12 Conclusions

This book has reviewed the development of radiata pine plantation forests as well as current management practices. It has illustrated how global experiences in growing the species and a wealth of research have contributed to building current-day management practices. The expansion of radiata pine plantation forests into the most widely planted non-indigenous conifer did not occur by accident but, rather, was the result of persistence by visionary people and societies. It is an inspiring story that has been an encouragement to those seeking to plant trees to provide for the needs of people in the widest sense. Although beyond the scope of this publication, it is important to note that the steps taken towards the domestication of radiata pine did not happen in a vacuum but unfolded in parallel with work on other species; this undoubtedly assisted in the establishment of today's radiata pine plantations.

LESSONS FROM THE RADIATA PINE EXPERIENCE

There are many ways in which forest managers and the wider community can benefit from the experience with radiata pine forest plantations. The major lessons learned are given below.

Growth characteristics

Compared with many other pine species, radiata pine is:

- fast-growing and able to produce large logs in under 30 years;
- flexible in growth habit, so can take advantage of a range of climates;
- a nutrient-demanding species;
- a versatile (although not exceptional) general-purpose timber.

Species niche

A major lesson from experiences in growing radiata pine is that it is vital to recognize its ecological niche (see Chapter 2), and planting outside this niche should be avoided. The radiata pine niche is:

- Regions with temperate maritime environments with a relatively dry summer period and certainly not humid summers. An annual rainfall greater than 600 mm suits the tree best. Suitable rainfall distributions are winter-biased or near uniform. Sites with the possibility of very low temperatures, hail or heavy snow should be avoided.
- The species is generally grown between latitudes 34° and 44° and below 1 000 m altitude (although the native Mexican island populations are outside this latitude range).
- The species has occasionally been grown at high altitudes in some low-latitude sites and in summer-rainfall areas with low humidity, but this could be risky because of pests.
- Planting on shallow, waterlogged or highly alkaline soils is not recommended, unless these limitations can be improved.
- Radiata pine is moderately tolerant of salt spray.

Climate change may alter the locations where radiata pine can be grown successfully. To date, however, information on the impacts of climate change or on radiata pine's resilience is scanty. Further research is being undertaken in this field.

Radiata pine forests and societal values and needs

The expansion of radiata pine plantations occurred in Australia, Chile, New Zealand, Spain and South Africa because of the demand for wood products (see Chapter 3). For the most part, governments were instrumental in promoting and supporting these programmes, but as private-sector investment in tree-growing and wood industries has matured, direct financial support from governments has decreased. Some direct and indirect support has continued, primarily through the provision of an enabling policy framework for investment and supportive research and education. Wealth creation has been an important consequence for countries or regions that have developed large-scale radiata pine plantation forests. Owners have generally obtained satisfactory economic returns from radiata pine plantations, although returns have decreased in recent years.

In addition, other societal benefits (see Chapter 3) are increasingly being recognized, including the effects of radiata pine plantations on:

- Generating employment, although the amount of employment changes over time. Employment increases with the development of associated industries but can also fluctuate with the rates of new planting, silvicultural practices, changes in company structures and innovations. About 30 jobs are supported for every 1 000 ha of radiata pine plantation, although most of these are outside the forest itself.
- Increasing biodiversity conservation compared with some alternative land-uses and reducing the use of natural forests for wood production. Radiata pine forests can also be important habitats for some native species.
- Mitigating climate change by reducing CO^2 emissions. This can result from using plantations to sequester and store carbon, and by reducing the carbon emissions arising from construction and fossil energy sources.
- Controlling erosion and regulating water quantity and quality.
- Developing more sustainable farming systems by integrating trees into landscapes (see Chapter 11).
- Furnishing rural landscapes valued for recreation and amenity.

Some negative issues with large-scale radiata pine plantations have emerged, however, and these need to be actively managed (see Chapter 3). These include landscape issues, wilding spread, reduced water flows in streams and changes to, or impacts on, existing local communities. Active engagement by forest managers with stakeholders has proved beneficial to both communities and forest enterprises. Forest managers have generally embraced environmental standards to reduce impacts and increase other societal benefits.

