant at the beginning of the 20th century. It had been introduced early (1789) into the United Kingdom, and was reported flowering for the first time in 1809 at Springwell, the villa of one E. J. A. Woodford Esq. The Royal Horticultural Society awarded it an Award of Merit in 1914, and a First Class Certificate in 1922.[11]

Initially, waratahs were picked from the bushland for market, but by the early 20th century, a few plantsmen grew concerned at the development of urban areas at the expense of bush, particularly areas noted for wildflowers. Percy Parry of Floralands in Kariong developed the idea of "Preservation by Cultivation" and investigated the commercial cultivation of waratahs and other native plants. Meanwhile, the New South Wales Government was looking to curb flower and plant collecting from the wild, and considered prohibition in 1944, but after witnessing the ability of Parry to manage and develop cultivation, introduced compulsory licences for wildflower collecting the following year. With his wife Olive, Percy promoted and developed knowledge over fifty years and received the Order of Australia medal in 1981.[26] Following on from the Parrys were Howard Gay and Arch Dennis, who pioneered growing waratahs at Monbulk in the Dandenong Ranges in the 1940s, Sid Cadwell and Frank Stone, who did likewise in Dural and the Blue Mountains respectively.[27] The growing movement for cultivating and preserving native plants saw the establishment of the Society for Growing Australian Plants in 1957,[27] and the waratah was featured heavily in the first edition of its journal *Australian Plants*.[28]

Today, New South Wales waratahs are grown commercially in Australia north of Sydney and in the Dandenong Ranges near Melbourne. They are also grown commercially in New Zealand, Israel,[1] and Hawaii, where they have been grown since 1961.[29] One major challenge is that the flowering season is generally short (five weeks total, with only small numbers in the earliest and latest weeks) in any one location. The season may be extended, however, with plants grown at different latitudes. The vase life of a cut waratah is 10 to 14 days, and cut flower waratahs can be revived somewhat by water.[6]

Although they grow naturally on deep sandy soils, the species has proved adaptable to other deep, well-drained soils, especially where natural slopes assist drainage. Despite their natural occurrence in woodland, waratahs flower best in full sun, although they tolerate the dappled shade of eucalypts.[11] Heavy pruning after flowering reinvigorates plants and promotes more profuse flowering in the next season.[11] Waratah blooms are highly susceptible to damage from wind, and benefit from some protection from prevailing winds.[30] Waratah blooms attract birds to the garden.[11] The species is
readily propagated from fresh seed, but cultivars must be reproduced from cuttings to remain true-to-type.[31]

Several species of fungi can cause damping off or root rot,[32] and is an uncommon pathogen. Cylindrocarpon scoparium and C. destructans (now Nectria radicicola) are also uncommon causes of infection[35] and result in decay of the crown of the plant.[33] Although significant problems, fungi are less likely to be the cause of plant morbidity than poor drainage or soil conditions.[32]

The larvae of the Macadamia leafminer (Acocercops chionosema), a moth, burrow along and disfigure the waratah's leaves, and are mainly a problem in lowering the value of cut flower crops. More problematic is the larger caterpillar of another moth, the Macadamia twig girdler (Xyloryctea lateotactella) which can burrow into and disfigure the developing flowerhead.[33]

**Cultivars**

A number of natural forms have been selected for cultivation as follows:

- **Telopea 'Brimstone Blush'** is a shrub of smaller size than the species, reaching a metre (3 ft) tall, and was originally found growing on a property of Ben Richards in Oakdale, southwest of Sydney. Flowering takes place in October. The flowerhead is globular with a pink crown and has 160 individual flowers, the styles of which are pink and white towards the ends. Three rows of whorled dark red bracts surround the flowerheads.[36]

- **Telopea 'Cardinal'** is a form originally found on the property of Lucille Pope in Werombi, from where it was propagated and made available commercially. The original plant was a vigorous specimen reaching 3 m by 3 m (10 ft by 10 ft) and producing 100 to 120 flowerheads each year. It is named for its large dome-shaped cardinal red flowerheads, which bear 210 individual flowers and are surrounded by two rows of dark red bracts. These blooms have long vase life.[37]

- **Telopea 'Corroboree',** a form with longer styles, has compact inflorescences measuring 12 cm (5 in) high and wide, and is a vigorous grower. It was selected for commercial propagation in 1974 by Nanette Cuming of Bittern, Victoria, and registered with the Australian Cultivar Registration Authority in 1989. It is grown principally for the cut flower industry.[38]

