3 Social, economic and environmental considerations

In the last 100 years there have been rapid changes in how society views forests. Perley (1997) suggested that these changes have been driven by evolving human values. Human values and our world view arguably dictate which management regime is "right" at any given time. Initially, radiata pine plantations were seen as a means for meeting wood requirements. Over time, economic return became the priority. Today, a higher value is placed on ecological values, social services and sustainability. The nature of societies is also evolving rapidly. This chapter reflects these changes in human values.

SOCIO-ECONOMIC SETTING

The establishment of radiata pine plantations began in the first half of the twentieth century and expanded rapidly in the second half. Only in the last decade has planting on new land decelerated and in some cases even contracted. This pattern of development has occurred because of changing societal needs and values. Although the contexts and societies are diverse, in all cases the impetus for planting radiata pine plantations derived from the demand for timber, at least in part. The social setting and the drivers for radiata pine plantations is explored below in the contexts of Australia, Chile, New Zealand, South Africa and Spain.

Australia

Australia is a developed industrialized country (Table 3.1) with some 147 million ha of native forest stretching over 19 percent of its total land area (ABARES, 2011b). Almost all the native forests are hardwoods and 78 percent are eucalypt forests. Closed native forests, however, with over 80 percent crown closure, cover only 4.3 million ha. About 26 percent of native forests are privately owned, with another 44 percent leased from government. In 2010, native forests accounted for about 26 percent of total wood production in Australia, but this had decreased by 44 percent in the previous ten years.

In Australia, plantation forests cover 2 million ha, of which half are softwood plantations. Radiata pine plantations cover 773 000 ha; it is the main softwood species, accounting for three-quarters of the softwood plantation estate (Table 1.2).

Radiata pine forestry began in Australia in the late nineteenth century and, by 1956, some 122 000 ha of plantations had been established (Scott, 1960). Until 1960, almost all radiata pine planting was done by state governments as part of the "softwood import replacement policy" (Gerrand, *et al.*, 2003; FAO, 2004). This was followed by a rapid expansion of radiata pine plantations from the 1960s with the implementation

TABLE 3.1
Characteristics of the main countries with radiata pine plantations

Country	Area ('000 km²)	Population (millions of people)	Average income ($US)	Human Development Index (rank)	Main official languages
Australia	7 741	22	34 300	2	English
Chile	775*	17	13 300	44	Spanish
New Zealand	268	4	23 700	5	English; Maori
South Africa	1 220	50	9 500	123	11**
Spain	505	46	26 500	23	Spanish

* Excludes Antarctica.

** Of the 11 official languages, the main ones are English, Afrikaans, IsiXhosa and IsuZulu.

Source: UNDP, 2011

of a softwood self-sufficiency policy. This successful policy was supported by low-interest loans from the federal government to state governments, which have the primary responsibility for forest management on public lands (FAO, 2004). The state governments of New South Wales and Victoria also provided low-interest loans to farmers, and Landcare programmes were implemented throughout Australia, but these had a relatively small impact on radiata pine planting rates. During this period, private industrial-scale planting of radiata pine forests also occurred, largely without subsidies.

From the 1990s, an expansion of short-rotation eucalypt plantations occurred because of private investment, while the expansion of softwoods declined (FAO, 2004; ABARES, 2011b). During this period there were also tax changes and the removal of other impediments to assist forestry. The 1997 strategic policy "Plantations for Australia: The 2020 Vision" aimed to increase forest plantations to 3.3 million ha, although it is doubtful if this target will be achieved (FAO, 2004). Many state-owned plantation forests were transferred to the private sector from the late 1990s through privatization or corporatization (Gerrand *et al.*, 2003; FAO, 2004). Currently, the biggest role of government in plantation forestry is to provide indirect incentives, such as an enabling environment for commercial plantation investments and their associated industries, and support for research and development. Climate change is likely to limit the area in which radiata pine is suitable for planting (see Chapter 2). Moreover, associated greenhouse gas control measures, including carbon price mechanisms, may eventually have an impact on Australian forest plantations.

In summary, the Australian government's policies have consistently supported forest plantation investment for over 100 years. This stability has given investors confidence that the government is unlikely to change the ground rules. This social setting has been critical for radiata pine plantation development in Australia.

Chile

Chile is a rapidly emerging Pacific economy with forestry accounting for 7.4 percent of its gross domestic product (Table 3.1). Native forests cover about 18 percent of the land area (13.5 million ha), of which 6 million ha is classified as production forest (Morales, 2005). Most of the native forests are in the temperate areas south of 38^{o} latitude. However, native forests supply a mere 6 percent of the country's wood production. Plantation forests cover 2.3 million ha, of which 63 percent is radiata pine; most of the remainder is made up of eucalypts.

The realization that the clearance of native forests was a problem for wood supply led to the passing of a law in 1931 to promote plantation forestry by providing tax incentives as well as greater protection for native forests (Morales, 2005; Armesto, *et al.*, 2010). There was also recognition that these forests could be planted on degraded agricultural land. This increased radiata pine annual planting rates, mostly by private owners, which reached a peak of 49 000 ha in 1949, after which rates declined because of concerns over political instability and land reform. By 1956 there were 200 000 ha of radiata pine plantations in Chile (Scott, 1960). Between 1970 and 1985 the state became involved in planting forests, building an estate of 377 000 ha (Morales, 2005). Towards the end of this period, planting also became a measure to provide employment. The recession of 1983–1985 held up privatization, but the state sold off its plantations in the years that followed.

In 1974, a key Chilean law (DL701) was passed that gave certainty of ownership and provided subsidies for planting forests (Morales, 2005). This law declared "preferred forestry aptitude" areas and provided a 75 percent subsidy for establishment, exemption from land taxes, a 50 percent reduction in income tax and other management subsidies. These benefits were conditional on replanting, and the conversion of native forest to forest plantations was not permitted. There was, however, substantial plantation establishment on degraded secondary forest (Armesto *et al.*, 2010). In the late 1990s the DL 701 law was altered to focus on small growers, erosion-prone areas and other aspects. In 1977, another law was passed to promote foreign investment, which brought in companies and further promoted forest plantations (Morales, 2005). A law promoting the management of second-growth native forest was promulgated in 2007.

