

Practical ways to enhance biodiversity in farm forestry projects.

David Carr¹, Bert Jenkins² and David Curtis.

1. Greening Australia (Ltd), PO Box 74, Yarralumla, ACT, 2600.
2. Greening Australia (North West NSW), PO Box 1467, Armidale, NSW, 2350.

(This paper was delivered by David Carr, GA Species Trialling Support Officer, to AFG2000 'Opportunities for the New Millennium' – the Biennial Conference of the Australian Forest Growers – Cairns, September 4-6, 2000)

Introduction

Australia has a unique diversity of flora and fauna that has evolved over millions of years of environmental change. The past two centuries have seen the most rapid change, brought about by European land management practices, which has led to the severe degradation of our biological diversity.

Revegetation is identified as a principal tool for addressing biodiversity loss and other forms of natural resource degradation such as salinity and erosion. However the scale of revegetation required to tackle these problems has proven to be beyond the scope of current government and private efforts. Farm forestry is seen as a way to increase the pace of revegetation and there has been a nation-wide investment in farm forestry development. While farm forestry provides an alternative income stream for landholders, it can be a commercial incentive to further address the decline in biological diversity and other natural resource issues simultaneously.

This paper shows some of the ecological components essential for biodiversity conservation and discusses how they can be integrated as design elements in commercial farm forestry. The conflicts between the commercial and nature conservation goals are examined and ways to minimize these conflicts are discussed.

What have farm forestry and biodiversity got to do with each other?

Biodiversity is defined by the the National Strategy for the Conservation of Australia's biodiversity (Commonwealth of Australia, 1996) as simply the variety of all life forms – plants, animals, microorganisms, their genetic material and the ecosystems they combine to form. The interaction of different life forms is a significant part of this definition, as it is this component which is often most affected by resource management practices. At the farm level, the biodiversity of a site is the collection of organisms that occur and interact at that site. Usually we refer to locally indigenous organisms when discussing on-farm biodiversity.

Farm forestry is broadly defined as the incorporation of commercial trees and shrubs (in Australia, this usually excludes horticultural species) into farm operations. Farm forestry includes not only the production of sawn timber but also more diverse products such as fodder, oils, biofuels, flowers and carbon sequestration.

Farm forestry is best considered as a spectrum with industrial plantation forestry at one end and farm plantings that incorporate timber at the other (Donaldson and Gorrie, 1996). Carr and Jenkins (1998) use a triangular model to demonstrate where individual revegetation projects fit between three apices of commercial production, natural resource conservation and farm enhancement. The model demonstrates that commercial farm forestry can incorporate other goals, such as biodiversity, with an estimable degree of compromise, rather than being mutually exclusive.

One of the premises underlying most revegetation projects is that Australia's biological diversity is in decline and needs to be enhanced wherever possible (Commonwealth of Australia, 1996).

Whether it is the role of farm forestry to solve this problem or not is doubtful, but the enhancement of biodiversity should be considered wherever possible in farm forestry projects and weighed up against possible compromises to their commercial intent. Ultimately there are trade-offs between commercial values, the efficacy of land degradation control and biodiversity values (Carr and Jenkins, 1998). Long-term environmental sustainability is a substantial incentive to encourage the incorporation of biodiversity conservation into all incarnations of commercial forestry, including farm forestry.

In Australia, individual farmers, agricultural corporations and all levels of government (Robins *et al.*, 1996) share the burden of addressing biodiversity decline. If farm forestry is to incorporate biodiversity enhancement at a cost to its commercial values, the cost will need to be shared proportionately to the benefits gained.

Farm forestry can have a direct impact on local biodiversity and vice-versa. This impact can be either negative or positive. Dames and Moore NRM/FORTECH (1999) found very little in the scientific literature specifically relating to the links between farm forestry and biodiversity. By examining the interaction between plantation forestry and revegetation on the one hand and the biodiversity and ecology of agricultural ecosystems on the other we can come to a better understanding of the actual, or possible, interactions between farm forestry and on-farm biodiversity.

In a positive sense, farm forestry projects can be designed to:

- increase the diversity of plant species at a site,
- utilise, and therefore give value to, local indigenous species,
- change the structure of the vegetation to a form which is more suitable for wildlife habitat,
- conserve local genetic diversity of both plants and animals,
- encourage a more complex soil ecosystem,
- buffer existing native vegetation,
- increase water quality to maintain stream biodiversity,
- provide opportunities for regeneration of native species susceptible to grazing and
- provide a more diverse range of niches.

Increased habitat diversity can result in more insect diversity (Stamps and Linit, 1998). This can result in positive effects on adjacent agricultural enterprises in terms of predator-pest relationships (Dix *et al.*, 1995). Trees can improve site fertility and understorey composition and biomass (Belsky *et al.*, 1993). Even monocultural commercial stands can have some positive effects on biodiversity. For example, commercial plantations have been observed to host a diversity of birds in four year old trees (Hamlet, 1997) and pine plantations have been observed to increase the number and diversity of birds, but to a lesser degree than native forests (Davidson, 1976; Driscoll, 1977). The field of restoration ecology provides numerous examples of how biodiversity can be restored on previously degraded land (Curtis *et al.*, 1995-2) as does the field of "restoration forestry" (Pilarski, 1994)

Farm forestry can also have a negative effect on biodiversity (Poore and Fries, 1985). Whether the effect is negative or positive largely depends on the pre-existing ecosystem when the farm forestry project is established. Most beneficial effects referred to above, are based on the premise that the farm forestry project will be carried out on previously degraded natural landscapes (eg: forest cleared for pasture, grass or shrubland altered by grazing, eroded topsoil etc (Sawyer, 1993). However, when farm forestry projects are established as a replacement for a natural or complex ecosystem (i.e. forest, woodland or grassland is cleared for the project), then the effects of such activities will invariably be negative. Farm forestry plantings offer more complexity than degraded ecosystems, but when compared with natural or near-natural ecosystems, they are very simple and limited in biological diversity (Sawyer, 1993).

