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Agroforestry as integrated natural resource management

Ian Nuberg, Rowan Reid and Brendan George

Integrated NRM: a time of great change for the better

‘It’s a great time to be involved in the management of agricultural lands and forests in Australia.’ If we wrote that sentence 100 years ago, we would have probably substituted the word ‘management’ with ‘opening up’ and ‘exploitation’. We might have added that this was essential to secure Australia’s place as one of the leading economies and nations of the modern world. While the focus of the task is very different, the scale and urgency of the many issues facing land management in Australia today has not diminished.

As we continue to develop the economic productivity of our land we are confronted with the question of how to sustain this development. Agriculture and forestry both impact, and are impacted upon by, soil and water resources, native and feral plants and animals, and by atmosphere and climate. The people who manage the land are responsive to community perceptions of appropriate land management, either by legislative coercion or by gradual changes in their own environmental awareness. The agriculture and forestry sectors share much in their response to the future, and for those involved there is a great opportunity to contribute to the development of truly sustainable and economically viable rural landscapes that are uniquely Australian.

The challenge of the early 20th century was to remove the forests and woodlands to make room for agriculture; the challenge for the future is understanding the interactions between forests and farming and designing new agricultural landscapes that integrate them for conservation and profit. Agroforestry, a marriage of forest and agricultural science, is a pivotal discipline in the practical implementation of this change.

This chapter lays the foundation for appreciating the urgency and nature of this change. We begin with a robust and pragmatic definition of agroforestry. Then follows an explanation of how agroforestry emerged in the efforts to secure sustainable agriculture and forestry in Australia. We mount our argument for agroforestry as a key strategy for on-ground action that integrates many natural resource management issues.

Moving from theory to practice, we describe the design and planning processes by which farmers integrate their individual vision and resources with real and meaningful changes on the ground.

We then introduce the rest of this book by summarising and linking each of its chapters.

What is agroforestry?
The terms agroforestry and farm forestry are used interchangeably in Australia with respect to the establishment and/or management of trees on farms for productive purposes. We have chosen the term agroforestry for this book because it reduces the emphasis on timber production, thus acknowledging the equally important role of non-timber...
products. It also particularly recognises the use of trees and shrubs on farms to support agricultural production, protect soil and water resources, enhance biodiversity, sequester carbon, and improve landscape values. At its simplest, agroforestry, in our view, is a useful all-encompassing term for the deliberate management of trees and shrubs on farms.

Nonetheless, specific or comprehensive definitions are important. Shared definitions improve understanding, particularly with respect to new land management practices. Definitions are also important for policy-makers and funding bodies. For example, the increasing government support for farm forestry in Australia during the 1990s generated a great deal of debate over whether farm forestry was different from forestry on farm land. Alexandra and Hall (1998) highlighted the importance of a clear distinction because ‘the lumping of all forestry together tends to blur the issues which are important to farm forestry’. Detailed definitions of plantation types, they argued, are required, not for pedantic reasons but because, by accurately recognising the differences, policies and programs can be targeted accurately.

The National Policy Director for Australian Forest Growers, Alan Cummine (1999), acknowledged that political forces were instrumental in driving sector and government support for particular definitions during the 1990s. He suggested that the industrial sector, while initially keen to discredit farm forestry, were nonetheless seeking to promote the concept of a seamless continuum between industrial forestry and farm forestry when funding for the National Farm Forestry Program was increased in 1995. This is evident in the model for defining forestry-related land management practices produced by Prosser (1995), representing the National Association of Forest Industries (Figure 1.1). His model was later adopted by many agencies including government departments responsible for administering farm forestry research and development (Donaldson and Gorrie 1996).

Within a few years, social research commissioned by government in response to community and environmental concerns over the rapid expansion of corporate or industrial plantations on formerly family-owned farms rekindled debate on terminology and definitions. Pearson et al. (2000) argued that ‘language is important and acceptance of farm forestry is made more difficult when it is confused with social, stakeholder and environmental issues which relate to plantation or industrial forestry’. Schirmer (2000) agreed, confirming that among those in the rural communities where industrial forestry is seen as a threat, farm forestry or the ‘development of plantations on agricultural land owned by farmers’ is seen as very different from

**Figure 1.1:** Farm forestry distinguished from industrial forestry and land protection plantings on the basis of scale and emphasis on timber production (Prosser 1995).
industrial plantation forestry even if it involves the same species grown in a similar manner.

The discussion of plantations on agricultural land continued through the 1990s, but there was also a growing interest in non-timber species (for example for fodder, shelter, groundwater management and non-timber products) recognised as a form of agroforestry without dispute (RIRDC 1992; Bird et al. 1994; JVAP 2002).

A definition for every purpose

Internationally, the definition adopted as the basis for an international scientific journal (Agroforestry Systems Journal) and the International Council for Research into Agroforestry (now the World Agroforestry Centre) in the early 1980s attempted to provide a scientific basis for agroforestry research and acknowledge the wide diversity of existing land use practices that might be included:

*Agroforestry is a collective name for land use systems and technologies where woody perennials are deliberately used on the same land unit as agricultural crops and/or animals, either in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both economical and ecological interactions between the different components (Lundgren 1982).*

This definition is cumbersome but does contain some important elements, especially in defining how agroforestry science might be distinguished from other formal disciplines. First, the term ‘woody perennials’ includes not only trees but shrubs, palms and bamboos. Some of these are important elements of integrated farming systems. Second, the definition emphasises the integration of the woody perennials with agricultural species (crops, pastures, animals) and acknowledges that this may occur at a number of scales, from paddock to farm or even landscape scale. It may also occur over time. Phase farming systems are an example of temporal integration where productive trees may be used to draw down a watertable, then clear-felled, and thereby make the ground suitable for an agricultural phase (see Chapter 3).

A third and most critical point is that in agroforestry systems there is an interaction – physical, environmental or economic – between the agricultural and tree or shrub components. This interaction can be positive or negative. The science of agroforestry focuses on understanding these interactions so that land managers can better design and manage systems that minimise the negative and maximise the positive interactions in a way that best satisfies those involved.