In summary, the development of forest plantations in Chile was driven by a need to stimulate economic development and the use of degraded agricultural land. The expansion of the estate was underpinned by free enterprise, free trade and large government incentives. This led to three strong vertically integrated industries based on radiata pine plantations, with much of the manufactured produce exported. Log and chip exports of radiata pine remain minimal.

New Zealand

New Zealand is the smallest of the industrialized countries that grow substantial areas of radiata pine (Table 3.1). Native vegetation covers almost 44 percent of the land area. Improved pastures, native forests and exotic plantation forests cover 33, 24 and 7 percent of the land area, respectively. The plantations are largely on lower-quality land (Adams and Turner, 2012) and 90 percent are radiata pine (Table 1.2). Nearly all the native forests are legally protected, while the plantations are in private ownership and grown for commercial purposes.

Before human arrival some 800 years ago, about 85 percent of New Zealand was forested. By the time of European settlement in the mid 1800s this had decreased to 53 percent, and over half of what remained was subsequently removed for agriculture (FAO, 2004). There was already interest in plantation forests in the late nineteenth century, but large-scale planting only began during the Great Depression of the 1930s and was partly assisted by government schemes for the unemployed. This impetus arose from the 1913 Royal Commission of Forestry, the development of government policies to address issues of wood supply, and the formation of the State Forest Service in 1919. By 1936, almost 300 000 ha of plantations (60 percent radiata pine) had been established, of which the private sector planted about half. In this period, the State Forest Service provided direct and indirect incentives, including research into the management and use of introduced forest trees. Some of this planting was on degraded land or land considered unsuitable for agriculture because of nutrient deficiencies.

The first planting boom was followed by a period (1936–1958) in which the New Zealand government promoted and led the development of large-scale harvesting and use of trees planted during the Great Depression (Roche, 1990; FAO, 2004). These were largely indirect incentives, but the industry and interest in further planting were hampered by price controls on wood.

From the 1960s the government initiated a second wave of forest planting aimed at providing wood and fibre for export, so that by the mid 1980s there were over 1 million ha of plantations. This was assisted by direct incentives to the private sector and tax changes. By 1984, incentives had been used to support one-third of private plantation planting (FAO, 2004). Indirect incentives by way of research and education were also instrumental in developing the industry. Some of this afforestation effort was also aimed at erosion control and providing employment.

From 1984 there was large-scale deregulation of New Zealand's economy, which included the privatization of the vast majority of the state's plantation forests (FAO, 2004). The New Zealand Forest Service was dissolved and subsidies, including indirect subsidies for research and education, were largely removed. One of the objectives of privatization was to spur large-scale industry investment, but, since this did not occur, log exports increased markedly as harvesting increased.

A third wave of private-sector planting markedly expanded the plantation forest area in New Zealand from the 1990s, partly propelled by tax changes and small investor interest, but this dwindled in the first decade of the twenty-first century

(FAO, 2004). In recent years the area of radiata pine plantations has actually decreased (Table 1.2). This decrease, which will be discussed later, has been caused by the reduced profitability of plantation forestry compared with other land-uses, particularly dairy farming. Deregulation in New Zealand also led to large changes in agriculture, including its intensification, which led in turn to concerns about environmental impacts and long-term sustainability (PCP, 2004; MacLeod and Moller, 2006). Finally, there is a possibility that a recently introduced greenhouse gas emissions trading scheme will see renewed interest in planting forests, although as of 2013 this had not eventuated.

One major result of the privatization of the state's plantations was that much of the land on which planting took place was subsequently transferred to Maori tribes as part of the Treaty of Waitangi settlements (MAF, 2009). The trees themselves are often owned by others, such as institutional investors or foreign-based forestry companies, and management arrangements vary. Relatively small areas are managed by Maori tribes, while a significant area is owned by farmers and small investors.

In brief, the New Zealand radiata pine plantations were promoted initially to provide timber for domestic use and subsequently for export revenue. Some planting was also for erosion control in addition to providing timber. The expansion of the plantation estate was supported up to the mid 1980s by government policies, indirect incentives and limited direct incentives. Today, New Zealand has an open economy and relatively little government involvement in promoting forestry. Moreover, there is no comprehensive national forest policy (MAF, 2009). Despite its open economy, plantation forestry is still not on a level playing field with respect to agriculture, as ecosystem degradation by agriculture is not usually accounted for in land-use decisions.

South Africa

Despite its large area (Table 3.1), South Africa has always been lightly forested. Today, there are only 0.5 million ha of closed native forests and 23 million ha of open woodlands, which together cover less than 20 percent of the country (Dlomo and Pitcher, 2005). These forests produce minimal timber, although woodland (bushveld) is an important source of firewood and is rich in biodiversity. The closed forests have high conservation value.

Experimental plantations of introduced trees for wood supply were set up by the state in the latter part of the nineteenth century. However, large-scale afforestation did not occur until after the Second World War, when there was a rapid expansion of private planting. By 1972, the total plantation area had reached about one million ha, of which three-quarters had been planted by private industry (Dlomo and Pitcher, 2005). Private planting was promoted by incentives and a guaranteed price. Larger companies tended to focus on pulpwood, although there was also significant investment in plantations to produce sawlogs.

In 2003, plantation forests covered 1.5 million ha, which is 1.2 percent of the country's land area (Dlomo and Pitcher, 2005). The South African plantation forest resource is almost evenly split between hardwoods (eucalypts and acacias) and pines. The area of radiata pine plantations (57 000 ha) is small compared with plantings of other pines such as *P. patula* and *P. elliottii* (Donald, 1993), and the area has decreased slightly in recent years (Table 1.2). About half of the pine plantations were privately planted, although the state owned 63 percent of the radiate pine resource (Donald, 1993). Most private radiata pine plantations were small in size and less well-managed than state plantations.

In 1996, in post-apartheid South Africa, the government moved towards the privatization of the state's plantations. Details of this complex process are described by Dlomo and Pitcher (2005). The government has pledged to transfer 30 percent of white-owned land to black owners by 2015; an estimated 40 percent of privately owned plantations and 70 percent of state-owned plantations are subject to land claims. In addition, new controls on plantation forestry have been introduced to control and tax water use.