Other instances where farm forestry has a negative effect on biodiversity include;

- where commercial farm forestry occupies sites and time which would otherwise be utilised for more diverse plantings,
- where feral animals are harboured in plantings enabling a larger impact on native biodiversity (Catling and Burt, 1995),
- where farm forestry monocultures enable large pest populations to build up which then have a detrimental effect on local natural ecosystems (Shedley, 1997),
- where management practices such as fertiliser application and runoff, biocide application and soil disturbance affect adjacent natural communities to the detriment of their biodiversity (Dames and Moore NRM/FORTECH, 1999),
- indirect effects on biodiversity through alteration of natural hydrology, soil chemistry and structure and changes to stream sedimentation levels (Turner *et al.*, 1999),
- where native species used in farm forestry hybridise with local populations of the same species, displacing local genetic diversity (Boland *et al.*, 1980; Mortlock and ATSC, 1999), and
- where farm forestry species become agricultural and environmental weeds (Willows and *Pinus radiata* in Australia and eucalypts outside Australia) (Sawyer, 1993; Lindenmayer, 2000-1).

Biodiversity can also be lost in the process of harvesting. Any farm forestry project will have other plants and animals associated with it to some extent. During harvesting, whether clearfell or selective, there will be loss of some or all of these associated organisms. Where large percentages of the vegetation in an area is made up of farm forestry plantings there will be a severe impact if all the stands are felled simultaneously. Approaches where planting and harvesting are spread over time, such as the Greening Australia “one-hectare-per-year” approach (Sandstrom and Parker, 1998), minimise the impact of harvesting on local biodiversity. Where farm forestry plantings closely replicate natural forests, harvesting will usually be selective and will result in a lesser impact on the biodiversity (Pilarski, 1994; Drengson and Taylor, 1997).

As farm forestry has an impact on biodiversity, so biodiversity has an effect on farm forestry. Revegetation work designed specifically for biodiversity enhancement is often used for other commercial or farm enhancement gains, such as timber production or farm shelter (Curtis *et al.*, 1999; Bird *et al.*, 1992). While the primary thesis of this paper is the modifications that can be made to commercial farm forestry to capture biodiversity enhancement, it is also true that biodiversity projects can be modified to capture more financial benefits through the planting of species with commercial value.

Incorporating biodiversity into farm forestry projects is likely to have a beneficial effect on the commercial species in terms of increasing numbers of enemies of pests of these trees (Dix *et al.*, 1995). It has been suggested that planting mixed species in plantation can minimise insect pest problems in those stands (Abbott, 1993). Increasing species richness in a stand of commercial species gives it more resilience to build-up of insect pests of the commercial species (Southwood *et al.*, 1979). Where the commercial stands are integrated into the landscape, with corridors and adjacent habitat areas, they become even more resilient to pests (Curtis *et al.*, 1995-1). Incorporating nitrogen-fixing species such as Acacias into tropical forestry plantations has been shown to increase growth of the commercial species in those plantings (Khanna 1998).

Farm forestry plantings that incorporate biodiversity values are more likely to gain acceptance from the broader community. The neglect of nature conservation values in the past has made forestry in native forests a much-maligned industry in certain sectors of the community (Turner *et al.*, 1999; Sawyer, 1993; Shell/WWF, 1993). There is also less likely to be resistance to large-scale forestry projects in traditionally agricultural areas if these projects incorporate other values such as biodiversity enhancement, crop or livestock shelter or land degradation control (Reid and Stephen, 2000).

On the other hand, biological diversity can also have negative impacts on farm forestry plantations. Wildlife has been demonstrated to cause problems through damage to trees (Montague, 1996; Shedley, 1997). It has been suggested that the potential for endangered species of animals or plants to move into farm forestry plantings is a disincentive to planting due to the fear of landholders that these blocks will not be able to be harvested (Campbell White & Associates Pty Ltd and Black, 1999). This has led to the establishment of Harvest Guarantee legislation in several states (Dames and Moore NRM/FORTECH, 1999). Population increases in vertebrate agricultural pests (such as Port Lincoln Parrots) are possible with increased tree planting associated with farm forestry. However this is more likely to be a consequence of local ecology already being severely disrupted by habitat fragmentation (Shedley and Adams, 1998).

Enhancing biodiversity of farm forestry projects

Enhancement of the biodiversity values of farm forestry plantings can be achieved two ways;

1. Minimising the negative impacts of farm forestry, and
2. Actively increasing the biological diversity of the planting by design and management.

This will be subject to the degree to which the landowner or project manager is willing to sacrifice commercial or other benefits of the project in order to achieve nature conservation benefits. There will be some biodiversity benefits that can be obtained with little compromise in commercial returns, while others will have a substantial effect on returns (Carr and Jenkins, 1998).