The ecological interactions between these components (Table 1.1) underpin the economic interactions. Even without any ecological interactions the inclusion of trees into a farming system might complement agricultural production by diversifying income or better utilising farm labour or equipment. These economic interactions can be just as significant as the environmental or agricultural benefits that drive most agroforestry projects.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Between (tree, non-tree)</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>(- , -)</td>
<td>Competition between plants for light, water, nutrients and space.</td>
</tr>
<tr>
<td></td>
<td>(0 , -)</td>
<td>Allelopathic interference</td>
</tr>
<tr>
<td>Predation</td>
<td>(-,+ )</td>
<td>Predation of insects pests by birds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Herbivory by pests and livestock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parasitism of productive and pest species</td>
</tr>
<tr>
<td>Mutualism</td>
<td>( + , + )</td>
<td>Mycorrhizal associations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nitrogen-fixing associations</td>
</tr>
<tr>
<td>Commensalism</td>
<td>( 0 ,+ )</td>
<td>The effect of shelter provided by trees on the growth and development of plants and animals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cycling of nutrients of one species via surface litter, organic matter and soil fauna to be available to another species</td>
</tr>
</tbody>
</table>

Source: Modified from Anderson and Sinclair (1993)
One of the difficulties of assessing the net result of the many interactions is that some of the benefits of growing trees may not accrue for many years. Similarly, if the trees are being grown to minimise the impact of a possible environmental or agricultural risk, such as soil erosion, drought, bad weather or failing markets, it may be difficult to quantify the impact of the trees. There may be no way of telling when the trees will be required. Agroforestry design and management is very much more complex than simply selecting a planting configuration or mixture of trees and farming that appears to be more productive or sustainable than farming alone.

Although the International Council for Research into Agroforestry definition provided a useful basis for physical research for the development of a new scientific discipline, it was not appropriate for those outside science. With an eye on the political realities of government funding and public promotion, there has been a tendency to include the anticipated benefits of agroforestry and farm forestry in definitions. For example, when ICRAF was renamed as the World Agroforestry Centre in 2001 it redefined agroforestry as:

A dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (FAO 2008).

The Australian Joint Venture Agroforestry Program (JVAP) provides and manages funds for research on agroforestry and farm forestry, and facilitates delivery of that R&D to industries, communities and government. Its definition of agroforestry and farm forestry presumes the intention of the land manager: ‘Agroforestry or farm forestry is the incorporation of trees into farming systems, for commercial and natural resource management benefits’ (JVAP 2006).

Reid and Stephen (2001) argue that it is not appropriate to define farm forestry as a predefined set of land use practices or to distinguish it from other forms of revegetation on the basis of scale or intention. Nor is it proper to embellish the definitions with attractive outcomes that suggest agroforestry or farm forestry is more profitable or sustainable than alternative land uses. They suggest that what clearly distinguishes a farm forest or an agroforest from a corporate, industrial or government forest is ownership. Not just ownership of the land or the trees, but ownership of the decision to do it and how it is done. Reid and Stephen argue that farm forestry and agroforestry are terms that relate not to the outcome but to the process by which these forests are established and managed, and that it is this process of farmer decision-making that should guide the research and development of agroforestry. They offer the following definition:

Farm forestry (or agroforestry) is the commitment of resources by farmers, alone or in partnerships, towards the establishment or management of forests on their land.

Just as there is little need to define agriculture or forestry, other than what is done by those who see themselves as agriculturalists or foresters, there is no need to define agroforestry on the basis of what it looks like. As Reid and Stephen (2001, p. 7) say:

Farmers may establish and manage their forests for any mix of the benefits they might provide. They may place an emphasis on a single outcome, such as timber production or biodiversity, or they may seek to balance a range of benefits in a multipurpose planting. Their priorities may vary over the farm and change over time. A forest initially established or managed for wildlife or land protection might later be harvested for timber or valued for its beauty (amenity value). Forests on farms may increase agricultural production or simply displace it. They might be sustainable, even improve economic, social and environmental capital, or they may deplete these assets. The farmer, or their partners, may profit from farm forestry or come to regret their involvement. Making a commitment to forestry is not necessarily a good decision – it is simply a decision.

The goal of this book is that: knowledge and experience can improve decision-making, thus helping all land managers, and those working with them, to design and maintain landscapes that better meet their economic, environmental and social aspirations. If that involves the establishment and management of trees on farms, then it might be called agroforestry.
For those involved in the plant and animal sciences of agroforestry, the World Agroforestry definition which emphasises the interaction between the tree and agricultural components of the system provides a clear basis for research. For those more interested in policy, definitions of agroforestry or farm forestry that focus on the ownership of the land may be more appropriate. Our interest, for this book, is the role that trees and forests can play in supporting and sustaining farming systems in Australia. It may not be important whether the trees are integrated with agricultural crops or stock. Neither may it be critical who owns the trees or the purpose for which they are being grown. For us, agroforestry is about the deliberate establishment and/or management of trees in the agricultural landscape of Australia.

Agroforestry in Australia

How and where agroforestry develops in Australia will reflect the interests and motivations of the farmers involved, and the preparedness of various interest groups to reward those who are able to provide the products and services the community value. Some will be consumers of particular products, such as timber or water. They will look to agroforestry as a means of improving the supply and quality of the particular products they are seeking at a price that they are willing to pay. Others will be more interested in the potential for agroforestry to support farmers by improving agricultural productivity, ameliorating land degradation and improving farming incomes or viability through diversification of income. A third group of stakeholders is concerned about broader environmental and social issues such as biodiversity, climate change, social stability and regional development. All the expectations and views of the respective groups are valid, but the link between the groups can be tenuous. Generally, large-scale change is underpinned by tangible markets that provide an income from agroforestry activities.

Much has been made of the great potential for agroforestry to become a valuable contributor to the economic and environmental well-being of rural Australia (Reid and Wilson 1985; Alexandra and Hall 1998). Agroforestry, in its different forms, represents a significant proportion of Australia’s native forest estate and if the trend towards increased plantation establishment continues then farm forestry could become an important component of planted forests. In comparison, in North America more than 10 million non-industrial private forest owners collectively manage approximately half the national forest estate and surpass the combined timber production from industrial and government forests (Biles 2001). However, despite a dramatic increase in the number of farmers taking an active interest in agroforestry and the rise in the financial and political support from government, industry and community groups in Australia, it remains difficult to ascertain if this potential will be realised in the short term.

In this book we review the potential of agroforestry to produce various wood products. We introduce the issues and opportunities facing those establishing and managing agroforestry systems for non-wood products of commercial value. If these forests can also address some of the opportunities for enhancing and sustaining agricultural production, for example by reducing soil erosion or offering protection for livestock, their attraction for farmers is obvious.