Spain

There are 18 million ha of forest in Spain, of which 30 percent is publicly owned (MMAMRM, 2006). Spain had been deforested over a 4 500 year period and reforestation only began in the twentieth century (Valbuena-Carabaña, *et al.*, 2010). However, in the northwest, where radiata pine is planted, forest cover is higher than most of Spain. Ownership patterns vary within this region. In the Basque country, for example, where radiata pine plantations cover 21 percent of the land (and constitute 39 percent of the forest area), about 85 percent of plantations are under private ownership (Michel, 2006). In Galacia, in contrast, the National Forest Service manages 55 000 ha of communal forests, while small private stands cover 27 000 ha (Rodríguez *et al.* 2002a). Much planting of radiata pine has taken place on abandoned agricultural land.

Between 1940 and 1975, under the dictatorship of General Franco, radiata pine planting was supported by the Spanish National Forest Service. From 1976 to 1982 this role was transferred to regional administrations and, beginning in1983, planting was undertaken by landowners receiving subsidies under the European Union's Common Agricultural Policy (Valbuena-Carabaña *et al.*, 2010). Spain has a national forest policy.

In short, the development of large areas of radiata pine plantations in northwest Spain was largely a response to long-term deforestation, which in later years enjoyed benefits from the European Union's agricultural policies. These policies have served – to varying degrees – to reduce land degradation and erosion, but above all they have been crucial in securing a wood supply.

Synthesis

After achieving self sufficiency in wood supply, both Chile and New Zealand have planted radiata pine for export markets. Chile has developed strong vertically integrated industries around radiata pine, but this is less evident in other countries. New Zealand has a different ownership pattern in that it has often separated ownership of the tree crop from ownership of the land on which it grows. Despite some consolidation, Spain still has a very high proportion of small growers. In South Africa the radiata pine resource is small compared with other forest plantations, while in New Zealand the reverse is true, with radiata pine accounting for 90 percent of the entire forest plantation estate. Australia, Chile and Spain have developed more diverse plantation forest resources. The establishment of new radiata pine plantations has slowed in recent years.

The large-scale development of radiata pine plantation forestry and associated industries in the five countries outlined above share the following common aspects:

- Most major countries where radiata pine is grown boast a high Human Development Index (Table 3.1).
- There was a perceived need to supply timber that was not readily available in natural forests.
- Central government policies were established to promote afforestation. Subsidies were usually available, although in different forms in different countries, with variations over time.
- The governments themselves usually took a direct role in planting forests. Subsequently, many of the state forests were privatized and governments concentrated on removing barriers to the forest industry and supporting research, education and training.
- Plantation forestry has also been used to reduce land degradation or restore landscapes, and there is growing awareness of its role in providing other ecosystem services (see discussion below).

ECONOMICS OF RADIATA PINE PLANTATIONS

Economic evaluations have been used for both evaluating radiata pine plantation projects and deciding management options. Discounted cash flow analysis (DCF) is almost always used, although the assumptions and difficulties with this process are seldom considered by managers (Horgan, 2005). For example, the choice of a discount rate has major implications on evaluations because of the long-term nature of forest crops and the inherent exponential nature built into calculations. Discounting treats future events with decreasing significance until they become of little consequence; this is the antithesis of sustainability. Another complication with DCF is deciding on what to include in an analysis. For example:

- Are calculations to be made pre-tax or post-tax?
- Are land values to be included?
- Does the evaluation include harvesting or manufacturing?
- Should a single or an infinite number of rotations be used?
- Are social benefits to be evaluated?
- Is risk – including market and biotic and abiotic risks – a factor?
- How should sustainability, including intergenerational equity, be addressed?
- Is inflation a consideration?
- Is future uncertainty a factor?

Moreover, social benefits are often ignored, despite their vital contribution to people's lives and livelihoods. For example, plantation forestry has received criticism for ignoring impacts on local communities, even though the forests are generally profitable for owners (Menne and Carrere, 2007; Du Monceau, 2008). Other social benefits, some of which are often difficult to quantify, are discussed below.

Hepburn and Koundouri (2007) have reviewed new discounting theories and argued that decisions should be made based on a "social discount rate" that decreases over time (Box 3.1). Social discount rates are not the same as market interest rates but are a shadow price on capital. Uncertainty and intergenerational equity are taken into account by using decreasing discount rates for longer-term investments. Thus, using decreasing discount rates would be appropriate when evaluating long-term social benefits such as carbon storage, biodiversity and landscape values. Another approach is to use two different discount rates, as was done in a recent Western Australian study (Townsend *et al.*, 2012), when a lower social discount rate was applied to social benefits compared with those derived from growing trees for timber. Similarly, Manley (2012a) pointed out that the cash flow accruing from plantation management for wood production may be quite different from that accruing from carbon accretion and therefore need to be evaluated separately.

A common approach in industrial radiata pine plantation forestry is to use a discount rate selected by the owner or manager, perhaps based on the cost of borrowing (Horgan, 2005). Often, projects are assessed on whether they achieve the selected rate, and the choice of project to pursue is based on net present worth (NPW). Sometimes land costs are included, or land expectation value (LEV) is compared with actual land values. The internal rate of return (IRR) may also be calculated and used to compare alternatives. Another use of DCF is to determine a break-even stumpage (i.e. the minimum price at which wood should be sold to cover compounded costs at a selected discount rate). Sensitivity analysis is also frequently employed to explore uncertainty. These approaches, however, do not consider the recommendations given in Box 3.1 to account for social values.

The practice of increasing the discount rate to allow for risk is not recommended because it is too simplistic (Manley, 2012a). A better option is to change the cash flow, as Rodríguez *et al.* (2002a) did to account for fire risk in radiata pine plantations in Spain.

Typical discount rates and plantation forest profitability

In 1923, a discount rate of 4.5 percent was employed for the evaluation of plantation forestry prior to undertaking large-scale planting in New Zealand (Roche, 1990). This was the usual rate used at that time by the State Forest Service for loans. Similar discount rates have been used more recently in Spain (Rodríguez *et al.*, 2002a). These discount rates are lower than the 7–10 percent currently used in Australasia and Chile to evaluate radiata pine plantation management options.

Discount rates used by plantation forest valuers in New Zealand average 8.7 percent (with a range of 8–12 percent) when applied to pre-tax cash flows (Manley, 2012b); valuers include land costs in these calculations. Similarly, estimated pre-tax discount rates that are implicit in the transaction prices of forests sold in Australasia in 2009–2011 averaged 9.3 percent (with a range of 7.8–10.6 percent). These implicit discount rates have not varied greatly since 1997. Post-tax discount rates are lower than pre-tax discount rates.

