Revegetation and Wildlife

A guide to enhancing revegetated habitats for wildlife conservation in rural environments

Andrew Bennett, Sally Kimber and Paul Ryan,
School of Ecology and Environment
Deakin University

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Preface

Revegetation is an important and urgent issue in natural resources management in Australia. There is widespread acceptance among the community that extensive revegetation is needed to counter environmental problems arising from the loss of native vegetation, including the decline in biodiversity.

This project was funded under the Bushcare Program, through the Natural Heritage Trust, to identify ways in which revegetation activities can be undertaken to maximize their value in providing habitat for wildlife. We have addressed this task in two parts: by carrying out a review of existing information on revegetation and wildlife conservation in Australia; and by developing principles for enhancing present revegetation activities to increase their value for wildlife conservation. This report fulfils the second part of the task. The first part is presented in a companion report (Kimber et al. 1999) that provides a comprehensive guide to scientific information concerning revegetation and nature conservation.

The project was guided by a Steering Committee, comprising Kathy Tracy and Peter Lyon (Environment Australia), Geoff Barrett (Birds Australia), Stephen Platt (Flora and Fauna, Department of Natural Resources and Environment Victoria (NRE)), Dale Tonkinson (Greening Australia Victoria) and Des Stackpole (Centre for Forest Tree Technology, NRE). We gratefully acknowledge their advice and constructive contribution. We also warmly thank those people who attended a one-day workshop in February 1999, and whose deliberations and discussion on a range of issues related to revegetation provided valuable insights (see photo below). For comments on drafts of an earlier manuscript we thank Kathy Tracy, Ian Hislop, Geoff Barrett, Ian Davidson and Neil Collins.

Diagrams to illustrate principles, as set out in Section 4, were prepared by Alexis Beckett (Greenhood Graphics) to whom we are most grateful.

Photo: Participants at a workshop (Feb 1999) to discuss revegetation and nature conservation.
Back (standing): Andrew Bennett, David Goldney, Paul Ryan, Stephen Platt, Geoff Barrett, Brenan Wotherspoon, Ian Davidson, Dale Tonkinson, Louise Gilfedder, Richard Loyn, David Parkes, Doug Robinson, Hugh Bramwells, Karen Barton, Ian Hislop, Kathy Tracy. Front: Jim Robinson, Des Stackpole, Peter Lyon, Neil Collins, Richard Hobbs, Sally Kimber.

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1 Revegetation- a growing activity in Australia

In the last two decades there has been a marked increase in the extent of revegetation activities in Australia. Revegetation—the deliberate planting or regeneration of trees, shrubs and other plants in areas formerly cleared of their natural vegetation—is presently being undertaken by a wide range of individuals, community groups, business organisations and local, state and federal government agencies across the country. Planting of trees has been a central feature of a number of national environmental initiatives by the Federal Government, such as the One Billion Trees Program (established in 1989), the National Landcare Program (including the Decade of Landcare 1989-1999), and the National Corridors of Green (1996). Subsequently, these and other programs have been incorporated within the Natural Heritage Trust (established in 1997), a national framework for integrating activities directed at environmental and natural resource management in Australia. The largest single program under the Natural Heritage Trust is the Bushcare Program, which aims to reverse the decline in extent and quality of Australia's native vegetation. Other recent federal initiatives promoting planting of trees include Plantations for Australia: the 2020 Vision, the Farm Forestry Program and Bush for Greenhouse.

Why is there such interest in revegetation?

Revegetation is undertaken for a wide range of purposes, most of which relate to concern about the sustainability of land and water resources in Australia and the maintenance of agricultural productivity in rural environments. Purposes include:

- *to combat degradation of land and water resources*, including efforts to control the rise of saline groundwater, to reduce soil erosion by wind and water, to reduce waterlogging, and to protect water quality in streams;
- *to increase nature conservation values*, including restoring and expanding habitats for native flora and fauna species and communities and establishing corridors to link otherwise-isolated habitats;
- *to increase agricultural productivity* by providing shade and shelter for stock and protection for crops;
- *to plant trees for wood and other products* including large commercial plantations, agroforestry systems on farms and planting for fodder;
- *to restore land that has been severely degraded or denuded of vegetation*, such as mine sites or quarries; and
- *to enhance scenic quality and human amenity values* including revegetation in urban reserves or vacant land, and along roadsides adjacent to highways and freeways.

The main focus of this report is on ways in which revegetation can be used to increase nature conservation values, especially through enhancing the habitats required by native wildlife. In many situations this can be achieved through an integrated approach to land management, in which revegetation activities are planned to achieve goals in both sustainable land use and nature conservation.

Revegetation for nature conservation

Excessive clearing of natural vegetation in many parts of Australia and the resulting detrimental consequences of habitat loss on plants and animals is an important motivation for revegetation for nature conservation. Clearing of natural vegetation has been most extensive on the fertile slopes and plains of temperate southern Australia, where there is greatest potential for broadscale wheat/sheep agriculture. The recent State of the Environment Report (1996) estimated that nationally nearly 90 per cent of temperate woodlands and mallee vegetation have been cleared and modified, and that more than 99 per cent of temperate lowland grasslands in south-eastern Australia have been lost. In many agricultural districts the remaining native vegetation is less than 10 per cent of that present originally and it has been fragmented into a mosaic of small, usually isolated, patches that are subject to disturbance from surrounding land uses. Altered hydrological patterns, invasion by weeds and pest animals, changes to microclimates, and grazing by domestic stock are among the many processes that influence the status of remnant vegetation and its ability to sustain wildlife populations.