The extent to which biodiversity and nature conservation concerns drive farm forestry is difficult to ascertain as studies of motivations for revegetation (Wilson *et al.*, 1995) clearly distinguish between conservation and farm forestry plantings. It would be useful to assess the ranking tree planters give to each of the multiple benefits obtained from their plantings. Black (1999) suggests that the motivation to undertake revegetation may be decided by the existence of land degradation problems (such as biodiversity loss) and the perception of these problems.

The purpose of this paper is to discuss the integration of biodiversity into planted farm forestry projects. For ideas on managing biodiversity in existing regrowth forest, refer to the recent publication, "*A farmers guide to maintaining biodiversity when thinning regrowth forest*" (Murray and Thompson, 2000).

Minimising the impact of farm forestry

The easiest way to enhance biodiversity conservation in a new farm forestry project is to minimise the negative effects it will have on existing biological diversity. There are several ways this can be done:

1. Don't replace natural ecosystems with farm forestry.

This is the most obvious but also the most significant point. If you clear a complex ecosystem for your farm forestry project there is very little you can do to enhance the biodiversity of the subsequent farm forestry planting (Sawyer, 1993; Poore and Fries, 1985).

Establish new farm forestry projects on land containing altered or degraded ecosystems. Previously cleared agricultural land, "improved" pastures and degraded grasslands are more suitable, from a biodiversity point of view, than clearing native vegetation or establishing forest in natural grassland.

2. Adopt cautionary practices for chemical application.

When applying fertiliser, herbicide or insecticide, the effects should be maintained within the site and their effects on existing biodiversity, including soil organisms, should be ameliorated.

As an alternative to chemical herbicides, non-chemical methods such as cultivation, mulches, fallow, flaming or hand-weeding can be used. Encouraging a diverse population of enemies will encourage natural pest control.

3. Maintain isolated trees and standing dead trees

Where possible, leave isolated trees or clumps of trees standing, including dead ones. The habitat value of these will be significant in the new plantation, particularly where the plantation is composed of exotic species (Fisher and Goldney, 1998). The effect of the retained trees on the growth of the commercial species will be determined by the species of trees, their proximity to the planted trees, the spread of their crown and roots and the number of trees retained.

Patches of existing bushland incorporated into a new plantation will significantly increase its biodiversity conservation value. Recent studies have found that 10% native vegetation within a radiata pine plantation is the threshold limit for many native fauna species to persist (Lindenmayer, 2000-2). Other species will require much higher percentages of native vegetation to persist or establish. Other studies have shown that maintaining patches of native bushland within radiata pine plantations can increase the habitat value of those plantations for birds (Fisher and Goldney, 1998)

Standing dead trees will not exert a competitive influence on the farm forestry trees, but may take up required space or make site preparation difficult, or increase the fire risk. Often old dead trees will be more advanced in their decay than living trees, providing more hollows for hollow-dependent fauna. Many birds prefer to roost in large dead trees in order to gain a clear vantage-point for both prey and potential predators. Straw-necked ibis are examples of this.

4. Protect waterways from soil erosion.

Care should be taken to ensure that soil does not wash or blow off the site and into waterways during site preparation or as a result of it. Eroded soils carry nutrients and particles that can degrade aquatic ecosystems, by causing algal blooms, encouraging dense plant growth, blocking flow and causing turbidity. It may be necessary to install erosion control barriers as a temporary measure during site preparation until bare or disturbed soil is stabilised by vegetation (Davies and Nelson, 1994).

The establishment of buffer strips of native vegetation, including trees, shrubs and grasses will minimise any risks of stream pollution from farm forestry activities. These should be 20 – 40 m wide (Lindenmayer, 2000-2; Breckwoldt, 1983).

5. Plan a rotational or selective harvesting regime.

In order to minimise the destructive effects of harvesting on the nature conservation values of farm forestry stands, a harvesting plan that spreads or reduces the impact of harvesting can be designed. Rotational harvesting and planting systems are ideal for farm forestry in that management is spread over the plantation rotation (Sandstrom and Parker, 1998). A small area is planted each year, which subsequently spreads the management, maintenance and harvesting over time. In any one year only a small area of the total farm resource is harvested, minimising the impact on biodiversity at the farm level, even though effects at the stand level may be catastrophic.

Eco-forestry models, which seek to reestablish natural forest conditions, rely on selective harvesting of trees, in much the same way as natural forests are managed. This reduces the impact on biodiversity compared to clearfelling regimes (Pilarski, 1994; Drengson and Taylor, 1997).

6. Minimise the spread of seeds and genetic material into nearby natural vegetation.

Minimising the spread of potential weeds from farm forestry stands and controlling genetic pollution of natural vegetation stands can be achieved in a number of ways. Active monitoring and weed control in adjacent vegetation will stop seedlings of commercial species establishing and displacing native species. The use of sterile plant material (where available) will stop the spread of exotic species such as radiata pine (Lindenmayer, 2000-1). Isolating native commercial species from similar species or species with which they have the potential to hybridise is one way to reduce genetic pollution of natural plant populations. Isolation can be by distance, physical means or by separation using other plant species (Boland *et al.*, 1980).

Active biodiversity enhancement in farm forestry

Constructing forest and woodland ecosystems on agricultural or degraded land requires a set of “building blocks” (Barrett and Ford, 1993). These blocks form the basis of a future functioning ecosystem. By examining these ecosystem components in the context of farm forestry, we can assess the methods and practicalities of their incorporation. In some cases, these ecosystem components will enhance the commercial goals of the project while in others they will limit or even preclude commercial opportunities.