Agroforestry can help meet some larger social and environmental objectives, such as catchment-based biodiversity goals. The key issue for landholders whose actions provide these community benefits is the lack of tangible rewards. The relationship between the on-farm and off-farm impacts of agroforestry is therefore critical. Agroforestry systems designed and managed to enhance the viability of the farm may also provide catchment and community benefits. For example, a well-established and maintained windbreak can lead to reduced soil erosion or an improvement in the livestock survival rates from key operations such as lambing. These outcomes will be at a local or farm level and may directly (e.g. increased lambing) or indirectly (e.g. reduced erosion) assist with the sustainability of the agricultural production systems. They will also reduce the off-farm impact of soil erosion, including dust storms.

The most difficult component of valuing the non-wood returns from agroforestry relate to larger sustainability issues and concerns such as biodiversity. There is clear evidence that planting of native trees, especially in mixed species stands, can
dramatically improve the biodiversity habitat of many species (Kavanagh et al. 2005). But how do we establish a system where land managers can do this and gain some economic return? The lack of markets does not detract from the importance or the biophysical need to consider increased mixed species planting to meet these non-wood opportunities. However, the lack of economic certainty limits the capacity of land managers to invest. To increase the appeal of agroforestry we need to understand not only the markets and wood and non-wood values, but also the key social and biophysical drivers.

**Timber production as a driver for agroforestry development**

For large-scale development of any industry it is important that there is a sound economic base and a capacity to operate in domestic and international markets. Due to our large land area and efficiency of production, the majority of Australian agricultural commodities are exported (approximately two-thirds). This varies across the sectors but is expected to increase. Most of the trade now occurs with countries within the Asian sector. In 2005–06 the value of Australian forestry exports was estimated at $2.1 billion, predominantly to countries in the Pacific region including Japan, New Zealand and China. By value, the major export commodities were woodchips ($839 million), paper and paper products ($593 million), panel products ($151 million) and sawn timber ($118 million) (Commonwealth of Australia 2007). In the same period Australia imported approximately $4.0 billion in wood products. The majority of the imports were value-added forest products, predominantly paper, paper manufactures and paperboard ($2.6 billion), miscellaneous forest products, such as furniture ($528 million) and sawn wood ($419 million). The large trade deficit of approximately $1.9 billion acts as an incentive to develop the forest industries that can take low-value products, such as woodchips, and convert them to high-value products, such as paper products. Further, there is a significant opportunity to develop high-value sawn timber. This is of particular interest to agroforestry managers in valuing a long-term product (the sawlog) while managing the system to deliver on agricultural products and environmental services.

The sector needs to yield a competitive return on the investment, however, to be favourably considered. And the investors need to understand some of the risk associated with their investment activities. Agroforestry systems can help address both aspects of financial gain and, with consideration, larger economic gain for the community. Appropriate government policy and initiatives are critical to meeting these targets.

Much of the policy developments in Australia over the last 15 years have been driven by the National Forestry Policy statement (NFPS) delivered in 1992 (DAFF 1995). The goals offer a strategic direction for private native forests and plantations. For native forests, the NFPS goal is:

*Ensure that private native forests are maintained and managed in an ecologically sustainable manner, as part of the permanent native forest estate, as a resource in their own right, and to complement the commercial and nature conservation values of public native forests (p. 4).*

The NFPS clearly recognises the importance of private native forests. Their capacity to contribute to the total value of native forests wood products has increased significantly since the introduction of the Regional Forest Agreements in the mid 1990s.

The NFPS goals for plantations are:

*Expand Australia’s commercial plantations of softwoods and hardwoods so as to provide an additional, economically viable, reliable and high-quality wood resource for industry. Other goals are to increase plantings to rehabilitate cleared agricultural land, to improve water quality, and to meet other environmental, economic or aesthetic objectives.*

The scale of plantations has increased in Australia since the end of the 20th century. This activity is underpinned by *Plantations for Australia: The 2020 Vision* (Plantations 2020 2003). This strategy aims to guide the sustainable expansion of the plantation forest estate, including significant private sector investment. By 2020, the expanded plantation forest estate will provide Australia’s plantation-based processing industries with the capacity to:

- operate in the global marketplace;
- be internationally competitive;
be commercially oriented – market-driven and market-focused in all their operations (Plantations 2020 2003, p. 5).

Thus the development of plantations is intended to increase the production of wood and wood products, especially from private investment and generally based on cleared agricultural land. Importantly, the 2020 Vision states that ‘returning trees to the landscape as a profitable crop can also significantly benefit rural and regional communities and the environment’ (Plantations 2020 2003, p. 5). However, this objective leads to conflict in some areas over production-scale forestry replacing cleared agricultural land operations.

Carbon markets and other drivers for agroforestry development

Not only is the potential value of wood products changing in a dynamic international market, but so are the expectations of delivering non-wood products and values from government and privately controlled land. This recognition is being followed, albeit slowly, by developing markets such as carbon trading.

Nicholas Stern, when reviewing the potential economic impact on climate due to changing greenhouse gas concentrations, described it as the greatest market failure the world has seen (Stern 2007). The potential impacts from climate change on life, human lifestyles and the economy in Australia are highly significant and calling for urgent action (Garnaut 2008). The potential mechanisms for international carbon markets are described in Yamin (2005) and Australia has responded with its Carbon Pollution Reduction Scheme (Australian Government 2008).

While agroforestry will have a role in addressing some of the market drivers (e.g. sequestration of carbon within an emissions trading scheme), the opportunity and influence on agroforestry activity should be viewed within the context of other non-wood products and issues. The relative importance of the drivers may change (for example, the introduction of the Carbon Pollution Reduction Scheme in Australia will lead to the development of a price for carbon and forestry activities benefit from early participation). But the development of robust agroforestry activity needs to account for multiple outcomes for large-scale implementation. Some of these considerations, from an economic perspective, are outlined by Thompson and George in Chapter 18.

Not only will agroforestry be able to meet opportunities through mitigation of climate change, but there will need to be further consideration of adaptation for the long-term survival and productive capacity from the systems. Climate change will potentially lead to altered conditions for species as temperatures increase, rainfall patterns shift and the general climatic patterns become more variable. These issues are beyond the scope of our work but should be considered in the planning and management of future agroforestry systems, especially where species may already be at the limit of their natural ecophysiological range.