Some species of animals have benefited from these changes and have increased in numbers, but for most species that depend on natural or near-natural

habitats, the consequences of excessive clearing of native vegetation have been detrimental. These include:

- disproportionately severe loss of habitats on land with the best agricultural potential;
- massive reduction in the overall amount of habitat with consequent declines in population sizes;
- isolation of habitats and populations from others nearby;
- loss of key resources for food and shelter through changes to remaining vegetation; and
- exposure to introduced animals, such as the red fox, feral cat, house mouse, black rat, European rabbit, common starling and common mynah.

There is increasing evidence of the results of these changes, including declining numbers and loss of species in local areas, loss of species from entire regions, marked reductions in the geographic ranges of some species, increasing numbers of 'threatened' species and, for some species, extinction. To counter these detrimental effects there is an urgent need to prevent further loss of depleted woodland and grassland ecosystems, to protect and restore viable remnants of native vegetation and to expand the total area of native vegetation. However, nature conservation in rural landscapes can not be addressed adequately in isolation from other land uses that affect ecological sustainability. A 'whole landscape' approach to restoration is needed that encompasses both nature conservation and the restoration of processes that affect the sustainability of the land, particularly soil and water resources. Revegetation is an important tool that contributes to all aspects of the essential task of restoring rural environments.

Purpose of this guide

The purpose of this guide to revegetation is to provide information to assist land managers and project facilitators to carry out revegetation in ways that will increase its value as habitat for native wildlife. The focus is on revegetation in rural environments. Revegetation for the rehabilitation of mine sites, for the establishment of commercial tree plantations for timber production, or for large-scale farmforestry is not directly addressed here. However, the guide provides information on how these activities could better contribute to achieving nature conservation outcomes.

The approach taken is to outline general principles based on current ecological understanding, and to discuss how these principles will benefit nature conservation (Section 4). To put these in a broader context, consideration is first given to the role of revegetation in nature conservation and ways in which it can be used to enhance wildlife habitats (Section 2); and to a framework for understanding the habitat requirements of animal species (Section 3). Because the primary motivation for many revegetation activities at present is to achieve goals *other* than nature conservation (see Box 1), ways in which such revegetation can be adapted to obtain better conservation outcomes are also discussed (Section 5).

An accompanying report (Kimber *et al.* 1999) reviews scientific literature relating to revegetation in Australia and the use of re-established habitats by wildlife. It includes an annotated reference list as a guide for those seeking further information, and provides a scientific basis for the principles outlined here.

Box 1. Current trends in revegetation in rural Australia

The following summary is based on a survey of about 2000 farmers across Australia, conducted in 1994 by the Australian Bureau of Agricultural and Resource Economics (Wilson *et al.* 1995). Few other published statistics are available on recent revegetation activities in Australia, but information from local areas indicates the same general patterns.

How widespread are revegetation activities in Australia?

Tree planting has been widely practiced by landholders in rural Australia in the last 15 years. Nationally, 35% of farmers surveyed planted trees in the period 1991-92 to 1993-94, including 34% in the wheat-sheep zone, 39% in the high rainfall zone and 4% in the pastoral zone. In the southern states, activity was greatest in Western Australia (57% of farmers) and Victoria (50%).

What are the primary reasons for revegetation on farms?

The main responses of farmers from the wheat-sheep (ws) and high rainfall (hr) zones, respectively, when asked: (1) to list up to three main functions of planted trees on their property; and (2) the purpose for their most recent planting (1991-92 to 1993-94), were as follows.

	1. Major functions of planted trees		2. Purpose for most recent planting	
	ws (%)	hr (%)	ws (%)	hr (%)
Provide shade and shelter	81	93	55	81
Rehabilitate or protect degraded land	58	38	29	12
Conserve native vegetation and wildlife	29	26	3	1
Produce sawlogs and pulpwood	3	6	1	1

Planting trees for timber or non-timber products for sale was of minor importance, with less than 2% of farmers listing these as the main purpose of recent plantings. This value may have since changed. The Plantations 2020 initiative, launched in 1997, set the goal of tripling Australia's plantation estate by 2020, by establishing about 80 000ha of plantations annually on cleared land.

How is revegetation undertaken?

The most common type of revegetation is the planting of linear strips, including shelterbelts, tree rows and corridors, reported nationally by 63% of farmers as their most recent planting. Next most frequent were blocks of trees (20%), alley belts (8%) and widely spaced trees (9%). Nationally, 67% of farmers reported planting predominantly local native species, while 21% and 12% had established other native species and exotic species, respectively. Exotic species were planted more frequently in the high rainfall zone.

How large are revegetated areas?

The average size of the most recent stand planted (1991-92 to 1993-94) was 5.1ha for blocks of trees, 3.8ha for alley belts (including the area between tree belts) and 5.7ha for widely spaced trees (data not given for linear strips—the average was 657 trees per planting). Values for local regions support this pattern. For the South Tammin Catchment, WA, 70% of revegetated areas are less than 5ha and 81% less than 10ha (Brandenburg and Majer 1995). In the Goulburn-Broken Catchment, Victoria, the average size of revegetated plots funded by salinity management incentives in 1998 was 1.2ha (Kimber *et al.* 1999).

Summary

Revegetation is widespread in rural areas and is primarily undertaken to achieve agricultural production and land management goals. More than 25% of farmers recognise that it also has benefits for nature conservation but little revegetation is undertaken directly for this purpose. Planting is mostly in the form of linear strips, generally of native species, and planted areas are relatively small.

2 An ecological approach to revegetation in rural landscapes

The role of revegetation in nature conservation

An important question for land managers is, 'What priority should be given to revegetation activities compared with other measures that enhance nature conservation?'. There is widespread agreement that the highest priority for vegetation management in rural environments is to identify, protect and manage *existing remnants* of natural vegetation. Although the remnants may have experienced varying degrees of disturbance, protection and restoration of remnant vegetation generally offers greater potential for nature conservation than attempting to develop new habitats by revegetation. There are, for example, many natural elements likely to be present in remnant vegetation that are not easily established in newly revegetated plots, including soil fungi, ground-dwelling invertebrates, native grasses, herbs and shrubs. Even when degraded, remnants represent at least a skeleton of the natural environment that can be restored.