Table 3.2 shows the variation in LEV and IRR (at 8 percent and without land costs) by species and country. Many of the growth rates for species other than radiata pine are considerably higher than those given in Table 1.4. Profitability depends on growth rate, cost and revenue, and rotation length. On average, radiata pine is not as profitable as some other species, such as *Eucalyptus grandis* grown on short rotations and where IRRs often exceed 20 percent but, even so, there is an overlap in IRRs between the two species (Table 3.2). For radiata pine, the best returns are in Chile: at an 8 percent discount rate an investor could pay up to US$2 780 for new land, whereas in New

BOX 3.1

The new concept of using declining discount rates in forestry evaluations

In their paper on the implications of recent advances in discounting for forest economics, Hepburn and Koundouri (2007) found that:

> "There are several clear conclusions from our analysis. First, moving to declining discount rates based on uncertainty is theoretically justified. Second, this has important impacts for long-term investments. Third, it has little impact on short-term investments (where a constant discount rate may serve as a legitimate approximation to the correct declining scheme). Fourth, the particular shape of the decline matters a great deal ...
>
> "Given these conclusions, it would appear sensible for forestry managers to employ declining discount rates in their economic analysis, which would both increase inter-temporal efficiency, and contribute to intergenerational equity and sustainability. Hence our basic recommendation is to build declining discount rates into proprietary software used for forestry financial analysis. Moreover, forest managers will no doubt realize that the implementation of a declining discount rate scheme is not only important for the economic value of future timber products. It is also crucial in determining the net present value of forestry benefits that people derive from forest services, such as extraction of genetic material, tourism, protection of watersheds, support of other ecosystems, carbon storage, etc. Some of these benefits, especially those derived from genetic material and carbon storage, provide very long run benefits, and hence are highly sensitive to the choice of the discount rate schedule used in their economic evaluation."

Source: Hepburn and Koundouri (2007)

TABLE 3.2
Economic comparison of forest plantations of various species in selected countries

Species	Country	Details	Rotation (yr)	MAI (m³/ha/yr)	LEV (US$/ha)	IRR (%)
P. radiata	Chile	Sawlogs	22	30	2782	15.6
		Pulpwood	16	20	894	13.1
	New Zealand	Sawlogs	28	17	-230	7.6
		Sawlogs[a]	25	29	1215	9.5
	Spain	Sawlogs[b]	30	21	NA	9.0
		Sawlogs[b]	38	14	NA	5.8
P. taeda	Argentina	Sawlogs	18	30	3202	20.0
	Brazil	Sawlogs	15	30	5242	20.8
	Paraguay		20	32	1658	12.8
	Uruguay		24	20	1048	12.8
	USA	South	30	15	171	8.5
		North Carolina	23	12.5	-324	6.9
P. patula	Columbia		19	19	1592	11.2
	South Africa	Sawlog	30	14	1862	11.1
E. grandis	Argentina		15	35	3178	18.2
	Brazil	Sawlog	15	40	8311	25.5
	Paraguay		12	38	4233	21.4
	South Africa		16	32	2872	12.4
	Uruguay		16	30	1389	13.9
	Paraguay		12	38	4233	21.4
	South Africa		16	32	2872	12.4
	Uruguay		16	30	1389	13.9

Note: Land costs are not included and LEV is calculated at an 8 percent discount rate; NA = not available; a = based on an average New Zealand site (Maclaren *et al.*, 2008); b = based on good and poor sites in Spain (Rodríguez *et al.*, 2002b).
Source: Cubbage *et al.*, 2010 (except where noted)

Zealand the LEV has even been negative. The major reasons for the difference in profitability between New Zealand and Chile are the latter's lower growing costs and shorter rotations (Cubbage *et al.*, 2010).

Cubbage *et al.* (2010) argued that their analysis partly explained why the radiata pine-based industries in New Zealand and Chile are so different, with Chile being vertically integrated and New Zealand much less so. In the case of Chile, the break-even cost for growing sawlogs was about US$11 per m^3, while the stumpage price was US$34 per m^3 (not shown in Table 3.2). Cubbage *et al.* (2010) argued that this favoured vertically integrated industries that own the land and can transfer wood cheaply within their industry. In New Zealand (and incidentally also in the United States with other species), the break-even growing cost is similar or higher than stumpage prices, so it makes financial sense for companies to pass the risk of owning land to others and not to be vertically integrated. However, as noted above, other social reasons have also had an effect on the situation in New Zealand.

While overall rates of return are important when deciding where to invest capital, decision-makers also need to take into account infrastructure, technology and industrial development, labour, interest rates and biological, political and economic risks (FAO 2004; Cubbage *et al.*, 2010). These can vary widely between countries. Land costs and availability, which are not included in the analyses in Table 3.1, are also critical factors for investors to consider.

Discount cash flow analysis can be used to compare the profitability of different land uses. One such analysis in New Zealand (Evison, 2008), which included capital on-farm investments, found that dairy, viticulture and arable farming provided the best returns (IRRs of 5–8 percent). Radiata pine plantation forestry and sheep and beef farming gave intermediate returns (IRRs of about 2 percent), while kiwifruit orchards gave negative returns on investment (an IRR of -1 percent). The study took into account the type of land being used. Dairy farms, for example, are primarily on high-quality land, while forestry and sheep and beef farming are generally on lower-quality land (Adams and Turner, 2012). The results are also dependent on the date at which the analysis was undertaken. Moreover, the relative returns on investment could easily alter with changing market conditions, subsidies and other assumptions. In Chile, for example, small treegrowers can obtain subsidies for plantations that can increase IRRs by up to 40 percent (Sotomayor, Helmke and García, 2002).

SOCIAL AND ECOSYTEM SERVICES

This section focuses on the services provided by radiata pine plantations beyond wood production. Ecosystem services can be classified using the Millennium Ecosystem Assessment framework (MEA, 2003) as either provisioning, regulating or cultural (Table 3.3). Underlying these services are soils, nutrient and water cycles, biota production and ecological processes. Forests have major effects on stream water quantity and quality and on erosion (Hock *et al.*, 2009) which were reviewed in Chapter 2.

Forest managers often need to optimize and combine commercial and social benefits.