It is also illustrative to look at some actual case studies to see how some of these design elements have been incorporated. Excellent case studies which show, amongst other things, how biodiversity is conserved or enhanced as part of farm forestry operations can be found in Guijt and Race (1998) and Campbell White & Associates Pty Ltd and Black (1999).

Ecosystem components that help build biodiversity into farm forestry projects are: (Barrett and Ford, 1993; Johnston and Don, 1990; Curtis *et al.*, 1995-1)

1. A diversity of plant species

Diversity is a cornerstone of habitat. A diverse range of plants and animals will require a diverse environment to live in. The diversity of plants is crucial to ensure there are lots of nesting sites, food sources and shelters. Different animals need different food sources at different times of the year. Finches require seeding grasses, honeyeaters require nectar, scoliid wasps need tea-tree and blackthorn nectar during their breeding periods (Barrett and Ford, 1993), sugar gliders need nectar and blossoms or wattle gum in winter and possums rely on mistletoe when other food is not available (Reid, 1997). A diverse fauna will also provide food for other animals.

To incorporate into farm forestry –

- Include a diverse range of commercial species either in a mixed pattern (making management more complex), or in species groups (Abel *et al.*, 1997).
- Include local species diversity in strips throughout the planting (Acacias as nurse trees, biodiversity belts throughout etc).
- Include indigenous local vegetation species in blocks in paddock ends or corners, where they can easily be fenced off if livestock are let into the paddock once the commercial species are big enough to withstand grazing.
- Include local species diversity in buffer rows around the plantation. Use buffers to genetically isolate the plantation or to link it as a corridor to other stands of vegetation.
- Utilise local indigenous species as the commercial species.

Commercial compromises - Increasing the species diversity can increase the establishment costs, make less land available for commercial species, increase competition for resources and make management and harvesting more difficult.

2. A diversity of plant structures – trees, shrubs, grasses, mistletoe, cryptograms etc.

There is a great diversity in the places animals and plants need to live. A 'niche' is a unique place in the environment, usually occupied by one particular organism. Having diverse structures in a habitat provides lots of niches. Small birds and animals need a dense and complex understorey (a variety of shrubs, sub-shrubs, herbs, grasses and other life forms in the ground layer) to hide from predators.

To incorporate into farm forestry –

- Include shrubs and understorey plants within a commercial plantation, by planting or direct seeding during plantation establishment.
- Allow some trees with poor form to remain.
- Maintain some trees with full branch structures.

Commercial compromises - incorporating structural diversity may increase establishment costs, reduce growth rates of the commercial species and make harvesting and management more difficult.

3. Using local indigenous species for farm forestry

Using local species commercially will make a significant contribution to local biodiversity conservation by conserving local genetic material and by providing habitat well suited to local conditions and communities. "Conservation through utilisation" (Curtis *et al.*, 1999) best combines the dual goals of farm forestry and nature conservation.

To incorporate into farm forestry –

- Select local species suited to farm forestry products with existing or potential markets.
- Collect seed from local trees that have desirable farm forestry characteristics (such as good form).
- Develop markets and uses for local species.
- Incorporate local-species plantations into native forest management programs.

Commercial compromises - Unselected material may not have the form or growth rate of selected native or exotic species. Markets may not exist for products from local species

4. A diversity of plant ages

At different ages plants provide different habitats. This is true even for exotic plantations (Sawyer, 1993). For example, trees at a very young age may provide food as leaves, some shelter for insects and some strata for establishment of soil fungi. As trees grow and begin to flower they provide nectar and pollen as additional food sources. Once thick bark develops (depending on the species), more niches for insect, reptile, small mammal and amphibian shelter are created. It is not until trees are older and have been exposed to decay, limb damage and insect attack that hollows form which provide shelter and nesting sites for larger mammals, reptiles and birds.

A regular pattern of disturbance followed by long periods of growth favour a mixed age structure, providing abundant niche opportunities for a diversity of organisms (Cannell, 1999).

To incorporate into farm forestry –

- Establish plantings at different times as in rotational systems (Sandstrom and Parker, 1998).
- Plantings can be arranged to be harvested selectively as in an eco-forestry model (Pilarski, 1994), leaving trees of different ages.
- Natural regeneration should be encouraged in both the commercial and understorey species.

Commercial compromises – Rotation times will be greatly extended and cash flow will be small but continuous. This would be difficult to achieve in large clearfell plantations intended for a second rotation unless blocks of trees of different ages were left

5. Water

Water is essential for life to exist and as such all species in an ecosystem require it in one form or another. For many small birds and animals, free water considerably enhances the quality of habitat, enabling fauna to stay within the shelter of the planted vegetation without having to venture out to find it. For aquatic and semi-aquatic organisms a variety of water types are required, including different depths and widths and both flowing and still water (Breckwoldt, 1983). The best sources of water are natural creeks and waterways, so siting a farm forestry project adjacent to these will considerably enhance its biodiversity benefits (Barrett and Ford, 1993).