In many situations, however, protection and restoration of remnant natural vegetation will not be enough on its own. There are a number of reasons why 'putting back' additional vegetation into the landscape also has an important role.

- Regional processes that affect the sustainability of the landscape (such as rising water tables, degradation of soils) still continue even though existing vegetation may be protected, and are likely to threaten the viability even of these protected remnants. Revegetation can be used to directly tackle such problems.
- Existing remnants may be too small to maintain wildlife populations of sufficient size to be self-sustaining in the long term. Revegetation can be used to enlarge individual remnants and increase the total amount of habitat in the landscape.
- Not all types of vegetation are adequately represented in the system of remnant vegetation, and many local areas have little remnant vegetation present. Revegetation offers the potential to replace these missing elements by careful restoration of particular types of vegetation, or restoration in strategic areas.
- The sheer scale of the environmental problems in many rural areas demands urgent and extensive restoration and revegetation efforts.

Revegetation activities also have an important social function. They offer an opportunity for many people to be involved in nature conservation in a practical way, to see positive outcomes for their efforts and to learn more about the natural environment.

The role given to revegetation in a particular area will vary depending on local circumstances. In landscapes where *substantial areas* of remnant natural vegetation remain, revegetation activities are likely to be most beneficial where they are directed towards restoring and expanding this existing vegetation, and linking remnants. Regeneration of plant communities, rather than direct planting, may be particularly important. In contrast, in landscapes where *little* natural vegetation remains there must be greater emphasis on large-scale establishment of new tracts of vegetation to stabilise the environment and to expand the total area of habitat for nature conservation.

How can revegetation be used to benefit wildlife?

There are a number of ways in which revegetation activities can provide conservation benefits for wildlife within the context of a 'whole landscape' approach to restoration (Hobbs 1994; Hobbs and Norton 1996; Kimber *et al.* 1999). *Direct* measures are those that benefit wildlife by providing habitats in which species may live, or from which they obtain resources such as food and shelter. *Indirect* measures are those that do not necessarily provide an immediate benefit, but by preventing the decline and degradation of the natural environment they indirectly benefit species that use these habitats. These measures are briefly outlined below, and are discussed further in Section 4.

Direct measures

Revegetation can be used in three ways to directly benefit wildlife species (Figure. 1). These are:

- increasing the *amount* of suitable habitat in the landscape, either by adding to existing vegetation or by establishing new blocks of vegetation;
- improving the *quality* of existing habitats by selective replanting or seeding with additional plant species to enhance the composition or structure of the vegetation (such as adding understorey shrubs where only a tree layer is present); and
- promoting the *connectivity* of existing habitats by filling in 'gaps' to complete an existing link (e.g. in roadside or streamside vegetation), or by establishing a new habitat corridor or 'stepping stones' of habitat between otherwise isolated areas.

Indirect measures

Revegetation can be used to protect and bolster existing habitats in several ways. These include:

- acting as a *buffer* for existing vegetation to reduce microclimatic changes at the edge of the stand (such as wind speed, exposure to the sun), and to minimise impacts from surrounding land uses (such as fertiliser drift, invasion by weeds or pest animals); and
- *stabilising* disturbance processes in surrounding lands to prevent the entire landscape (including wildlife habitats) from being degraded. Revegetation that counters soil erosion and drift, waterlogging, and rising saline water tables will help to increase the sustainability of the landscape and reduce the likelihood that natural habitats will be further degraded or lost.

Figure 1. Three ways in which revegetation can be used to directly benefit wildlife: by increasing the amount of habitat, by improving the quality of habitats, and by promoting the connectivity of habitats in the landscape

Adaptive management

A major limitation in evaluating the role of revegetation in nature conservation is our almost complete lack of knowledge of the extent to which revegetation actually does achieve conservation goals. There are few studies of the use of revegetated habitats by wildlife and there is a lack of information about basic ecosystem processes in revegetated habitats, such as litter decomposition, nutrient cycling and plant–animal interactions. Similarly, there is no information about the rate at which components of natural ecosystems, such as soil fungi, soil and litter invertebrates, lichens and ground layer herbs can colonise and re-establish (if at all) in newly revegetated plots. This scarcity of ecological research stands in contrast to the growing body of information on the values of planted vegetation as shelter for stock and crops; on local hydrology and the effect of controlling water tables in controlling soil erosion; on the productivity and economics of tree plantations for agroforestry; and on silvicultural techniques for tree establishment and growth (Kimber *et al.* 1999).

We cannot afford to wait until full information is available. Restoration and revegetation for nature conservation must proceed based on the best available knowledge and experience, but with a commitment to revising techniques and procedures in the light of new information. This is the concept of *adaptive management*—an approach based on 'learning by doing' with the results from practical experience used to guide the next phase of planning and implementation. A critical component of adaptive management is monitoring the outcomes of current practice. Effective monitoring and research programs on the conservation benefits of revegetation are not being adequately undertaken at present and there is limited feedback to guide and improve future activities. This is a serious shortcoming, given the present commitment of time and resources to revegetation activities throughout Australia. Quantitative monitoring and research must be included as an integral part of management activities.

This report recognises the importance of an adaptive approach to revegetation. The principles outlined here are based on present knowledge and understanding of wildlife biology and landscape ecology. There are many opportunities to plan and implement revegetation activities to test these principles, and it can be expected that they will be modified and improved in the future.

Photo: Shelterbelts to protect livestock and crops are the most common type of revegetation being undertaken on farms in southern Australia.