TABLE 3.3
Ecosystem services provided by radiata pine plantation forests and associated agroforestry systems

Product provision	Fibre and farm products (renewable)
	Fresh water
	Energy (renewable bioenergy)
	Carbon sequestration (long term)
	Biodiversity (habitat and protection)
	Shelter on farms (microclimate)
Regulating	Air quality
	Climate and microclimate
	Water quantity and quality
	Erosion
	Biotic and abiotic hazards
	Landscape quality
Cultural	Social relationships, communities
	Wealth and employment
	Cultural diversity, heritage
	Spiritual, inspiration, lifestyle
	Knowledge, education
	Aesthetics
	Recreation, tourism

The difficulties with the economic evaluation of social and ecosystem services are discussed above and some approaches suggested. An alternative approach is premised on the need for stakeholders to be involved in appraising forest values, which do not necessarily need to be quantified in monetary terms (Rivas Palma, 2005). The results of such appraisals should be taken into account by managers and planners and can be part of decision-support systems (Höck *et al.*, 2001). The evaluation is often undertaken by surveys of various forms. In New Zealand, a study in two contrasting areas found that plantation forests were viewed by stakeholders as having high ecological value for water regulation and erosion control but as having lesser value for biodiversity, climate regulation and nutrient cycling (Rivas Palma, 2005). Of the social services that directly affect people, employment was considered the most important, followed by living standards and recreation.

There can also be tradeoffs in the services associated with plantation forestry. A study by Dymond *et al.* (2012) on radiata pine plantation forestry showed that in some locations the value of carbon sequestration and reduced erosion can be offset by reduced water flows.

Employment

Employment opportunities are often cited as one of the benefits accruing from establishing plantations and their associated industries. In 2009 in New Zealand (where 90 percent of production forests are radiata pine plantations), 3.5 and 9.6 people per 1 000 ha of plantation were directly employed in radiata pine growing and harvesting and in growing through to the first stage of processing, respectively (FOA, 2011). This number fell by one-third between 2002 and 2009, largely due to difficult trading conditions, the downturn in planting, and greater automation. About one-quarter of the people employed were Māori. The number of people employed in New Zealand in wood-using industries after the first stage of processing is of the same order as the number employed to the first stage of processing.

Australian softwood plantations may support more workers (although direct comparison is difficult). Paul *et al.* (2013) found that 6.1–12 people were employed per 1 000 ha of softwood plantation in forest management and harvesting and 1.2–13 people were employed per 1000 ha in sawmilling, preservation and log or chip export. The flow-on effect to support industries in Australia has been estimated at 0.65 people for each person employed in the forest plantation sector (Schirmer *et al.*, 2005). On the basis of these estimates, about 30 people are employed for each 1 000 ha of plantation forest.

According to Paul *et al.* (2013), there would be little change in total employment if forest plantations replaced pastureland. In New Zealand, however, plantation forestry and associated industries employ more people than do agriculture on comparable land (Fairweather, Mayell and Swaffield, 2000). Furthermore, as plantation estates mature and industries grow, employment per unit of forest area increases.

Changes in forest ownership, rates of new planting, silviculture and wood-using industries, together with the drive for increased productivity, can all influence the number of people employed (McClintock and Taylor, 1999). The afforestation of farmland may redistribute jobs from farms or small towns to larger places and regional centres with processing facilities or ports. These changes can alter the nature of communities and can create resentment against plantation forestry.

Biodiversity

There has been considerable debate over how forest plantations, including those using radiata pine, influence biodiversity (Bremer and Farley, 2010; Brockerhoff *et al.*, 2008). A common myth is that forest plantations are biological deserts and should be avoided. Research on radiata pine and other forest plantations does not support this myth, although such forests do alter what is present. For example, radiata pine plantations favour insect-feeding birds rather than nectar feeders or obligate cavity nesters, while some vertebrates may be absent or less common (Lindenmayer, Hobbs and Salt, 2003). Bird species associated with open habitats are reduced by afforestation, while species preferring forest are at an advantage (Lindenmayer, *et al.*, 2008). In some cases, endangered species may inhabit radiata pine forests. In New Zealand, for example, endangered animal species that have been found in radiata pine plantations include the brown kiwi (*Apteryx mantelli*), the New Zealand falcon (*Falco novaeseelandiae*) (Figure 3.1), the long-tailed bat (*Chalinolobus tuberculatus*), the ground beetle *(Holcaspis brevicula)*, land snails (*Powelliphanta spp*.) and the native frog (Maunder, Shaw and Pierce, 2005; Brockerhoff *et al.*, 2008), although the role of such plantations in the conservation of these species is unclear. Native plants are also common in radiata pine plantations (Figure 3.2; Ogden *et al.*, 1997; Ramírez *et al.*, 1984).

Generally, larger numbers of birds, both native and introduced, are found in older stands and on stand edges (Seaton, Minot and Holland, 2010). Biodiversity is usually higher in mature radiata pine plantations and in pruned and thinned stands than in young, unpruned or unthinned stands because they have increased spatial and vertical heterogeneity, more ambient light, well-developed soil organic layers, increased dead wood on the forest floor and a wider range of understorey species (Estades and Temple, 1999; Brionesa and Jereza, 2007; Brockerhoff *et al.*, 2008). Understorey vegetation changes as stands age, with adventive exotic species often dominating initially, followed by native species that are frequently introduced by birds (Ogden *et al.*, 1997; Brockerhoff *et al.*, 2008).