To incorporate into farm forestry –

- Locate the plantation or farm forestry project adjacent to water such as farm dams, creeks or rivers. Riparian zones are often fertile and moist for forestry plantings.
- Link the forestry operation to areas of natural bushland by establishing corridors of local species along existing waterways.
- Provide artificial water sources such as dams, tanks, troughs or even bird baths.
- Farm forestry adjacent to waterways should have buffers of native species.

Commercial compromises – Areas adjacent to drainage lines may be more frost-prone, more saline or more waterlogged. Clearfelling trees in riparian zones would increase the risk of stream degradation and may pose legal difficulties. Extra care will be needed with chemical application near streams which is therefore best avoided or minimised.

6. Logs and fallen timber

Fallen trees and branches form significant habitat for ground feeding fauna, (e.g. speckled warblers and quails). Many lizards, snakes and frogs also utilise these especially when they are hollow. Insect species utilise fallen timber as food, assisting in the decay process and providing food for other animals as well. Decay fungi will utilise both surface dead wood and dead and broken roots below ground. Maintaining a healthy fungal population can assist tree growth through mycorrhizal associations and prevent harmful plant pathogenic fungi from establishing in living trees (Sierota, 1986).

To incorporate into farm forestry –

- Leave logs on the ground that existed prior to establishment, lining them up with rows to facilitate ground preparation, before replacing them.
- If clearing first, leave windrowed material in place, rather than burning.
- Leave prunings and thinnings in situ or in piles.
- Resist the urge to “tidy up”.

Commercial compromises – May make site access difficult (leave tracks) and will increase fire risk (create fire breaks around and through the planting).

7. Rocks

Like fallen logs, rocks provide important habitat for ground dwelling animals. Clumps of rocks are often refuges for native plants in areas where domestic stock have been grazing. Rocks often host large populations of lichens and mosses which trap soil, break down rock, and provide food for other plants and animals.

To incorporate into farm forestry –

- Many rocks are likely to be disturbed during ground preparation, if present. Leave or heap these for habitat value.
- Incorporate rock outcrops (in situ) into plantation areas.

Commercial compromises – Large, exposed rocks may make machinery access difficult and may take up land otherwise designated for trees.

8. Size

When it comes to habitat quality, size and diversity are two of the most important principles. Larger areas of vegetation are more likely to have sufficient quantities of food and shelter to maintain populations of animals than are small ones. Large areas of vegetation allow for sufficient genetic diversity to be maintained for both flora and fauna. In exotic plantations size may be negatively correlated with nature conservation values. Recent work in Radiata pine plantations has shown that small mammals such as the Agile Antechinus are not restricted in their movement by plantations 50-100 metres wide, but are limited in their movement between remnant native vegetation stands by plantations > 500m wide (Lindenmayer, 2000-2).

To incorporate into farm forestry –

- Plant large areas, particularly of native species! To make this manageable, plant adjoining small areas regularly or look into joint venture opportunities with commercial operators.
- Use forestry plantings to increase the size of existing farm plantings or natural bushland.
- Large plantations of exotic species will require concurrent plantings of diverse native species to provide significant habitat improvement.

Commercial compromises – Larger areas may be difficult to incorporate into farm plans and operations and will take more time to establish and manage. Large plantings are more expensive to establish although there are economies of scale

9. Shape

The shape of a patch of vegetation is important for habitat quality. The edge of the patch is vulnerable to invasion by predators and to exposure to elements. By minimising the edge of the patch in comparison to its area, the biodiversity conservation value can be increased. A circular shape does this best and a square would be better than a long linear planting. Designers of wildlife corridors often specify a minimum width to cut down on the edge to area ratio. Corridors that are too narrow run the risk of drawing wildlife out of safe large habitat blocks into the open where they are vulnerable to attack by predators (Saunders and Hobbs, 1991). However some species, such as koalas and gliders are able to use narrow linear corridors (Suckling, 1980).

To incorporate into farm forestry –

- Block plantings may suit the corners of paddocks, odd-shaped soil patches, hill-tops or as off-shears or livestock shelter.
- Linear plantings should be as wide as possible – a feature which suits both the timber production and biodiversity values.
- Bird *et al.*, (1996) have proposed some circular designs for timber and shelter, which would enhance the biodiversity value of a planting.

Commercial compromises - While block-shaped plantings are ideally suited to forestry purposes they may not necessarily suit farm forestry, where linear plantings are often preferred.

10. Hollows

Many species of mammals, reptiles and birds require hollows for nesting, with some being obligate hollow-nesters (Johnston and Don, 1990). The size of the hollows is also important, depending on what species are likely to use them.

To incorporate into farm forestry –

- Allow some trees to develop hollows. For most species this means very long rotation, retaining some trees after clearfelling or designing an “eco-forestry” system (Drengson and Taylor, 1997)).
- Install artificial hollows in trees – nesting boxes can be custom made to suit different species of birds and animals (Barrett and Ford, 1993).
- Locate the plantation near existing trees (dead or alive) with hollows or retain these trees when establishing plantings.

Commercial compromises - Long rotations and selective harvest are not easily compatible with clearfell plantation options.

11. An absence of dominant weeds

Although many weeds are utilised by wildlife for shelter and food, they compete with native plants for resources and often displace them. This can lead to an increase in some wildlife species (such as berry-eaters) at the expense of others (such as honey-eaters). The spread of Firethorn (*Pyracantha spp*) and Red-berry bush (*Cottoneaster spp*) in many tableland areas of NSW has led to an increase in Currawong numbers at the expense of many small birds (Curtis *et al.*, 1995-2)

To incorporate into farm forestry –

- Basic management of the farm forestry project for commercial products will ensure that weeds are controlled.
- Maintain access for weed control to all parts of the planting.
- Identify plants present in regenerating understorey to identify any weeds also present.