3 Understanding the habitat requirements of wildlife

Revegetation will have greatest value for wildlife when it is planned and undertaken in a way that meets the requirements of animal species. A useful way to identify these requirements is to consider different levels of an ecological hierarchy within which all living organisms are situated (Figure 2). These levels include the individual animal; a population of animals of a particular species; a community made up of many species of plants and animals; and an ecosystem, comprising a community together with the non-living components of the environment (such as soil, water, air). Land management activities can also be considered at different levels (Figure 3), with different kinds of issues being relevant at each level.

An ecological hierarchy

Individual

The basic requirements for an individual animal to survive are *food*, *water*, *shelter* from hostile climatic conditions and *refuge* from predators. Animals obtain these *resources* from their habitat, the place where the animal lives. If areas of revegetation are to function as a habitat for animal species, they must be able to provide these necessary resources for part or all of the animals' life cycle. This means being able to provide the appropriate *type* of resource and an adequate *amount* of the resource through time.

Different species and groups of animals use many different types of resources for food, shelter and refuge. Several examples are given in Table 1 to illustrate the wide range of resources used by some common species of animals in woodlands and forests of south-eastern Australia: namely, the sugar glider, superb fairy-wren, Boulenger's skink, spotted marsh frog and huntsman spider. In revegetated habitats, these resources will largely be determined by actions that are taken at the *site level*, such as the types of plants that are established and the management actions undertaken.

Population

Animals live as part of a population—a group of individuals of the same species that occur in the same place. In addition to the needs of each individual for essential daily resources, a population

Table 1. Examples of resources used by individuals of several common species in forests and woodlands of south-eastern Australia

Species	Foraging substrates	Food	Shelter or refuge	Reproduction
Sugar glider *Petaurus breviceps*	branches and among canopy of trees, tall shrubs	acacia gum, nectar, eucalypt sap, invertebrates, invertebrate exudates	tree hollows	den in tree hollow
Superb fairy-wren *Malurus cyaneus*	bare ground, litter, shrubs, logs, dense vegetation	insects and other small invertebrates	shrub patches, bracken, dense low cover	nest among shrubs, tussocks, or dense cover
Boulenger's skink *Morethia boulengeri*	grass cover, ground litter and debris, fallen timber	spiders, termites, ants and other small invertebrates	fallen timber, ground debris, under bark	eggs deposited under cover on ground
Spotted marsh frog *Limnodynastes tasmaniensis*	ground layer, marshy vegetation	insects and other invertebrates	cracks in ground, rocks, logs, close to wetlands or damp areas	egg masses in open water attached to emergent vegetation
Huntsman spider *Isopeda montana*	trunks, branches of trees	small insects and other invertebrates	beneath loose bark of trees	egg sac under bark of trees

has additional requirements including suitable habitat resources for reproduction and a total area of habitat sufficient for all individuals to live. Habitat resources for reproduction include areas for reproductive display, nests or den sites for rearing young, and sites for depositing eggs. Different groups of animals use many different resources for these purposes, including tree hollows, cavities under rocks or logs, cavities within logs, constructed nests in shrubs or trees, burrows, pools of water, and many others (Table 1). The availability of these resources is influenced mainly by management at the *site level.*

An area of sufficient size to maintain a viable population varies greatly between species, ranging from perhaps a few square metres for soil microinverterbrates, to many thousands of hectares for large predatory birds or mammals. For mobile species, such as many birds, a revegetated habitat may be occupied by a few individuals or a single pair as long as there is a nearby 'source' area from which the species can regularly colonise the revegetation. For other species that are isolated by surrounding land uses, the revegetated habitat must be large enough for a self-sustaining population (typically tens to hundreds of individuals).

Community

A community consists of a set of interacting populations of plants and animals that share a common environment. It is the interactions between species that are of particular interest at a community level. For example, interactions between herbivores and plants, and between predators and their prey, determine the structure of food webs and the flow of energy through a community. Other types of interactions—such as those between plants and animals for the dispersal of seeds and spores, or the pollination of flowering plants—'tie together' the community in interdependent relationships. If particular species are lost or reduced in numbers in the community, there may be far-reaching effects on other species.

A goal for revegetation is to establish diverse communities of plants and animals in which the interactions between species maintain the healthy functioning of the community. This requires revegetated habitats to provide resources for a wide range of species and to be sufficiently large to meet the area required by all species' populations. Meeting this goal will depend on what is done at the block level (such as the size of blocks and the composition of the vegetation) as well as at the landscape level (such as the total area of suitable habitat, landscape connectivity, representation of vegetation types).

Ecosystem

An ecosystem is made up of the community of plants and animals together with the non-living components of the environment. Characteristic processes that operate at the ecosystem level include the storage and cycling of nutrients, water and other materials; and the flow of energy through the living and non-living components of the environment. Storage and recycling of nutrients such as nitrogen, phosphorus, potassium and calcium are essential to the function of a healthy ecosystem. If the system 'leaks' and these nutrients are lost, they are not available for plant growth and may result in reduced productivity.