It is generally agreed that natural forest and other native ecosystems have richer biodiversity than forest plantations. Plantations are most likely to contribute to biodiversity when established on degraded lands or on agricultural land rather than replacing these natural ecosystems (Bremer and Farley, 2010; Brockerhoff *et al.*, 2008; Hock *et al.*, 2009). Conversely, the conversion of forest plantations to pasture may reduce biodiversity. Establishing plantations can also alleviate pressure on native forests by reducing the demand for wood. However, excluding native forests from wood production is not always possible, and multiple objectives that include both

FIGURE 3.1
The New Zealand falcon *(Falco novaeseelandiae)* in a radiata pine plantation forest in Canterbury, New Zealand

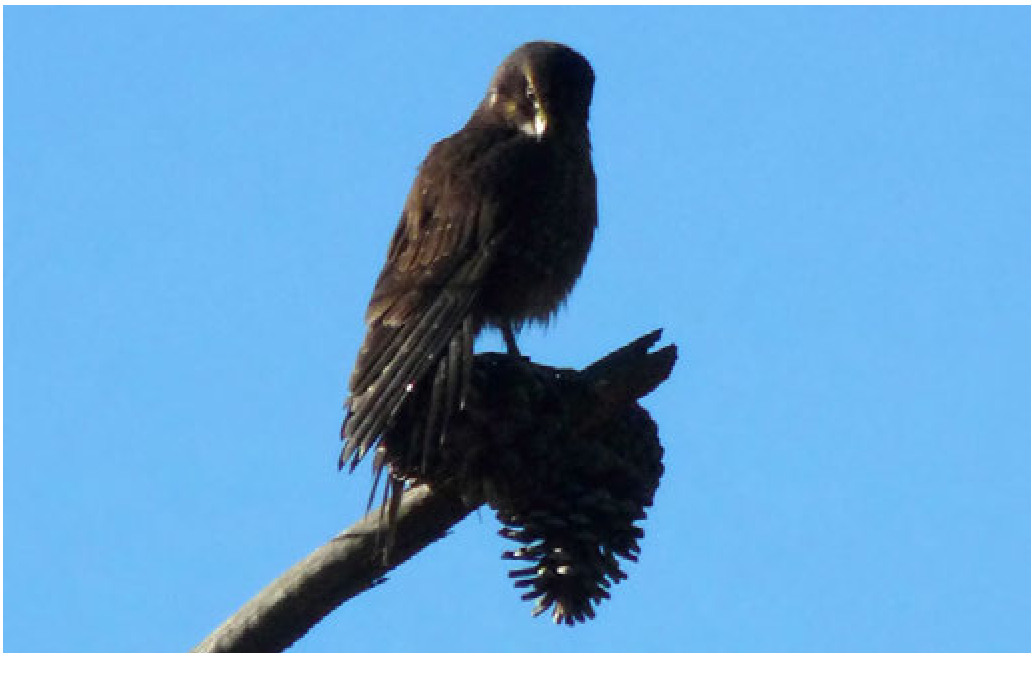


FIGURE 3.2
Copihue, the Chilean national flower, growing in a radiata pine plantation forest in the BioBio region

wood production and conservation may be preferred. Where the restoration of native forests is an important objective, forest plantations are usually a better starting point than agriculture (Brockerhoff *et al.*, 2008). In Spain, radiata pine plantations play a crucial role in promoting the regeneration of original oak forests (Onaindia and Mitxelena, 2009).

Even small patches of remnant native vegetation embedded in forest plantations are important for maintaining the biodiversity of vertebrates (Figure 3.3). In this vein, the importance of promoting heterogeneous landscapes is crucial (Lindenmayer *et al.*, 2008; Estades and Temple, 1999; Hock *et al.*, 2009). In Western Australia, it has been found that indigenous logs left in radiata pine plantations are important habitats for bryophytes (Pharo and Lindenmayer, 2009). Riparian areas can be important as wildlife corridors and for the protection of streams, even when narrow (e.g. 10 m in width), although wider strips are often advised (Langer, Steward and Kimberley, 2008). Over a radiata pine rotation cycle, riparian strips can become botanically similar to the natural forest provided there is a seed source, and they can survive careful plantation harvesting and re-establishment.

There is good evidence that streams in radiata pine plantations and native forests have similar fish assemblages and that these are different to streams in pasture areas (Hicks, Glova and Duncan, 2004). In New Zealand, whitebait (*Galaxias* species), for example, are very much lower in streams surrounded by pasture than those in forests (Rowe, 2000). In a Chilean study, the abundance of native fish was lower (mean 1.1, range 0.23 per 10 m^2) in nine catchments with more than 50 percent native forest compared with two catchments where there was a preponderance of radiata pine plantations (3 per 10 m^2) (Lara *et al.*, 2009). However, this result may partly be due to higher trout numbers in native forest areas; the authors considered the presence of trout to be a positive social benefit. The main danger to waterway ecosystems arises from reduced water quality and sediments associated with harvesting operations.

Low-cost nesting boxes placed in radiata pine plantations in Chile have been found to be successful in attracting birds (Muñoz-Pedreros, Gantz and Saavedra, 1996) and have been recommended in New Zealand (Clout, 1984) but have not yet been widely used.

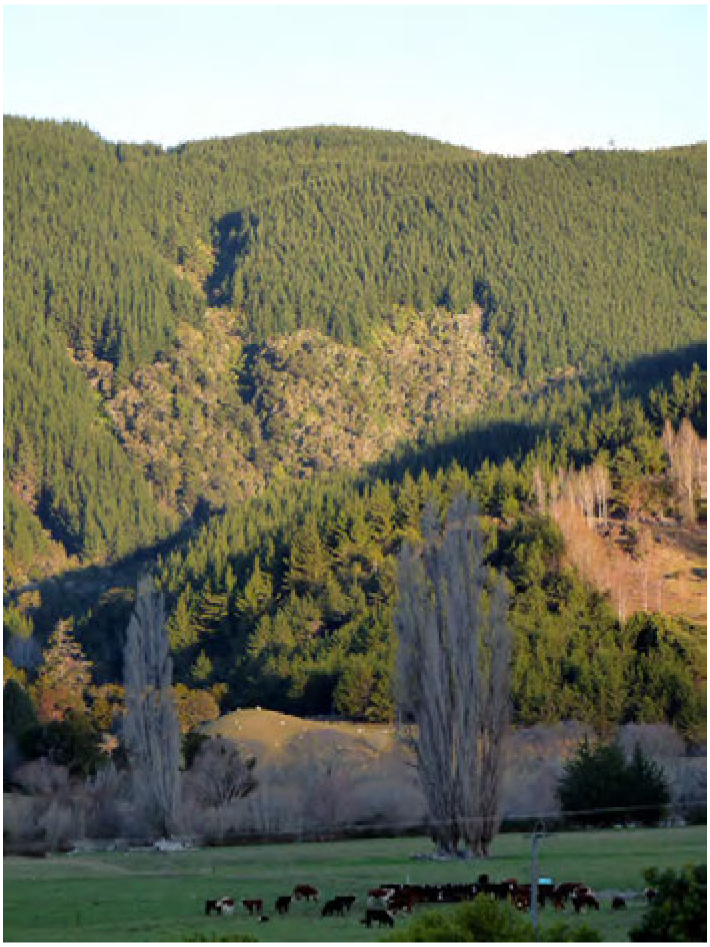
Management practices that can benefit biodiversity in radiata pine plantations include:

- protecting remnant indigenous ecosystems (Figure 3.3);
- using riparian strips, preferably with native species, greater than 10 m wide;

- limiting herbicide sprays during the establishment phase, especially blanket applications on indigenous plants;
- leaving woody debris, particularly indigenous logs, on site;
- manipulating stand density – where stand density is high, the understorey gets shaded out quickly, but if it is too low, light-demanding adventive weed species may persist longer;
- using longer rotations;
- minimizing disturbance during logging – this, together with careful roading and leaving riparian margins undisturbed, is also important for stream health;
- developing special management plans for some threatened species – these may be required to limit the impact of forestry operations or to control predators;
- planning at the landscape level to ensure the retention of wildlife corridors and maintain a diversity in stand ages – for large-scale afforestation or farm forestry projects, an even more heterogeneous landscape can be planned, perhaps at the catchment level (Box 11.1);
- the additional planting of species favoured by native wildlife;
- monitoring biodiversity over time using indicator species suitable to the region.

Plantation certification has increased the number of plantation biodiversity surveys, as well as improved their management and the management of embedded remnants of natural vegetation (Hock and Hay, 2003). It has also improved general awareness among radiata pine plantation managers of biodiversity issues. Australia has produced a scoring method for plantations to assess their biodiversity potential, but this has yet to be employed by plantation managers (Cawsey and Freudenberger, 2008).

FIGURE 3.3
A native forest remnant in radiata pine plantation forest in New Zealand



Note that the farmland is on the more fertile flatland.

Landscape

Radiata pine plantations or smaller on-farm plantings such as shelterbelts have an impact on how people perceive a landscape. Large-scale plantation forests can reshape landscapes and affect community values (Gerrand *et al.*, 2003). Surveys of public perceptions show that many people prefer "pure natural" landscapes, but others are happy with modified "cultural" landscapes (Fairweather and Swaffield, 2003). The "cultural" view sees landscapes as a resource for human enjoyment and is not so concerned if it is modified. However, even these people often find planted pines at the lower end of acceptability. Generally speaking, more mature plantations are preferred over young plantation forests and recently logged sites, and a mixed landscape is preferred over blanket plantation forests (Figure 3.3). Similar conclusions were reached in a Chilean study, which found that large-scale radiata pine plantations rated very poorly on visual grounds and had resulted in a large decline in landscape values (Muñoz-Pedreros and Larraín, 2002). Clearcut and burnt sites were particularly disliked, but mixed-species exotic plantings were often perceived as acceptable.

Landscape values and public concerns should be considered in forest plantation planning and management (Hock, 2005). The degree of planning depends on location and scenic quality and the number of people affected. The two basic approaches used are to screen operations and to reduce plantation visual impacts. Screening operations from view is sometimes an option. Reducing visual impacts can be achieved by altering the size, shape and pattern of operations and by avoiding excessive tracking and disturbance on visible slopes. Closer integration with farming can create a more complex landscape with increased biodiversity and better public acceptance (Gerrand *et al.*, 2003). A guide on how to incorporate plantation forestry into the landscape has been produced for New Zealand (Anstey, Thompson and Nichols, 1982). A Tasmanian manual for forest landscape management, primarily written for native forests, also provides detailed relevant advice on principles and practices (FPA, 2006).

Recreation in radiata pine plantations

Radiata pine plantation forestry is occasionally managed to encourage recreation or tourism (Figure 3.4). This primarily occurs in those forests close to urban populations,

FIGURE 3.4
Recreation in mature radiata pine plantation forest near Auckland, New Zealand

but more remote plantations may also be used for hunting and fishing. In New Zealand, for example, several forest plantations near cities are used intensively for activities such as picnicking, walking, running, horse-riding and mountain biking. A study in a commonly used part of a forest of 288 ha near Rotorua, New Zealand, found that most recreational users tended to be locals (Turner *et al.*, 2011). While some users expressed their preference for more stand complexity, others did not have strong opinions. The surrogate market value of these recreational services estimated by travel costs for this small part of the forest was estimated at US$12 million annually. A similar study in a radiata pine plantation close to Adelaide, South Australia, found that recreational benefits were worth 30 percent of annual timber sales (Smailes and Smith, 2001). In neither of these two examples were the values captured directly by the owners. Potential conflicts between users (e.g. between hikers and logging operations) need to be managed, such as by separating them in space.

Carbon storage

Carbon storage by afforestation is considered one way of mitigating climate change through a one-off capture of CO_2 (see Chapter 2). Planted forests are included in national carbon inventories, and new post-1990 planted forests may provide additional carbon storage under the Kyoto Protocol. However, the area of radiata pine plantations worldwide has remained static in recent years (Table 1.2). New Zealand has implemented an emissions trading scheme and this has the potential to increase tree planting (Manley and Maclaren, 2009; Adams and Turner, 2012). Australia has opted for a carbon tax in the short term, and this may become an emissions trading scheme in 2015 (Australian Government, 2011). Neither of these schemes has led yet to increased rates of new planting because of uncertainty and the changing value of carbon credits. The additional storage of carbon in wood products also has a modest positive effect (Manley and Maclaren, 2010).

Afforestation with species such as radiata pine can change landscape albedo, resulting in the greater absorption of light energy (Whitehead, 2011), and this needs to be considered when evaluating the impacts of afforestation on climate change. It is also necessary to account for changes in the storage of soil carbon, which can be either positive or negative (see chapters 3 and 10).

Other aspects need to be considered when discussing carbon storage and balance. The use of bioenergy from forest plantations can reduce the use of fossil fuels, as the energy balance is positive (Hall, 2009). Greenhouse gas emissions can be reduced by 75–94 percent, depending on the bioenergy technology employed. However, the economics of forest biofuel options in New Zealand have not changed much for 30 years, suggesting that widespread uptake is likely to be slow unless other factors drive their use (Horgan, 2009). In Chile, there is an incentive for greater uptake of biofuels because electricity companies are required by law to increase their use of non-conventional renewable sources (Acuña *et al.*, 2010), and unused forest residues from radiata pine plantations are currently the largest potential source of these. Substantial energy and CO_2 emission savings can also be achieved by building in wood rather than concrete, steel, aluminium or plastics.