Commercial compromises – Often native understorey species are perceived as weeds in plantations. Control of ecological weeds may be more comprehensive, and therefore more costly, than control of farm weeds.

12. An absence of feral animals

Feral animals, both omnivorous and herbivorous, contribute to habitat decline by competing for resources with native wildlife, preying on native species, damaging flora, particularly seedlings and ground flora, introducing diseases and parasites and spreading seeds of weed species.

To incorporate into farm forestry –

- As for weeds, feral animal control will be a normal part of farm operations.
- Allow good access.
- Fence the planting to exclude undesirable animals and use special fencing or gates to allow desirable wildlife to use the planting (Breckwoldt, 1980).
- Look for signs of feral animal activity when conducting routine forest management practices.

Commercial compromises – A planting which actively encourages wildlife may harbour feral animals and should be regularly inspected.

13. Leaf litter

The recycling of organic matter into the soil by soil organisms is a crucial component of many nutrient cycles and maintains good soil structure and chemistry. Leaf litter provides the food and shelter required for many of these organisms to exist, which in turn provide food for ground dwelling fauna. Leaf litter provides the nutrients, mulch and seed bed for plants and shelters small animals such as reptiles and amphibians. Leaf litter also provides the store of fuel for fire, which is an important component of many ecosystems.

To incorporate into farm forestry –

- Allow leaf litter to build up beneath the trees.
- If performing fuel reduction burns, adopt a mosaic approach (Breckwoldt, 1980). Burn parts of the planting at different times.
- If retaining leaf litter, ensure fire breaks are maintained around the plantation.

Commercial compromises – Maintaining leaf litter means planning for fire control must be rigorous.

14. Nectar

Nectar and pollen from flowers are rich sources of food, utilised by many insects, birds and mammals. Many Australian animals are especially adapted to extract nectar from flowers and require a year-round supply to survive. Other species require nectar at particular times such as during breeding. The provision of a diversity of flowering species ensures a range of fauna can occupy the planting. Many pollinators of agricultural crops depend on natural sources of pollen and nectar to maintain their local populations.

To incorporate into farm forestry –

- Incorporate nectar-producing species into the understorey as for Points 1 & 2 above.
- Use nectar-producing species as the commercial trees (eg; Eucalypts).
- Plant nectiferous species in clumps around or through the planting.
- Site plantations adjacent to existing bush or farm plantings that contain nectar-producing species.

Commercial compromises – Incorporating extra species adds time and cost and takes up land otherwise used for the plantation. Eucalypts may not be the most suitable tree for markets or sites.

15. Proximity to other areas of natural vegetation

It is important for small patches of newly-created habitat to be located close to other natural areas of vegetation or to be effectively linked to them by corridors. Different animals have varying abilities to cross different distances of open country. Small birds often need continuous cover, while other birds will cover large distances. Animals need to move around the landscape in order to breed and to find food. Plants also need to be close to other areas of natural vegetation so an adequate population of pollinators or seed-dispersers exists to maintain plant genetic diversity.

If patches of vegetation are not close to other areas of bushland, and are not well-connected to such areas, they effectively become islands in the landscape. Proximity and connection to other areas of vegetation effectively increases the size of the patch (see point 8 above).

Ecotones, the areas where different natural ecosystems meet, are important areas for biodiversity and often contain more, or different, species than the adjacent communities (Davies, 1999). For example, an ecotone between woodland and a pasture paddock may contain more species than the woodland or the paddock in isolation because they provide complimentary resources (one may provide shelter, the other food).

To incorporate into farm forestry –

- Locate farm forestry next to existing bushland (only where commercial species will not become weeds or hybridise with native species).
- Locate farm forestry plantings as part of a property, to best integrate commercial, conservation and farm enhancement benefits.
- Link plantings by corridors of native vegetation using riparian zones where possible.
- Use biologically-diverse forestry plantings as corridors for particular fauna species or manage existing planted corridors for timber.

Commercial compromises – Commercial returns may be reduced by using mixed species or using narrow corridor designs. It may be detrimental to harvest corridors upon which wildlife is dependent.

Conclusion

Biodiversity conservation in farm forestry depends on minimising the impacts of farm forestry on existing biological diversity and modifying farm forestry projects to actively enhance their conservation values. The utilisation of local species as commercial species and the adoption of ecologically diverse systems will maximise the biodiversity values of a farm forestry planting. However, the shape, structure and content of even the most commercial plantings can be modified to increase their biodiversity values.

Incorporating biodiversity into farm forestry plantings is not necessarily a goal of all farm foresters. There will be varying levels of impact on the commercial outcomes of farm forestry depending on the methods chosen to incorporate biodiversity. Most landholders will find that there are ways to enhance the biological diversity of their farm forestry operations with little or no compromise to the commercial values of the project. Others will accept these compromises in return for the complimentary benefits of enhanced biodiversity. Farm planning which looks at other conservation, agricultural and forestry operations on the farm is crucial to ensuring that biodiversity conservation and commercial values are not mutually exclusive in new farm forestry projects.

The successful incorporation of biodiversity into farm forestry projects will require further research at an institutional level and at a farm level. Research into sharing the costs of the resultant benefits is also needed if farm foresters are to take up a role in biodiversity conservation.