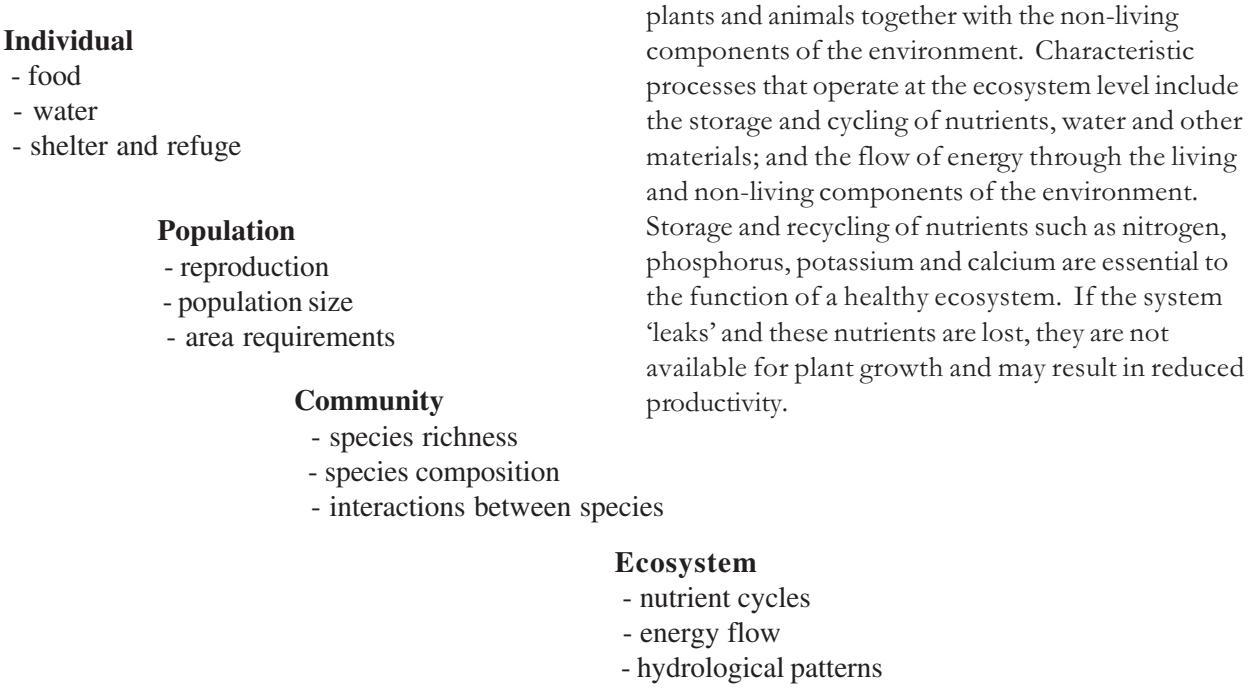


Figure 2. Diagrammatic representation of levels in an ecological hierarchy, indicating some of the important attributes at each level

Loss of nutrients occurs, for example, where bare soil is exposed and erodes to be either washed or blown away. An imbalance in ecosystem function may also occur when there are changes to the flow of water into or out of the system. Maintaining sustainable ecosystems in rural environments depends upon land-use planning at landscape and regional levels.

Land management at different levels

Different kinds of actions are undertaken at different levels of land management (Figure 3). Planting, direct seeding or regeneration of vegetation are undertaken at a particular *site*, resulting in vegetation with a particular species composition and structure. Likewise, management actions such as weed control, thinning, supplementary planting or tree felling for posts and firewood are also undertaken at a particular site and influence the vegetation. In turn, the vegetation at a site forms part of a *patch or block* of habitat.

The size, shape, location and diversity of vegetation types in a block are examples of features of revegetation at the *block level* that influence the block's value for wildlife. Land management at the site and block levels usually relates to a single property, such as a farm, and a single land manager.

The *landscape level* refers to an area from several to tens of kilometres across and usually involves a number of different properties and land managers (Figure 3). It is the appropriate level at which planning for revegetation activities is undertaken as part of property management planning or for a local sub-catchment plan involving a number of landholders. Important issues for nature conservation are addressed at the landscape level. Issues include the total amount of natural and revegetated habitat, the spatial pattern and connectivity of habitats, and the representation of different vegetation types.

The *regional level* (or catchment), spanning an area of tens to hundreds of kilometres across, is the level at which strategic planning for the use of revegetation for nature conservation and sustainable land management is most effectively undertaken. There are many groups and organisations that have responsibilities for land management at this level, and consequently coordination amongst governmental agencies, local government and community groups will be required.