Other social or environmental drivers of land use and management change include the development of peri-urban activities, where small-scale farms are being managed by people with off-farm income. There is significant opportunity for agroforestry systems to meet some of these non-wood values, but planning is required. There will always be an opportunity to balance the wood and non-wood values from agroforestry systems, but for large-scale uptake there must be markets that will allow land managers to remain economically viable. The value of wood products is important to regional areas and Australia; we now consider some of the scale of the forestry output.

Production value of agriculture and forestry in Australia

Australia is the most urbanised country in the world, with approximately 84% of its (now) 21 million people living in the major cities around the coast (Hamnett and Freestone 1999). Though now predominantly urbanised, Australia has historically relied upon significant primary production, especially for international markets. Following the fundamentals of economic development, primary production has retreated from that dominance as other sectors of the economy advance. Today, primary production directly contributes only about 3% to the Gross Domestic Product. Nevertheless, in 2005–06 the value of Australian agriculture was estimated at $38.5 billion while the gross value of logs removed from forests (value at the mill door) estimated at $1.7 billion (DAFF 2007). An important...
aspect of the forest industry is the value-adding along the supply chain. Wood and paper products, for example, support the manufacturing and construction sectors of the economy.

There are about 155,000 farm enterprises in Australia (ABS 2008) and forestry is the second-largest manufacturing industry, with 83,000 jobs (DAFF 2007). Agriculture and forestry are critical for employment and local economies for the estimated 16% of the population living in rural areas. Apart from the economic links between country and city inhabitants, agriculture and forestry together are highly significant in their impact on the ecological services provided by natural resources that all Australians rely on. Schirmer et al. (2005) estimated that, in the south-west slopes of New South Wales, for each dollar invested in plantation forestry approximately $1.63–1.81 was generated within the local economy. Of this, some $0.31–0.49 was spent in local wages. This has significant implications in areas where farm returns have declined over long periods and the capacity to increase local employment exists, especially through processing of wood products.

The size of the Australian agricultural sector is dependent on market conditions (including the Australian dollar and commodity prices) and on local environmental constraints such as drought. For example, in the summer of 2007 around 60% of broadacre farmers indicated their properties were drought-affected. This is the same proportion that was drought-affected in 2002 (ABARE 2007). The effect of drought is expected to worsen with climate change impacts – the capacity to adapt and mitigate the problem is critical.

**Land use and agroforestry**

Agricultural and public production forestry utilise significant areas in Australia to support the production of primary industries goods and services to the economy (Table 1.2). There are approximately 163 Mha of forests in Australia covering about 21% of the land area and comprising just over 4% of the world’s forests. About 13% of the forest estate is formally protected in nature conservation reserves (BRS 2007a). The majority (approximately 70%) of Australia’s native forests are controlled through private management, via leasehold or outright ownership. Thus private forestry has a significant role not only in meeting wood and wood products demand but also in managing forests to achieve better environmental outcomes through maintaining or enhancing biodiversity, water quality and carbon sequestration. However, the lack of transparent markets in these non-wood values limits some of the opportunities for the land managers. These managers carry significant costs, reducing production capacity to meet environmental policy (Productivity Commission 2004).

### Table 1.2: Land use in Australia

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area (Mha)</th>
<th>% of total land area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantations</td>
<td>1.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Agriculture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural and horticultural crops</td>
<td>26.7</td>
<td>3.5</td>
</tr>
<tr>
<td>Grazing</td>
<td>442.4</td>
<td>57.5</td>
</tr>
<tr>
<td>Total</td>
<td>469.1</td>
<td>61.0</td>
</tr>
<tr>
<td>Native forests and woodlands</td>
<td>162.7</td>
<td>21.2</td>
</tr>
<tr>
<td>Public native forest where timber production is permitted</td>
<td>11.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Forests in nature conservation reserves</td>
<td>21.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Other categories</td>
<td>129.8</td>
<td>16.9</td>
</tr>
<tr>
<td>Total</td>
<td>162.7</td>
<td>21.2</td>
</tr>
<tr>
<td>Total land area</td>
<td>766.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: Parsons et al. (2007)
The 2007 National Plantation Inventory Update (BRS 2007b) indicates that in Australia there are about 1.82 Mha of plantations. Some 807 500 ha are hardwoods, almost 1 M ha are softwoods and 9254 ha are unidentified (Table 1.3). Between 1997 and 2007 most of the increase in plantations was for hardwood investment. For example, in 2006 there were 67 200 ha hardwood established compared to 11 100 ha of softwoods. Most of the plantation development is carried out by companies linked with managed investment schemes.

The National Farm Forestry Inventory (NFFI) indicates that over the last thirty years there has been a significant increase in the area of small grower plantations (Stephens 2001). Table 1.3 shows that only about 9% of plantations are located on farms. While the penetration of forestry into the agricultural sector is good for correcting the trade imbalance for wood products and rehabilitation of degraded agricultural land, a balance must be found between changing land uses. Only 0.2% of the land resource is under plantation forestry, but there is a common perception of conflict with ‘traditional’ agricultural land use. As agricultural landscapes change with tree plantations, there is considerable concern about the social, economic and environmental impacts of large-scale monoculture eucalypt and pine plantations (Spencer et al. 1989; Schirmer 2000; Hopton et al. 2001; Schirmer et al. 2005).

In this context, the way that agroforestry is implemented becomes important in balancing the needs of production and scale with local community perceptions and aesthetic values. This leads us to consider the people in these communities who will implement these changes to land use and production.

### Human capital and agroforestry

As a group, farmers are getting older. The average age of farmers in 2006 was estimated to be 52, and it is increasing (ABS 2008). The next generation has less interest in managing the family farm. There are significant demographic changes in rural Australia, which mean there will be new attitudes to planting trees on farms. Many of the younger farmers who take control of existing family farms (and sometimes significant debt) need to maintain profit and cash flow. They will not be interested in broad-scale agroforestry unless it is a commercially competitive option. As detailed in Chapter 17, they will assess an agroforestry investment with a high discount rate. Other landholders, especially those near large regional towns or cities, are more inclined to focus on lifestyle over production or look at lower input systems (Barr and Wilkinson 2005). The ‘tree-changers’ who move from urban to rural areas for lifestyle reasons may view agroforestry with a low discount rate, i.e. environmental and aesthetic values dominate over future financial return. Age, attitude and financial means influence the individual likelihood and capacity to adopt agroforestry. Efforts to enhance the adoption of agroforestry to increase natural resource management outcomes will need to consider the heterogeneity of the audience and their preferences.