For farm forestry to become truly environmentally sustainable, the conservation and enhancement of biological diversity must become an integral part of all new projects.

References

Abbott, I. (1993) Minimising insect pests in eucalypt plantations: A review in the context of the concepts of optimal area, polycultures and patchiness. *Australian Forestry* **56** (4), 385-390.

*Abel, N., Baxter, J., Campbell, A., Cleugh, H., Fargher, J., Lambeck, R., Prinsley, R., Prosser, M., Reid, R., Revell, G., Schmidt, C., Storzaker, R. and Thorburn, P. (1997) *Design principles for farm forestry: A guide to assist farmers decide where to place trees and farm plantations on farms*. RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Program.

*Barrett, G and Ford, H (1993). Birds on farms. *Greening Australia Field Note* 93/5. Greening Australia North West NSW.

- Belsky, A.J., Mwonga, S.M. and Duxbury, J.M. (1993) Effects of widely spaced trees and livestock grazing on understorey environments in tropical savannas. *Agroforestry Systems* **24**:1-20.
- Bird, P.R., Bicknell, D., Bulman, P.A., Burke, S.J.A., Leys, J.F., Parker, J.N., Van Der Sommen, F.J. and Voller, P. (1992) The role of shelter in Australia for protecting soils, plants and livestock. *Agroforestry Systems*. **20**: 59-86.
- Bird, P.R., Jowett, D.W., Kellas, J.D. and Kearney, G.A. (1996). *Farm forestry clearwood production – a manual for south-east Australia*. Technical Report Series, Jan 1996, Agriculture Victoria.
- Black, A (1999). Impediments to the achievement of the commercial and conservation benefits of farm forestry. Ch 9 in *Robertson, A and Watts, R. (eds): Preserving rural Australia: Issues and solutions*. CSIRO Publishing, Collingwood, Victoria.
- Boland, D.J., Brooker, M.I.H and Turnbull, J.W. (1980) *Eucalyptus seed*. CSIRO, Canberra, Australia.
- *Breckwoldt, R (1983) *Wildlife in the home paddock*. Australian Natural Science Library. Angus and Robertson, North Ryde and London.
- Campbell White and Associates Pty Ltd and Black, A. (1999). *Practical farm forestry: Whole farm case studies*. RIRDC Publication 99/99. Rural Industries Research and Development Corporation, Kingston.
- Cannell, M.G.R, (1999). Environmental impacts of forest monocultures: water use, acidification, wildlife conservation and carbon storage. *New Forests* **17**: 239-262.
- Carr, D.B and Jenkins, B. (1998). Examining the compromises inherent in obtaining multiple benefits from revegetation. Paper presented to the 2nd Managing and growing of trees training conference, Oct 1998, Qld.
- Catling, P.C. and Burt, R.J. (1995). Why are red foxes absent from some eucalypt forests in eastern New South Wales? *Wildlife Research* **22**, 535-546.
- Commonwealth of Australia (1996) *The national strategy for the conservation of Australia's biological diversity*. Commonwealth Department of the Environment, Sport and Territories, Canberra.
- Curtis, D.J., Nadolny, C., Falconer, S., Metcalfe, P., Gaynor, S., Goldsmith, S., Fogarty, P., Mills, J., Williams, G., Moore, A and Hooper, S. (1995) *Re-leafing New England: A farmers guide to trees on farms*. Greening Australia, North West NSW, Armidale.
- Curtis, D.J., Nadolny, C. and Ford, H.A. (1995) Lessons from a network of dieback repairers. In; *Nature Conservation 4: The role of Networks*, ed by D.A.Saunders, J.L. Craig, and E.M.Mattiske. Surrey Beatty and Sons, 1995.
- Curtis, D.J., Sandstrom, M and Carr, D (1999) Combining nature conservation with production through farm forestry in northern New South Wales, Australia. In; *Nature Conservation 5: Nature Conservation in Production Environments: Managing the Matrix*, ed by J.L.Craig, N Mitchell and D.A.Saunders. Surrey Beatty & Sons, 1999.
- Dames and Moore NRM/FORTECH (1999) *Integrating farm forestry and biodiversity: A discussion paper*. Rural Industries Research and Development Corporation, Barton, ACT.