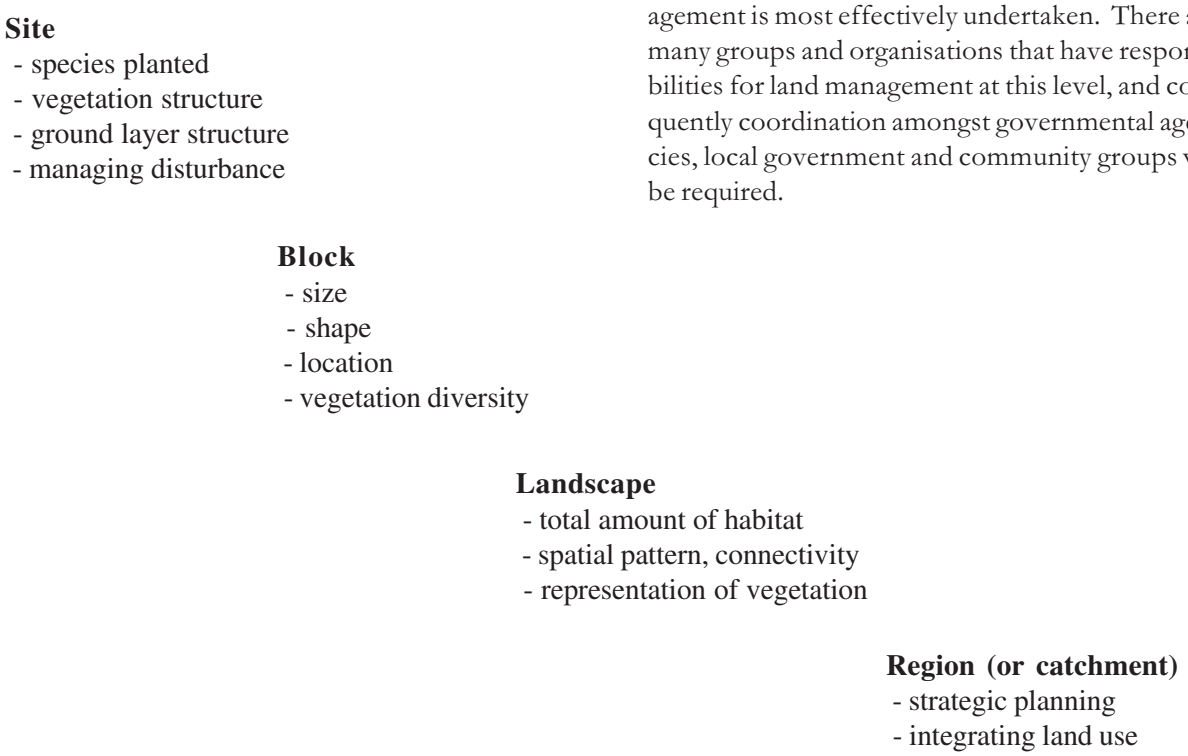


Figure 3. Diagrammatic representation of levels in a land management hierarchy, showing the types of issues that are relevant to revegetation for nature conservation

4 Enhancing the value of revegetation for wildlife

The following principles set out ways in which revegetation can be carried out to increase its value as habitat for wildlife. An underlying assumption is that revegetated habitats will be of greatest value for wildlife communities in the long term if they are modelled on the natural environment with an aim of re-establishing natural ecological processes, or at least of developing 'functional mimics' of them. These principles are grouped into four categories representing different levels at which actions are planned and carried out (Table 2):

- actions at the site level;
- actions relating to blocks or patches of revegetation;
- planning and design at the landscape level;
- strategic planning at the regional scale.

Ways in which wildlife values can be increased where revegetation is undertaken for purposes other than nature conservation are discussed further in Section 5.

Actions at the site level

Actions undertaken at specific *sites* during revegetation—such as the planting of selected species of trees and shrubs, the spacing and arrangement of plants and the preparation of the ground layer—largely determine the types and quality of habitat resources available for animals. Principles summarised here relate to the way in which the establishment of vegetation influences habitat quality for animals. Information about selection of species to plant, site preparation, planting techniques and other practical issues are well documented in other publications.

Use locally indigenous plant species

Where the goal of revegetation is to mimic 'natural' ecosystems, priority must be given to planting species indigenous to the local area, rather than exotics or plants from other environments. Locally indigenous species are those most likely to provide natural habitat resources (such as foods, foraging substrates, refuge, nest materials) that the local fauna requires. Using indigenous plants also maximises the chance of restoring plant–animal interactions such as pollination and seed dispersal, and ecological processes such as leaf litter accumulation and decomposition.

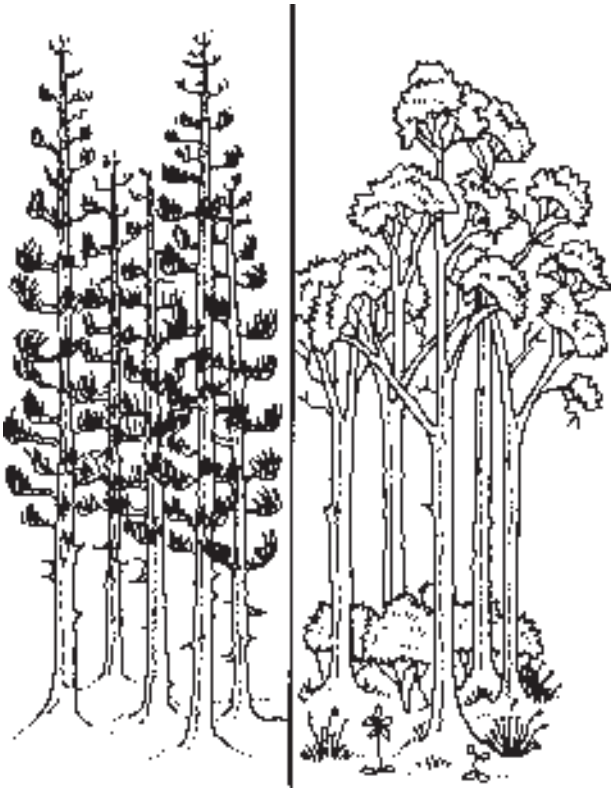


Table 2. Principles for enhancing the value of revegetation for wildlife conservation

Actions at the Site Level

Use locally indigenous plant species
Match plant species to the landform
Establish natural layers in the vegetation
Fine-scale patchiness of vegetation
Promote patchiness of vegetation by planting
Provide ground-layer components as resources for wildlife
Provide ground-layer components as resources for wildlife
Ground-layer components assist restoration of ecosystem processes
Management of vegetation
Manage the composition and structure of revegetated habitats
Control disturbance and degradation

Habitats at the Block Level

Size
Establish larger blocks for large populations
Ensure habitats meet the area requirements of particular species
Create large patches for diverse animal communities
Shape
Increase width to reduce edge effects
Design the shape and width of revegetation to meet species' requirements
Location of blocks
Position revegetation to increase opportunities for recolonisation
Build on to existing natural vegetation
Locate new habitats away from known sources of disturbance
Manage for diversity of vegetation

Planning and Design at the Landscape Level

The amount of suitable habitat in the landscape
Increase the total area of suitable habitat in the landscape
Establish multiple populations
Provide for species that use different habitats
Enhance connectivity in the landscape
Achieve connectivity by different configurations of habitat
Give priority to streams and watercourses as natural corridors
Recognise different kinds of movements through links
Ensure representation of ecosystems
Re-establish poorly represented habitats
Restore remnants of depleted vegetation types

Strategic Planning at the Regional Level

Develop a long-term vision for the region
Identify regional ecological priorities for revegetation
Implement effective monitoring programs

Match plant species to the landform

Natural vegetation corresponds closely with landform, soil types and topography. Different plant communities, for example, occur along drainage lines and streams compared with adjacent dry slopes. To re-establish natural habitats, the species planted must be appropriate to the position of the revegetated plot (such as upper or lower slope, gully) and its soil type. Knowledge of appropriate species can be obtained by checking nearby remnants of natural vegetation on the same landform, or by consulting revegetation guides available for some regions.