### Table 1.3: Estimated areas of plantations located on farms across Australia, 2005–06

<table>
<thead>
<tr>
<th>State</th>
<th>Total plantation area</th>
<th>Hardwood</th>
<th>Softwood</th>
<th>Unknown plantation</th>
<th>Estimated area ‘farm forestry’</th>
<th>% forestry on farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>WA</td>
<td>377 598</td>
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Source: BRS (2007a)
goals. The extension strategies used to support agroforestry are detailed in Chapter 19. We need to accept that provision of information alone will not necessarily increase the adoption of agroforestry (Pannell et al. 2006). The mechanisms of government policy for enhancing adoption are discussed in Chapter 18.

**Agroforestry for integrated NRM**

Agriculture and forestry are conventionally considered as separate sectors of the natural resource economy with traditionally different physical resource bases, geographic distribution and ownership and investment structures. Agroforestry straddles the two sectors, as the traditional boundaries are being blurred. The case has been made that drivers in the forestry sector will ensure that farm-grown trees will be an important component of that sector; the essential driver in the forestry sector is economic opportunity in a world market increasingly requiring more wood products. Earlier sections outlined changes in the resource base and social structure in the agricultural sector that underpin the increasing role of trees in agriculture. We could argue that the essential driver for agroforestry in the agriculture sector is the need for sustainable and profitable management of the natural resource base.

While agriculture is a still a significant contributor to Australia’s export income it has declined in relative importance to other sectors in the national economy. This decline has been shadowed by changes in the demography of rural populations and their political influence. Agricultural research has evolved from a focus on increasing productivity to considering the sustainability of agricultural systems, particularly in relationship with larger landscape processes. All this change has occurred across one or two generations of farmers – farmers who will be caring for the land in 2020 will have a very different environment from their predecessors. In aggregate, they will be wealthier and manage larger, more technologically and commercially sophisticated operations which will be more closely and efficiently linked into global commodity supply chains (Barr 2003).

These farmers will be widely recognised for their role in managing the landscape to sustain its ecological services, particularly water, carbon and biodiversity. Agricultural systems will have to be more closely adapted to Australia’s fragile soils, highly variable seasons and increasingly changing climate. Some agricultural systems may, to some degree, mimic natural ecosystems in structure and/or function (see Chapter 2). We may see a proliferation of new income streams as farmers are paid for non-wood values such as the carbon they store, the biodiversity they maintain and the extent to which they manage water, increase catchment water yield and reduce catchment salinity (Williams and Saunders 2002). Innovative thinking is leading discussion on the value of forest management for environmental outcomes and the concepts of stewardship payments to land managers (Southern Cross Group 2006). Already we are seeing concerted efforts to establish new tree-based industries for pulp and energy production in agricultural areas (Chapter 16).

The role of non-horticultural trees in rural landscapes has traditionally been secondary to the field crops and pastures that provide the marketable commodities. Trees and shrubs have had a role in protecting crops and soils (Chapter 5) and livestock (Chapter 13), and in providing fodder (Chapter 14) and landscape amenity (Chapter 8). However, over the last two decades there is general acknowledgment of the importance of farm trees in maintaining the hydrological balance (Chapters 3 and 4) and biodiversity of rural landscapes (Chapter 6). Direct income from farm trees is now a possibility for many landholders (Chapters 10–12), not just the enthusiastic few. There has also been growing awareness of the multi-functionality of rural landscapes beyond providing just grain and meat.

Agroforestry is finding a niche in ‘amenity farming landscapes’. Generally, this is the classic rolling green hills where urban escapees retire or seek a tree-change in lifestyle. Similarly, peri-urban landscapes offer an opportunity for small-scale tree planting. The price of land in these landscapes is usually beyond the means of viable farm business investment and the main income of landholders is from off-farm sources. Agricultural income may be niche horticulture or small-scale grazing of beef or sheep, not without attendant problems. The beef industry is increasingly geared to paddock-to-plate quality control procedures beyond the means of small producers. Running sheep in more densely
populated landscapes with non-farm dogs also has problems. Finally, weed and pest management can be a significant problem for time-poor or indifferent landholders (Barr 2003). In this context, small-scale tree planting for a long-term investment, perhaps to be realised as part of a local farm-forestry cooperative, offers an aesthetically and ethically satisfying alternative land use.

The Decade of Landcare (officially 1990–2000) was largely responsible for the huge expansion of farm tree planting in areas of broadacre agriculture and grazing (Walker 2000). Plantings were mostly for soil conservation, stock shelter and fodder, groundwater control and wildlife habitat. They were the sign of an awakening and cultural change, especially among younger farmers. Landcare relied on committed individual and community efforts, from people who could see beyond the bottom line of annual gross margins. It remains to be seen how firmly embedded the tree-planting ethos is as farm sizes increase, their business structures become more strongly coupled to global markets and the rural population continues to decline. For agroforestry to flourish in this context we will need new tree-based industries for low-rainfall areas. These are likely to be multi-product industries (e.g. fibre and energy) that are supported by incentives from other natural resource sectors, such as energy and water supply. Woody–perennial fodder systems may cover even larger areas of this landscape as they will be more easily integrated into existing agricultural systems. The search for these, as well as herbaceous–perennial farming systems, is central to the activity of the Cooperative Research Centre for Future Farm Industries (2008–2014).

Natural resource management is planned and implemented in Australia through 56 regional bodies or catchment management organisations with various structure and functional arrangements (Pannell et al. 2007). The funding of resources has been devolved to the local (catchment) level. This allows for better identification and recognition of, and relationship to, specific issues. For agroforestry opportunities and issues, placing responsibility and action at the local level delivers improved understanding and better on-ground outcomes.

NRM bodies share the task of integrated management of a broad range of natural resource assets, one of which is perennial vegetation. Agroforestry is a land use option that integrates income generation for landholders with, most notably, ground and surface water management, soil conservation and biodiversity management. It can also be a consideration in the regional management of pests, weeds and fire. Planning and management around these issues relies on a good understanding of the nature and options of agroforestry and a recognition of the dual role of production (e.g. wood) and sustainability from the managed system.