- **Telopea 'Fire and Brimstone'** is a vigorous form with large inflorescences selected by waratah grower and author Paul Nixon of Camden, New South Wales. It is a shrub which may reach 3–4 m tall and 2 m wide, with large leaves with more heavily toothed margins.[39] Each flowerhead is cone-shaped and has up to 240 florets. The stigmas are a light red and tipped with white. The bracts surrounding the flowerheads are relatively small, while the leaves are large and can reach 44 cm (18 in) in length.[40] The cultivar is thought to be tetraploid.[39] With a long vase life of 17 days, the cultivar is suitable for the cut flower industry.[40]

- **Telopea 'Galaxy'** has flowerheads with pinkish red tepals and white tips to the styles, surrounded by large bracts.[29]

- **Telopea 'Olympic Flame'** is a form with prominent bracts around the flowerheads. It has large leaves with toothed margins and flowers in early spring. Also known as 'Sunburst', it arose as a seedling in a breeding program conducted by Cathy Offord, Peter Goodwin and Paul Nixon under the auspices of the University of Sydney.[39]

- **Telopea 'Parry's Dream'** was a chance seedling in the early 1970s. It gave rise to this cultivar, a vigorous plant with red-pink flowerheads which reach a diameter of 10 x 10 cm (4 x 4 in) surrounded by pink bracts.[29]

- **Telopea 'Shade of Pale'** is an unusual pale-pink flowered form of *T. speciosissima.[39]* It is less vigorous than the parent plant. It was initially promoted as 'Light Shade of Pale' but there can only be three words in a registered cultivar name.
- **Telopea 'Sunflare'** is an early-flowering form. It has large leaves with toothed margins and flowers in early spring. It also arose as a seedling in the same breeding program by the University of Sydney mentioned above.[39] Selected in 1981, it has red flowerheads with white-tipped styles which reach 9 cm (3.6 in) in diameter.[29]

- **Telopea 'Wirrimbirra White'** is a white form from Kangaloon near Robertson. Aboriginal legends of white waratahs existed, and several had been encountered but none had been previously preserved in horticulture. Joseph Maiden had previously found a white waratah near Kurrajong,[11] and others had been sighted near Narara on the Central Coast in 1919, and Colo Vale in the 1950s. Horticulturalist Frank Stone reported one in his garden, possibly propagated from the latter plant.[41] ‘Wirrimbirra White’ was brought into cultivation in 1972 by cuttings from the original plant, which grew on water catchment property. It has pale greenish buds which open to a cream-white inflorescence. It is less vigorous than the parent species and vulnerable to borers.[42] It is also highly vulnerable to the Macadamia twig girdler.[29]

In addition, a number of interspecific hybrids have also been produced. These have been bred or used as more frost- or shade-tolerant plants in cooler climates such as Canberra, Melbourne or elsewhere.

- **Telopea 'Braidwood Brilliant'** is a frost-tolerant hybrid between a male *T. speciosissima* and female *T. mongaensis*. Dr Robert Boden of the Canberra Parks Administration began investigating this hybrid in 1962, and it was registered in 1975 by Richard Powell. It is a lignotuberous shrub to 3 m (10 ft) high and has oblanceolate leaves to 20 cm (8 in) long. The red blooms are 6–8 cm (2.4–3.2 in) in diameter, intermediate in size between the parent species.[11] It has grown well in cooler climates such as Canberra.[43]

- **Telopea 'Canberry Coronet'** is a cross between *T. speciosissima* from Wentworth Falls in the Blue Mountains and *T. mongaensis* intended for increased cold tolerance. It has red flowerheads to 6–8 cm (2.4–3.2 in) in diameter. Reaching 3–4 m (10–13 ft) high, it is a larger plant than 'Braidwood Brilliant'.[39] It was bred by Doug Verdon of the Australian National Botanic Gardens in Canberra.[36]

- **Telopea 'Champagne'** is a cultivar registered under Plant Breeders Rights (PBR) in 2006.[44] Its creamy yellow flowerheads appear from October to December.[29] It is a three-way hybrid between *T. speciosissima, T. oreades* and the yellow-flowered form of *T. truncata*.