Establish natural 'layers' in the vegetation

Different 'layers' in natural vegetation provide different types of foraging substrates, nesting locations and shelter for animal species. For example, some species search for food in the canopy foliage, others on tree trunks and branches, others in tall shrubs, and others in the ground layer. In revegetated plots, layers in the vegetation (i.e. habitat structure) can be manipulated by selecting plants that grow to different heights, such as trees, tall shrubs, low shrubs and ground cover. The type and number of layers can be determined by checking local examples of natural vegetation (that have been protected from disturbance).

Fine-scale patchiness of vegetation

In natural environments, plants are not regularly spaced in straight rows but occur in a 'patchy' manner that may include scattered thickets, areas with sparse cover and small open clearings. Natural patchiness is also increased by a mix of trees and shrubs of different ages and growth forms, and by trees with different textures of bark. Fine-scale patchiness of vegetation provides a range of resources for the wildlife community, such as different types of feeding habitats and a variety of refuge types.hiness is also increased by a mix of trees and shrubs of different ages and growth forms, and by trees with different textures of bark. Fine-scale patchiness of vegetation provides a range of resources for the wildlife community, such as different types of feeding habitats and a variety of refuge types.

Promote patchiness of vegetation

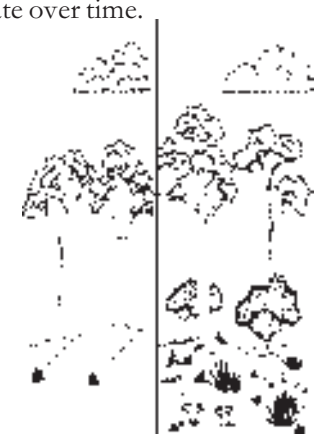
Fine-scale patchiness can be developed by spacing trees and shrubs at irregular distances, by trying alternatives to planting in straight rows, and by using indigenous plants with different growth forms and trees with different types of bark (e.g. 'gum', 'box' or 'stringybark' types). In the long term, management of larger blocks of vegetation by thinning or the use of fire can also be used to enhance patchiness.

Ground-layer components as resources for wildlife

Logs, rocks, leaf litter, soil-surface lichens and mosses, patchy low vegetation and open spaces are examples of important ground-layer components in forests and woodlands. however, these are seldom considered in revegetation activities and may take many years to re-establish (if at all).

Provide ground-layer components as resources for wildlife

Ground-layer components provide shelter, refuge and living space for a myriad small animals such as skinks, spiders, centipedes, cockroaches, beetles and ants. In turn, these are the food of larger animals and so the ground layer provides a foraging area for mammals, insectivorous birds and various reptiles (such as dragons, skinks, legless lizards). Many of these predators also use hollow logs, rocks or dense vegetation, as shelter and breeding sites. The provision of ground-layer components can be assisted by deliberately adding logs and rocks to revegetated areas, by planting indigenous ground-cover plants, and by allowing fallen branches and timber to accumulate over time.



G*round-layer components assist restoration of ecosystem processes*

Ground-layer components are also essential to the natural function of ecosystems. Ground vegetation and leaf litter trap rainfall and assist its infiltration into the ground, help prevent soil loss through erosion and contribute to soil formation. Leaf litter and associated fungi, bacteria and small invertebrates are involved in the decomposition of dead organic material and the recycling of nutrients (such as phosphorus, potassium and nitrogen).

Management of vegetation

The structure, composition and function of plant communities change through time. The way in which vegetation is managed has an important influence on its value as a habitat in the long term.

Manage the composition and structure of revegetated habitats

Maintaining habitat resources such as older trees, fallen timber, and multiple layers of vegetation requires management to ensure these resources are not completely removed (such as by harvesting for firewood or by 'tidying up'). Active management to *provide* resources (such as by adding logs or leaf litter, or planting additional shrubs or ground plants to increase structural diversity) can also be beneficial. Planting over a number of seasons can help provide a mix of age classes.

Control disturbance and degradation

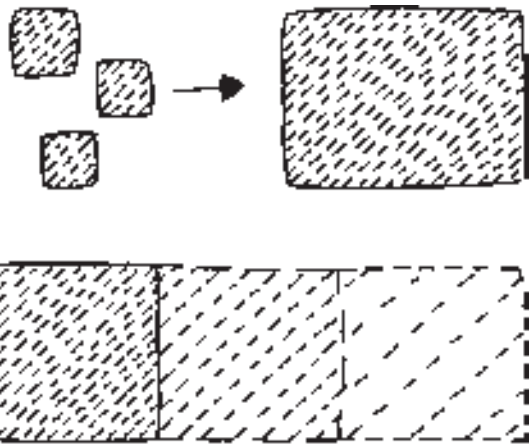
Revegetated plots and their fauna may experience disturbance from introduced predators, degradation of the ground and shrub layer by excessive stock grazing, weed invasion and disturbance by other pest animals. Management to control or minimise the negative effects of disturbance may be required. Fencing revegetated areas is one of the most useful and important management actions to take.

Habitats at the block level

In most landscapes we can recognise different types of 'patches'. In an agricultural landscape, for example, there may be scattered forest fragments, plantations, orchards, wetlands and others. Revegetation results in a new type of patch in the landscape that differs from surrounding vegetation and land uses. Important properties of a patch that influence its value as wildlife habitat include its size, shape, location and the diversity of vegetation present.