Whoever is considering agroforestry, whether at the level of an individual property or as an option that may that may be promoted across a region, will need an understanding of the design and planning processes in agroforestry (discussed below). Identifying the key objectives, and applying suitable species and styles to attain those objectives, is critical in developing a robust agroforestry system capable of delivering a successful outcome.

## Design and planning processes in agroforestry

There are essentially two approaches to agroforestry design: the ‘best bet’ and the ‘diagnosis and design’ approaches.

### ‘Best bet’ approach

The ‘best bet’ approach is where a landholder simply copies the species, establishment techniques, planting arrangement and management used or advocated by others. The design and practices being adopted may have been proven effective by industry, researchers or other landholders. This approach can be effective but overlooks the potential, and the possibly the need, to adapt the design and management of agroforestry systems to better reflect the objectives, resources, attitudes and opportunities facing each particular landholder.

If agroforestry design were as simple as selecting off-the-shelf packages or recipes there would be little need for a book like this. All that would be needed is a collection of best bets or design options developed by researchers and practitioners for every region. Landholders would simply pick the one that seems to suit. They might prefer options developed by people like them or those used in their region on similar soil types, or they could just
choose options that appear affordable and appeal to their sense of aesthetics. It would be a bit like going to a used-car yard – you look at all the models on offer and pick the one that seems the best, fits your budget and matches your self-image.

It is easy to assume that every tree-grower faces the same constraints (e.g. limited land, time or money) and measures success in the same way (e.g. discounted returns per hectare). In our experience this is not always the case (see Chapter 17). As every farm family and every farm is different, it follows that the most appropriate agroforestry design for each will be unique. People have different attitudes to investment risk, measure profit in different ways and have diverse views about the likely future value of different products and services. And these attitudes may change over time. The situation is even more complex where landholders are seeking a mix of commercial and non-commercial benefits from their trees.

**Diagnosis and design**

As Andrew Campbell wrote when he was the National Landcare Coordinator, ‘the complexities inherent in sustainability and the primacy of farmers in making land management decisions mean that a recipe approach to land management recommendations won’t work’ (Campbell 1994, p. 200). Fortunately the alternative is not only practical, it is less risky, more affordable and likely to be much more rewarding. It involves a diagnosis of the concerns, opportunities and aspirations of the landholders, a review of the role that trees and forests might play, the design of possible agroforestry systems and evaluation on the basis of the rewards, costs and risks associated with each.

The importance of this book lies in the fact that a landholder with clear objectives and some basic knowledge can design and manage an agroforestry system that best matches their own circumstances, acknowledges their particular exposure to risk and maximises the suite of rewards that are most important to them. The diagnosis and design approach provides a guide to developing unique agroforestry designs for each situation. The key difference is the starting-point: rather than having a particular species, layout or management plan in mind, it starts with a review of the landholder’s particular circumstances and the role that agroforestry might play in addressing them. Then, based on the landholder’s individual constraints and goals, possible designs are developed and tested. Their advantages and disadvantages are highlighted in a way that informs landholder decision-making.

An important advantage of this approach is that it acknowledges that forests planted for a particular purpose can be designed and managed to deliver a range of benefits over time. For example, the need for land degradation control or stock shade and shelter may define where trees must be established on a particular property and the role they must play to be effective in the short term. Then, if the landholder has an interest in producing timber, they may consider how to adapt their design to incorporate commercial species and forest management options that keep alive the possibility of harvesting a commercial product in the future (see Figure 1.2).

Much of this book is dedicated to providing an understanding of the processes underlying common land management problems and opportunities facing landholders across Australia. Chapters 2–8 describe the underlying processes and role of growing and managing trees on farms in meeting these needs. Chapters 9–16 go further by reviewing the growth and development of trees and exploring the management options available to landholders interested in producing commercial tree products and services. It is this type of knowledge, coupled with the aspirations and experience of landholders themselves, which is required to design and manage successful appropriate and adaptable agroforestry systems.

**Planning tools for agroforestry**

There are a number of planning tools and techniques that are can be used during the diagnosis and design process. Some are systematic or step-wise techniques for planning the most appropriate location of trees on a farm; others are conceptual tools for exploring the structural design and management options that may be feasible.

**Data overlay method**

Many landholders are now familiar with using an aerial photograph and a series of plastic overlays as a planning tool to determine the location of fences,
roads, stock laneways and revegetation projects. Information not shown on the aerial photograph, such as soil types, contour lines, vegetation types, threats, fence lines and recent improvements, can be added to a base overlay sheet, thereby providing more information when exploring possible fencing and planting locations.

The increasing availability of physical and production data and software means that the overlay method can be extended to incorporate annual crop-yield data, real-time soil moisture measurements and other information that can improve farm management decision-making. The value for agroforestry design lies in highlighting opportunities for fitting tree-growing into the farming landscape, complementing other farming activities and improving economic and environmental landscape function.

Analogue systems (mimicking natural systems)

The term ‘analogue forestry’ was first used to describe an approach to system design and evaluation that promotes options which closely mimic the structure and function of natural forests (Senanayake and Jack 1998). The underlying assumption is that we can learn a lot about the productive and ecological potential of a site by looking at the structure and function of the native vegetation. An example is the use of nitrogen-fixing tree species in eucalypt plantations that mimic the natural species mix common in native eucalypt forests found in the area. In some cases the emphasis might be on the aesthetics rather than functionality. For example, the aim might be to recreate the open woodland or parkland appearance thought to have been induced by Aboriginal fire-stick farming, but using sheep, improved pastures and wide-spaced

Figure 1.2: Appropriate agroforestry design for multiple outcomes begins with an understanding of the problems and opportunities. This example of a multi-purpose riparian buffer seeks to achieve a range of commercial and non-commercial outcomes while maintaining management flexibility (Abel et al. 1997).
commercial timber trees instead of kangaroos, native pasture and old twisted red gums.

Flow diagrams
Many natural and production systems that occur on farms can be broken down into a number of distinct steps or stages and presented in a flow diagram. Displaying the annual production cycle associated with the production of farm stock or crops as a flow diagram can highlight opportunities for trees to enhance productivity or reduce risk. The stages involved in establishing, managing and harvesting tree products can also be presented in a flow diagram. This may be useful in highlighting when and how much labour is required for particular management activities, planning harvesting operations or identifying when the landholder needs to begin learning new skills or negotiating with buyers.