Radiata pine's wood uses

Radiata pine plantations have become important sources of wood and fibre; this has stimulated the development of wood-using industries (Figure 12.1). Radiata pine is a versatile, medium-density softwood but is not suitable for all end uses (see Chapter 5). Its strengths are its even texture, long fibre length and ease in machining and painting. Its limitations include low-strength corewood, poor natural durability, poor surface hardness, frequent large knots and other defects. It is a commodity species rather than a high-value, special-purpose species.

It has also proved a difficult species to grow for poles or as widely spaced trees on fertile pasture sites in agroforestry, and in both cases care is required to achieve desired results (see chapters 9 and 11). An important lesson from experiences with radiata pine is the need to recognize a species' end-use advantages and limitations and decide how to maximize the use of its good features. This can influence the scale of planting as well as silviculture and management, as has occurred in the main radiata pine-growing countries. Another lesson is that site and silviculture, including tree-breeding, can alter the quality of the wood produced and hence affect end use (see chapters 6, 8 and 9).

FIGURE 12.1
Radiata pine logs on their way to the wood-using industry

Tree-breeding and silviculture

As a result of advances in tree-breeding and silviculture, researchers and managers have increasing confidence to successfully grow the species on a range of sites and with varying management objectives and end-use potential. The key lessons from these experiences are as follows:

- Radiata pine has considerable genetic variability that can be exploited through tree-breeding (see Chapter 6).
- Tree-breeding knowledge and systems have developed substantially and become much more sophisticated. This is ongoing, as technology developments are providing new options. For example, it is now possible to select tested clones for specific sites and wood properties.
- Tree-breeding and propagation systems are closely related.
- The choice of traits to improve has not been straightforward. This is shown by the inadvertent reduction in some wood properties in early breeding programmes.
- Tree-breeding has resulted in substantial improvement in tree form and growth rates.
- Radiata pine is flexible in its response to silviculture and thus in its response to management objectives and other requirements. There is a range of ways in which managers can grow this species (see chapters 8 and 9).
- Nursery practices, site preparation, establishment and later tending should be seen as components of an integrated system linked to management objectives.
- Improved tree breeds and nursery and establishment techniques have allowed managers to plant on more difficult sites and at lower tree stockings (see Chapter 8). Replanting after logging is also influencing establishment practices.
- Forest management decisions have become site-specific. This has been assisted by the development of a range of decision-support systems (see Chapter 9).
- The use of complex modelling support systems should be treated with caution. They can (and have in the past) inadvertently led to suboptimal decisions.
- The silviculture of radiata pine continues to change. In the 1980s there was a trend by growers to use pruning to grow clearwood. Some managers are moving away

from this approach aimed at improving wood quality in favour of a factory-based approach. The development of carbon-trading markets or the use of radiata pine as an energy source may see further changes in silviculture.
- The use of fertilizers has been successful in overcoming nutrient deficiencies as well as increasing the growth of apparently healthy stands with hidden hunger.

The domestication process of radiata pine, and the improvements in the way it is grown, has been based on a concerted 40–50-year research effort.

Sustainability

The two main issues affecting the ecological sustainability of radiata plantations are the possibility of soil degradation and the increasing risk posed by invasive organisms (see chapters 4 and 10). The evidence and research suggests that:

- The productivity of the first planted radiata pine plantations was generally higher than the natural forests because of the release from natural predators, the flexibility of the species to adapt to new environments, better sites, and to a lesser extent, the use of seed adapted to the new environment (land races).
- In general, later rotations have grown faster than earlier rotations because of improved genetics, planting stock and establishment practices. This is an ongoing process. New breeds, clones and silviculture are now being developed for specific sites and wood properties.
- With the exception of Spain, there has been wide acceptance of the use of fertilizers on nutrient-deficient sites.
- In the rare cases in which there was a decline in growth rate between rotations, the decline was due to poor management practices such as the removal of topsoil or the burning of slash.
- Nutrients extracted in logs will usually be offset by natural inputs. Whole-tree harvesting and short rotations pose bigger risks on some sites.
- The number of invasive organisms has increased (see Chapter 4). In some cases, particularly where radiata pine had been planted on unsuitable sites, invasive species have led to the abandonment of trees. In most cases, the problems have been ameliorated and can be lived with. For example, biological control has helped to control some insect pests.
- In general, growing healthy, vigorous trees should be the goal, since these are likely to be least affected by invasive organisms.
- There is recognition that quarantine and monitoring procedures need to be strict and that tree-breeding programmes should keep a wide genetic base.
- However, managers now face novel ecosystems in a changing environment and this makes it difficult to predict the future risk to radiata pine posed by biological threats.
- Abiotic damage from drought, wind, frost, snow and fire can be limited by careful site selection and stand management. However, climate change may increase such risks.

Sustainability is also about working with communities to ensure that societal needs are met and that negative aspects are reduced or mitigated (Figure 12.2; see Chapter 3). Forest managers also need to be mindful of the need to use global resources carefully. Many radiata pine plantation growers have embraced environmental standards, including independent certification, and this has assisted in obtaining a balance between productive and other ecological or societal services.

Radiata pine plantations have been sound economic investments to date, creating wealth for countries and communities. Further investment in the main areas that can grow radiata pine forests should make reasonable returns, provided that market acceptance remains buoyant and governments maintain consistent policies. In some places, land costs may limit expansion.

FIGURE 12.2
Radiata pine, other introduced trees, native areas and farming create an attractive landscape

Uncertainties

- The effects of climate change on radiata pine plantation forests are still insufficiently known, despite initial modelling on the topic.
- Associated with climate change mitigation is the use of afforestation to store carbon or to provide a renewable energy source. How governments will encourage or discourage these options, however, is yet to be seen.
- There is ongoing discussion and research on how to value the wider environmental benefits of plantation forests and how to manage these values for societies.
- Discounted cash flow is widely used to value forests and make management decisions (see Chapter 3). By its very nature, the use of commercial discount rates tends to downplay social benefits that may accrue to future generations. There is still no agreement on how to overcome this aspect of discounted cash flow.
- There is ongoing debate about whether radiata pine forest managers should aim to grow their trees for particular markets in the future or alternatively to provide industry with uniform logs that can be manufactured into products needed at a given time.

THE FUTURE OF RADIATA PINE FORESTS

After a rapid expansion from the 1960s, the growth in area of radiata pine forests has stagnated (Table 1.2). There is still some expansion in Chile, but globally this is offset by the contraction of radiata pine in New Zealand, where competition from other land uses is high. At the same time, many areas have been through several rotations successfully. The forests and industries they support are largely privately owned. The radiata pine industry is hence in a "mature" phase.

The prospect of a new era of radiata pine planting should not be discounted. There is no shortage of physically suitable land in major grower countries on which this could occur. Planting trees as carbon sinks, as well as for wood, fibre and energy, and the placing of financial values on other social services could perhaps drive this growth.

On the other hand, market uncertainty and the increasing cost of land resulting from competition from other land uses may be impediments to further planting.

It is very unlikely, however, that large-scale planting of radiata pine will occur outside the current major radiata pine-growing countries. Species–climate matching programmes suggest that suitable lands are relatively scarce in other countries.

Future radiata pine forests will change in nature in response to market and social demands and because there are strong research programmes. Concerns over ecological sustainability because of soil degradation have proved manageable. The greatest threats to radiata pine plantations seem to be from climate change, the uncertainty around invasive organisms, and other rapid changes as an expanding world population adjusts to limited resources. Market changes are also occurring with, for example, moves towards reconstituted wood with predictable properties tailored to specific uses, or to meet demands for energy-efficient "green" buildings. Market changes will therefore continue to influence the nature of radiata pine plantations.

Forest managers can look forward to further exciting developments and be confident that they are growing a species of benefit to their communities. Communities can be equally confident that radiata pine plantations and their products are renewable, environmentally friendly and energy-efficient. The future for radiata pine forests is bright.