Wilding spread

There has been increased regeneration of radiata pine in its native habitat following grazing and other disturbance, although it has not expanded its natural range without planting (Richardson and Higgins, 1988). However, wilding spread from wind-blown seed, usually within 500 m, has been recorded in all the major grower countries (Richardson and Higgins, 1998; Simberloff *et al.*, 2010) and, in Australia, cockatoos are also known to spread the seed. Radiata pine tends to invade open vegetation, sometimes after fire, rather than dense forest. In South Africa, there has been widespread invasion of radiata pine into fynbos vegetation over an area of about 340 km^2, although *Pinus pinaster* has spread over a greater area than radiata pine. In Australia, radiata pine has invaded heathlands, grasslands and dry open eucalypt forests while, in New Zealand, the species most commonly invades grasslands, tussock land and shrubland where farmland has been abandoned and grazing animals removed (Ledgard, 1988). In New Zealand, the species is not considered to be as invasive as other pines, particularly *Pinus contorta*. In South America, radiata pine has invaded burnt, grazed sites in Argentina and fragmented secondary forests in Chile. Wildings have also been recorded in burnt areas, along roadsides and on abandoned fields in Spain.

Radiata pine is reasonably palatable, so it can be controlled by grazing animals. Physical removal, sometimes aided by weedicides, has also been used. Avoiding planting pines on "take-off sites" such as ridges is another strategy to reduce wilding spread.

Working with communities

Building good relations with local communities and other stakeholders is an important part of forest management. This takes time and dedication and needs to be an objective of forest management planning (Barnard, Fitzgerald and Langer, 2005). One objective of community engagement is to identify local concerns and devise mutually agreed ways to resolve them. Typically, the process first develops insights into community concerns or controversies, often through scoping surveys. This is followed by wider community engagement – usually using social learning processes – to develop agreed strategies to address concerns and build ongoing relationships.

ENVIRONMENTAL STANDARDS

A range of approaches have been developed to reduce the environmental impact of forest plantations. These include voluntary forest management guidelines, local laws, the systems certification approach of ISO 14001 (taken up in the mid 1990s), the "sustainable forest management approach" that arose out of the 1992 United Nations Conference on Environment and Development (also known as the Rio Earth Summit) and the subsequent Montreal Process, international conventions such as the Convention on Biological Diversity and, increasingly, the use of third-party certification schemes. Chile, for example, has a range of forest and environmental laws that cover environmental damage, protect native biota and require forest management plans. The Government of Chile is a party to the Convention on Biological Diversity and has developed the CertforChile Standard for plantation forests, and plantations in the country have been third-party certified (Morales, 2005; Paredes, 2005).

The increasing emphasis by plantation managers on environmental management has been driven in part by forest certification, which demands adherence to prescribed standards, and in part by changes in societal values, which increasingly feature a demand for sound environmental performance by land managers. The Forest Stewardship Council (FSC) standards are applied in more than half of the radiata pine plantations in New Zealand (FOA, 2011). In Australia and Chile, locally developed standards, allied to the Programme for the Endorsement of Forest Certification (PEFC), prevail (Paredes, 2005; Crawford, 2009). Certification has been slower to be applied in Spain because of the preponderance there of small growers (Michel, 2000). New Zealand is developing a national environmental standard for forest plantation as a component of the Resource Management Act and aims to standardize regulations throughout the country.

Paredes (2005) has argued that the FSC and PEFC schemes were taken up rapidly by many large radiata pine growers because their structure allowed for easy implementation and they encouraged sound forest management. Companies also took up the schemes to ensure access to markets. Although large parts of the resource are still not well-managed from an environmental standpoint and remain uncertified, certification has improved environmental management in many enterprises and there is also increasing engagement between such enterprises and local communities (Dare, Schirmer and Vanclay, 2011). Small growers have had more difficulty in achieving certification because of the cost, but group schemes have sometimes helped to overcome this problem. Markets are yet to respond strongly by way of providing a price premium for certified wood (Hock, *et al.*, 2009).

TRENDS

Historically, radiata pine plantation forestry has focused on commercial objectives and supplying wood products. However, the increasing recognition of their multiple benefits and potential negative impacts is changing the attitude of government and forest managers (Hock *et al.*, 2009). This has included recognition of indigenous people's perceptions and rights (Du Monceau, 2008; Rotarangi and Thorp, 2009). There is also growing recognition that participatory decision-making needs to be embraced with an emphasis on equity, representation and transparency. Such societal interaction ties in with adaptive forest management (see Chapter 10) and is an important element of certification schemes and sustainable forest management.

There is also considerable research into how to quantify, value and increase consideration of ecosystem services (see for example, Hock *et al.*, 2009). This can include modelling systems, visual tools and using remote-sensing or allied tools. For example, an assessment was made of a range of regulating ecosystem services provided by planting radiata pine on an eroding, 585 000 ha pasture catchment in New Zealand (Ausseil and Dymond, 2010). Using a range of models, the assessment estimated that the plantation would increase carbon sequestration by 13.4 million tonnes of CO_2 per year and "natural" habitat by 155 percent. It also estimated that it would reduce:

- agricultural greenhouse gas emissions by 1.94 million tonnes of CO_2 per year;
- sediment yield by 3.8 million tonnes per year;
- stream water supply by 31 percent;
- stream nitrogen losses by 2 334 tonnes per year;
- stream phosphorus losses by 302 tonnes per year;
- stream faecal coliform by 51 x 10^{15} organisms per year.

Moreover, if only 5 percent of the catchment was planted to radiata pine, there would still be useful improvements in carbon balance, erosion control and nutrient retention (Ausseil and Dymond, 2010).

The use of direct government subsidies to promote the planting of radiata pine has largely halted, but indirect support is often present. However, governments have and will continue to influence the decisions of land managers through efforts to mitigate climate change and perhaps to increase the use of non-fossil energy sources. Society and governments are also concerned with reducing erosion and the loss of biodiversity while maintaining landscape values; a range of interventions is possible to achieve these goals. Certification schemes and other instruments have had an important role in promoting a better balance between production and ecosystem and social services, but the provision of wood products, wealth and employment that stem from forest plantations will continue to be a major goal.