Cause and effect relationships
In this book we review the theoretical and scientific knowledge of the processes underlying common natural resource management problems on Australian farms. When coupled with landholders’ experience, observations and on-farm research, this information can help build understanding of the processes that link a particular action (e.g. tree planting) with an outcome (e.g lowering water tables or reducing wind speeds). However, tree planting can result in unintended consequences. Good design requires broad-based thinking about the possible impacts of a proposed agroforestry system on all aspects of the farming system, before the trees are planted.

Good agroforestry design allows for change
Designing a new tree planting project is a little like designing a house to suit a particular family – a review of the family’s needs and aspirations now and in the future is essential. However, the process of managing a forest is never completed. Forests are dynamic and landholders must continually adapt their management in response to changing circumstances. Good agroforestry design involves exploring opportunities and planning for uncertainty so that the decisions made now provide the greatest prospect of success in the future.

Summary and invitation to this book
There are many good texts that lay the foundations for an understanding of natural resource management (Aplin 1998; Yencken and Wilkinson 2000; Dovers and Wild River 2003). There are some fine books describing and prescribing the practice of agroforestry in Australia (Abel et al. 1997; Reid and Stephen 2001). Agroforestry for Natural Resource Management presents a multi-disciplinary perspective of how agroforestry is being used as a strategy for sustainable management of Australia’s natural resources. The authors come from a wide range of disciplines – agronomy, forestry, community and molecular ecologies, agricultural economics, soil science, hydrology, landscape architecture and rural sociology. They are writing for students and professional practitioners of natural resource management as defined earlier in this chapter.

The scope of agroforestry in this book is the planting of trees and shrubs on rural property largely, but not exclusively, with an intention to manage dryland salinity. This will include plantings in high- (>700 mm) and low-rainfall zones in southern Australia. The trees may be grown for timber and other commercial outcomes or for environmental outcomes only.

The book is divided into three sections, each with a different focus.

Part I: Environmental function of trees in the landscape
This section examines the main environmental functions of trees in the landscape.

It opens with Ted Lefroy’s discussion, ‘Agroforestry for functional mimicry of natural ecosystems’.
The powerful concept that our agricultural systems should mimic the structure and function of the natural ecosystem has encouraged scientists to look for productive land management systems that are in tune with the landscape, that do not deplete resources and degrade the land. As most natural land ecosystems are dominated by woody perennial species, agroforestry is an obvious way to re-invent our agricultural landscape. Lefroy provides challenging answers to important questions. Is it necessary to mimic structure to achieve functional goals? Does perenniality inevitably imply a trade-off in productivity? Can competition be managed in synthetic polycultures of trees and crops? How can complex farming systems be successfully managed to ensure a return to the farmer?

An important function of agroforestry in some landscapes is to control groundwater and thereby mitigate dryland salinity. Land managers have to integrate a lot of difficult science to develop and implement revegetation strategies. It is equally important to know when revegetation is not the answer, when other strategies, such as drains, are more appropriate. In Chapter 3, 'Using trees to manage local and regional water balances', Keith Smettem and Richard Harper provide the fundamentals for understanding the hydrological and physiological processes behind the use of perennial vegetation for mitigating salinity. They offer advice for the strategic placement and configuration of tree planting in the landscape.

That chapter is complemented by the next, 'Agroforestry for the management of water, salt and agricultural diffuse source pollutants', by Tim Ellis and Albert van Dijk. Where Chapter 3 focuses on groundwater and salinity, Chapter 4 discusses the management of surface water and the pollutants it carries, including sediment and nutrients responsible for eutrophication as well as salt. It describes the hillslope scale processes by which tree plantings may capture water and pollutants and their effects on stream flow and dryland salinity at catchment scales. It provides an insight into the type of experimental and modelling work undertaken to understand these linked stream–groundwater systems. Guidelines on the design and placement of agroforestry plantings are provided specifically for the purposes of surface water and pollutant management.

The scale of revegetation required to restore the pre-agriculture hydrological balance is vast. Most of this landscape is under broadacre crops and pastures. We cannot afford to blanket the landscape with trees at the expense of agriculture. The shelter provided by trees is often touted as a commercial justification for integrating tree-planting with broadacre agriculture. In Chapter 5, 'Trees protecting dryland crops and soil', Ian Nuberg and Mike Bennell examine this concept in the light of international and recent Australian research. They show that trees can provide considerable shelter to dryland crops and are particularly important during extreme wind events in dry years. We are fooling ourselves if we believe that windbreaks will elevate net crop yields over large areas of Australia, but they can insulate against storm damage to crops and soil as well as enhance livestock production.

Protecting and enhancing biodiversity is another compelling reason for promoting agroforestry. Agroforestry plantings cannot substitute for native vegetation communities but they can provide some of the resources necessary for some regional wildlife and native plants. David Salt and David Freudenberger, in 'Biodiversity and habitat enhancement' (Chapter 6), help us understand biodiversity and how agroforestry can enhance it in agricultural landscapes. They provide very practical guidelines to follow in planning and managing an agroforestry enterprise for biodiversity. The chapter includes case studies where these principles have been applied.

The simple act of planting trees does not necessarily improve biodiversity. Indeed, as Chapter 5 explains, a poorly designed plantation can be an environmental liability. Not only can it have little positive value for local flora and fauna, it can have a serious negative impact. Most people relate this to exotic tree species, such as pines, and consider any Australian native species a more benign alternative. However, in Chapter 7, 'Environmental risk in agroforestry', Margaret Byrne, Lynley Stone and Melissa Millar describe the weed and genetic risks associated with the use of native species for large-scale revegetation for agroforestry, even within their natural range. This is not a call to limit agroforestry to protect biodiversity, but to employ risk management frameworks in the implementation of revegetation programs.

The final chapter on the environmental functions of agroforestry is Chapter 8, 'Landscape aesthetics and agroforestry', by Grant Revell. Revell
uses the word ‘landscape’ in a very specific way. The landscape is the way we sense the environment, filtered through our values and belief systems. Our perceptions about whether a landscape is being well or poorly managed are grounded in our culture. While land managers may think that they are managing biophysical resources for the private and public good, Revell shows how they are also the creative managers of cultural symbols. How do we make environmental features important for biological reasons and economic values important for landscape aesthetic reasons? Revell discusses different paradigms of landscape assessment according to their resource management priorities. The chapter offers design guidelines and case studies that illustrate the meaningful and multiple benefits of agroforestry planning from this understanding of landscape.