- Davidson, P.M. (1976) *Birds in pine forests*. Department of the Capital Territory, Studies in Forest Environment, No 1. Australian Government Publishing Service: Canberra.
- Davies, J. (1999). Benefits of conserving nature on farms. In; *Voller, P (1999). Growing trees on cotton farms*, Rural Industries Research and Development Corporation, Publication 99/65.
- Davies, P.E. and Nelson, M. (1994) Relationships between riparian buffer widths and the effects of logging on stream habitat, invertebrate community composition and fish abundance. *Australian Journal of Marine and Freshwater Research*. **45**, pp 1289-1305.
- Dix, M.E., Johnson, R.J., Harrell, M.O., Case, R.M., Wright, R.J., Hodges, J.R., Brandle, J.R., Schoeneberger, M.M., Sunderman, N.J., Fitzmaurice, R.L., Young, L.J. and Hubbard, K.G. (1995) Influences of trees on the abundance of natural enemies of insect pests: a review. *Agroforestry Systems* **29**: 303-311.
- Donaldson, J.D. and Gorrie, G.C (1996) *Farm forestry policy*. Paper presented at Australian Forest Growers Conference, Mount Gambier, S.A, 1996.
- Drengson, A.R. and Taylor, D.M. (eds.) (1997) *Ecoforestry: The art and science of sustainable forest use*. New Society Publishers, Gabriola Island, British Columbia.
- Driscoll, P.V (1977) Comparison of bird counts from pine forests and indigenous vegetation. *Australian Wildlife Research* **4**: 281-288.
- Fisher, A.M. and Goldney, D.C (1998). Native forest fragments as critical bird habitat in a softwood forest landscape. *Australian Forestry*, **61**: No 4, pp 287-295.
- Guijt, I. and Race, D. (1998) *Growing successfully: Australian experiences with farm forestry*. Greening Australia Ltd, Yarralumla.
- Hamlet, A. (1997) "Yet another benefit of Eucalypt plantations". *Agroforestry News* Vol **6**:2 June 1997.
- *Johnston, P. and Don, A. (1990). *Grow your own wildlife: How to improve your local environment*. Greening Australia Ltd, Canberra.
- Khanna, P. (1998) Gains from planting eucalypts and acacias together. *Onwood* **23**, Summer 1998/99. CSIRO Forestry and Forest Products
- *Lindenmayer, D. (2000-1). *Guidelines for biodiversity conservation in new and existing softwood plantations*. Short report No 77, Rural Industries Research and Development Corporation, Kingston.
- Lindenmayer, D. B. (2000-2) The Tumut fragmentation experiment: Using fragmentation studies to help in the design of "new" landscapes. *Australian Biologist* **13**: 47.
- Montague, T.L (1996) The extent, timing and economics of browsing damage in eucalypt and pine plantations of Gippsland, Victoria. *Australian Forestry* **59** (2), 120-129.
- Mortlock, W and the Australian Tree Seed Centre. (1999). *Florabank guidelines: Seed production areas for woody native plants*. Guideline No 7, Florabank, Yarralumla, Canberra.
- *Murray, J and Thompson, D. (2000). Native regrowth: *A farmer's guide to maintaining biodiversity when thinning regrowth forest*. RIRDC publication No 00/12, Rural Industries Research and Development Corporation, Kingston.

- Pilarski, M.(ed). (1994). *Restoration forestry: An international guide to sustainable forestry practices*. Kivaki Press, Durango, Colorado.
- Poore, M.E.D. and Fries, C. (1985). *The ecological effects of eucalyptus*. FAO Forestry paper 59.
- Reid, N. (1997) *Managing Mistletoe*. North West Slopes and Plains Vegetation Subcommittee, North West Catchment Management Committee, Tamworth.
- Reid, R. and Stephen, P. (2000). Farm forestry's role: Why pruning must be fun and not just economic. Paper presented at Outlook 2000- New directions/Future markets, Canberra, 1st March 2000, Vol 1, 186-193.
- Robins, L., McIntyre, K. and Woodhill, J. (1996). *Farm forestry in Australia: Integrating commercial and conservation benefits*. Greening Australia Ltd, Yarralumla, ACT.
- Sandstrom, M. and Parker, J. (1998) *The one hectare alternative*. Forestry For Farms field note. Greening Australia NSW, Marrickville.
- Saunders, D.A. and Hobbs, R.J. (eds.) (1991) *Nature Conservation 2: The role of corridors*. Surry Beatty & Sons, Chipping Norton, NSW.
- Sawyer, J. (1993) *Plantations in the Tropics: Environmental concerns*. The IUCN Forest Conservation Programme.
- Shedley, E. (1997) Pesky parrots invite control measures. *Agroforestry News* 6: 2 June 1997.
- Shedley, E. and Adams, M. (1998). Parrot damage in Tasmanian blue gum plantations in the south west of Western Australia. In *The future of vertebrate pest management: Direction for the third millenium*, Proceedings of 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia, pp 247 – 253.
- Shell/World Wide Fund for Nature (1993). *Shell/WWF tree plantation review examines the relationship between biodiversity and tree plantations*, Vol 6. Shell International Petroleum and World Wide Fund for Nature, London.
- Sierota, Z. H (1986). Ecological aspect of biological control of *Heterobasidion annosum*. *Proceedings of the IUFRO 18th World Congress, Yugoslavia, Division 2*, Vol 1.
- Southwood, T.R.E., Brown, V.K. and Reader, P.M. (1979) The relationships of plant and insect diversities in succession. *Biological Journal of the Linnaean Society*, 12: 4, 327-348.
- Stamps, W.T. and Linit, M.J. (1998) Plant diversity and arthropod communities: Implications for temperate agroforestry. *Agroforestry Systems* 39: 73-89.
- Suckling, G. C (1980) The effects of fragmentation and disturbance of forests on mammals in a region of Gippsland, Victoria. Ph.D thesis, Zoology Dept, Monash University. Cited in Breckwoldt, 1983.
- Turner, J., Gessel, S.P. and Lambert, M.J. (1999) Sustainable management of native and exotic plantations in Australia. *New Forests* 18: 17-32.
- Wilson, S.M., Whitham, J.A.H., Bhati, U.N., Horvath, D. and Tran, Y.D. (1995). *Trees on farms: Survey of trees on Australian farms: 1993-94*. ABARE Research Report 95.7, Canberra.

* These references are a good place to start for ideas on managing for biodiversity.