- **Telopea 'Golden Globe'** is a cultivar registered under PBR in 2005.[45] Larger than 'Champagne', it is also a three-way hybrid between *T. speciosissima, T. oreades* and the yellow-flowered form of *T. truncata*. It has been propagated and sold as 'Shady Lady Yellow'. It was originally bred in the Dandenongs east of Melbourne.[29]

- **Telopea 'Shady Lady'** is a larger shrub which may reach 5 m (16 ft) high and 2 or 3 m (6–10 ft) wide. A hybrid of *T. speciosissima* and *T. oreades*, it arose by chance in a Melbourne garden. The flowerheads are smaller and lack the bracts of the *speciosissima* parent. As its name suggests, it tolerates more shade.[39] It is vigorous and more reliable in temperate and subtropical areas, and grows in semi-shade or sun.[29] ‘Shady Lady Crimson', 'Shady Lady Red' and 'Shady Lady Pink' are three selected commercially available colour forms.[46]

- **Telopea 'Shady Lady White'** is a white hybrid between *T. speciosissima* and *T. oreades,[46]

### Symbolic and artistic references
The New South Wales waratah featured prominently in the folklore of the Darug and Tharawal people in the Sydney basin and Gandangara people to the southwest.[47] A Dreamtime legend from the Eora tells of a female Wonga Pigeon searching for her husband who has been lost while out hunting. A hawk attacks and wounds her, and she hides in a waratah bush. Her husband calls and as she struggles in the bush her blood turns the white waratah blooms red.[48] A tale from the Burragorang Valley tells of a beautiful maiden named Krubi, who wore a red cloak of rock wallaby adorned with the feathers of the Gang-gang Cockatoo. She fell in love with a young warrior who did not return from battle. Grief-stricken, she died, and up from the ground grew the first waratah.[49] The Dharawal people regarded it as a totem, using it in ceremonies and timing ceremonies to its flowering.[17]

The striking form of the New South Wales waratah became a popular motif in Australian art in the late nineteenth and early twentieth century and was incorporated in art nouveau designs of the time. Matchboxes, paperweights and especially tins have been decorated with the flower. Arnott's often used the waratah as an alternative to their parrot logo on biscuit and cake tins from the early 1900s.[50] Shelles soft drinks, established in 1893 in Broken Hill, also displayed it on their label.[50] The French artist Lucien Henry, who had settled in Sydney in 1879, was a strong proponent of a definitive Australian art style incorporating local flora, particularly the waratah.[51] His most famous surviving work is a triptych stained glass window of Oceania flanked by numerous waratahs overlooking the Centennial Hall in Sydney Town Hall.[52]

In 1925, artist Margaret Preston produced a hand-coloured woodcut depicting waratahs.[53] The species also appeared on an Australian 3 shilling stamp in 1959 designed by botanical illustrator Margaret Jones and a 30c stamp in 1968.[1]

After federation took place in 1901, the upsurge in nationalism led to the search for an official national floral emblem. The New South Wales waratah was considered alongside the wattle Acacia pycnantha, and debate raged between proponents of the two flowers. The economist and botanist R. T. Baker proposed that the waratah's endemism to the Australian continent made it a better choice than the wattle, as well as the prominence of its flowers.[54] He was nicknamed the "Commander in Chief of the Waratah Armed Forces". The South Australian Evening News also supported the bid, but to no avail.[54]

Telopea speciosissima was proclaimed as the official floral emblem of New South Wales in 1962 by the then governor Sir Eric Woodward, after being used informally for many years.[56] The species has also been adopted by others, including the New South Wales Waratahs rugby union team since the 1880s,[50] and the former department store Grace Bros in the 1980s.[50] Contemporary clothing designers Jenny Kee and Linda Jackson produced waratah-inspired fabric designs in the 1970s and 1980s during a resurgence of Australian motifs.[57][58]

See also

- List of Australian floral emblems

References

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Growing Waratahs for Cut Flowers
A guide for commercial growers

By Ross Worrall and Bettina Gollnow
Pub. No. 12/087

This ‘how to’ guide has been produced for members of the Australian wildflower industry who grow and market waratahs, including growers, wholesalers, retailers, florists, exporters, importers, research, development and extension workers and students.

It provides advice and information on all aspects of growing, harvesting, postharvest handling and quality management of waratah flowers.

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