Part II: Productive function of trees in the landscape

Chapters 9–16 provide a comprehensive discussion of how trees and shrubs can be used for productive purposes in southern Australia.

The primary productive function of a tree is its wood, and the section begins with Rowan Reid’s ‘Wood as a farm product’. Land managers dealing with tree planting do not have to be foresters, but they do need to understand wood as a product for the trees to reach a market and for the landholder to receive a worthwhile return. Reid describes tree and wood growth and how we can manage inter-tree competition in a plantation to achieve the optimum yield and quality of marketable wood. With an explanation of log prices and harvesting costs, Reid outlines management principles that will achieve the best trees for different target products. Reid follows this in the next chapter, ‘Growing high-quality sawlogs’, in which he describes in greater detail the silviculture, value-adding and marketing of farm-grown sawlogs.

Sawlogs are by no means the only wood product available from farms: firewood and pulp are two very important alternatives. Sawlog production has traditionally been restricted to higher-rainfall environments (>700 mm) and great advances are being made in extending its range into the lower rainfall zone (>400 mm). In Chapter 11, ‘Farm firewood production’, Peter Bulman and Ian Nuberg show how the relative value of firewood versus sawlog production is strongly determined by the costs of production, changes in the value of the products and the value given to an early harvested product. Depending on the physical and economic context, firewood production can sometimes compete with sawlog production even under relatively high rainfall situations.

In Chapter 12, ‘Pulpwood production’, Richard Harper, John McGrath, Keith Smettem, Rowan Reid and Andrew Callister describe the history and extent of this very important industry. Covering an area of approximately 500 000 ha in 2006, Tasmanian blue gum production for pulpwood is the largest form of farm forestry attracting significant private investment from urban sources. The chapter outlines the process of site selection and yield prediction, crucial elements of the planning process for blue gum establishment. It discusses the environmental, legal and marketing issues associated with blue gum production – understanding these is very important for farm foresters and land use planners, to ensure that the plantations are in the right place for the right reason. The chapter also includes an outline of the essential steps in the growing of blue gums.

There are more than 400 million ha of grazing land in Australia, where trees can most readily be integrated with the agricultural system. In Chapter 13, ‘Trees in grazing systems’, Rowan Reid reviews our understanding of the impact of trees on pasture and animal production. Trees will compete with pasture just as they do with crops but the relative net effect on pastures is less severe. When the marked benefits of shade and shelter on animal production are included, along with the opportunity for wood production in higher-rainfall areas, trees can be easily justified on a farm financial basis. Reid illustrates this with a case study of integrating multi-purpose trees and grazing on a property in Victoria.

About 1 million ha of Australia’s are in low-rainfall (300–450 mm) saline landscapes and may not be suitable for the trees and systems that Reid describes. Naturally occurring saltbush (Atriplex spp.) has long been the basis of the pastoral industry in the southern pastoral zone, where these plants have high levels of salt tolerance. Ed Barrett-Lennard and Hayley Norman describe the use of saltbush in Chapter 14, ‘Saltbush for fodder production on Saltland’. They describe the types of saltbush
that can be used for plantations as drought reserve or fodder on saline lands. When matching sites to pastures that include saltbush, it is important to understand the relationships between saltbush production and salinity, waterlogging and inundation. The chapter explains what can be expected from animal production and water use on saltbush pastures, and the key to their establishment.

Fodder is not the only productive land use on saline lands and Nico Marcar explores this issue further in Chapter 15, 'Productive use and rehabilitation of saline land using trees'. Salinity is one of the major forms of land degradation affecting agricultural lands, so Marcar outlines the problem's extent and nature before explaining the range of native timber species' genotypic response to salinity. This needs to be understood so that farm foresters can minimise the risks to growth when planting trees in saline landscapes. Marcar describes the main tree planting configurations being followed and how the economic opportunities in timber and non-wood products from these trees depend on growth rates, product quality and market considerations. He shares his thoughts on the prospects for the rehabilitation of saline lands with productive trees.

This section on the integration of productive woody perennials into farming systems is capped off with a case study of mallee in the wheatbelt of Western Australia. John Bartle's chapter, 'Integrated production systems', reviews the development of a short harvest cycle, mallee coppice system which produces oil, bioenergy and industrial wood and carbon products at the same time as controlling groundwater responsible for dryland salinity. It is a heroic task which, at the time of publication, is still not completed. The chapter shows the complexity and long development time involved in developing a new industry based on woody perennials.

Part III: Implementation of agroforestry

This last section (Chapters 17–19) of the book discusses the essential points of implementing agroforestry: how to evaluate agroforestry, how government policy can facilitate agroforestry, and the adoption of agroforestry by landholders.

David Thompson and Brendan George's chapter, 'Financial and economic evaluation of agroforestry', outlines the essential principles and techniques of evaluating the financial feasibility of agroforestry systems as a farm business, and the economic impact at the catchment level. It outlines a study of an agroforestry system, detailing the essential criteria and comparing farming options.

This systematic financial and economic approach is useful for landholders to make decisions about investing in agroforestry. It is also essential for resource managers to be able to make economic measures of the environmental benefits from agroforestry. However, other criteria are of equal importance, including farmer intentions and capacity to operate. Some issues and opportunities are poorly addressed through economic considerations and market mechanisms do not always reflect where community and environmental benefits can be realised, allowing the government to intervene. David Pannell's chapter, 'Enhancing the environmental benefits of agroforestry through government policy mechanisms', discusses the circumstances in which government intervention to enhance environmental outcomes from agroforestry is appropriate. He weighs the pros and cons of a wide variety of policy approaches and mechanisms, and concludes with the difficult question of who should pay for the public environmental benefits generated on private land.

In the final chapter of this book, Digby Race discusses the adoption of agroforestry in Australia. He presents a historical and policy context determining adoption of agroforestry, with a focus on medium- to low-rainfall areas or the wheat-sheep zone, then outlines various extension strategies for enhancing adoption of agroforestry.

The DVD

The DVD that accompanies this book offers the following material to complement and enhance the knowledge presented in the text. This material includes tools and instructions as well as inspirational stories.

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### References


– Investing in Future Wood Supply. 9–12 September, Mt Gambier, SA. p.7.