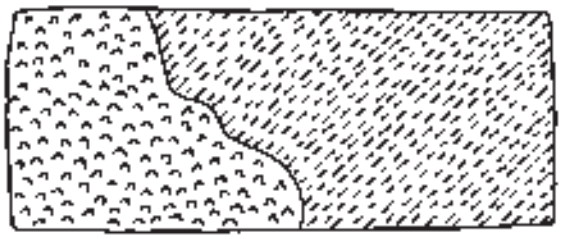
Size

The size of a block, whether it is a fragment of natural forest or a block of planted trees, is a particularly important consideration in wildlife conservation. It influences the size of animal populations, the richness of the faunal community, and the types of species that make up the community (Box 2). The relationships between habitat area and both the size of species' populations and number of animal species present are among the most strongly supported 'rules' in ecology. Consequently, because the average size of revegetated plots is relatively small, *increasing the size of revegetated areas is probably the most effective way in which land managers can enhance wildlife values.*



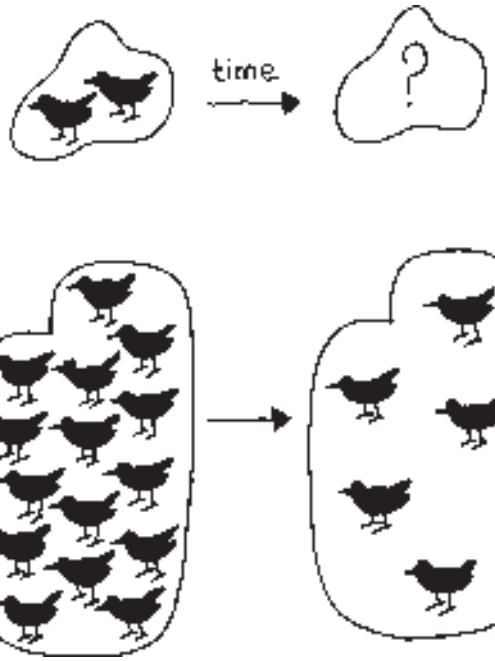
Increased size can be achieved by:

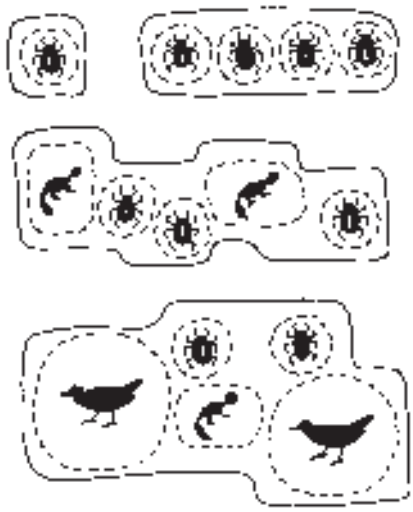
- planting a single large block rather than several small blocks of vegetation;
- planting multiple blocks that build on to each other over time;
- building onto existing remnant vegetation so that the combined size is larger.



Establish larger patches for large animal populations and long-term conservation

Larger blocks of habitat generally support a larger number of individuals than small patches of similar habitat. Large populations are more resilient to fluctuations in numbers, whereas tiny populations can be quite vulnerable to local extinction. This is particularly important for sedentary species (such as geckoes, small mammals, ground-dwelling invertebrates), that may find it difficult to re-establish if a local population disappears. Large populations are more likely to be conserved in the long term.





Ensure habitats meet the area requirements of particular species

The size of a habitat influences the type of species that make up the animal community. Small blocks usually favour animals with small home ranges and generalist habitat requirements, or highly mobile species that move between multiple habitats. Species that need large areas of habitat or that require specialized types of habitat are less likely to occur in small blocks. The size of revegetated habitats need to be planned in relation to the requirements of the species for which they are intended.

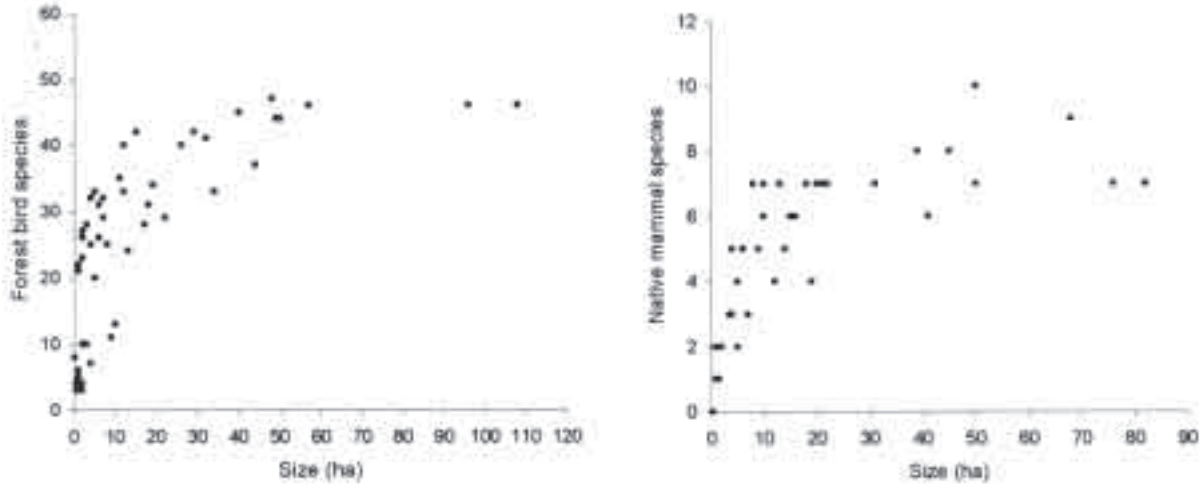
Create large blocks for diverse animal communities

There is a strong relationship between the size of habitat patches and the number of species present—the larger the block the greater the number of species likely to be present. Consequently, larger areas of revegetation (or of revegetation combined with other vegetation) are needed to support rich and diverse animal communities, whereas small blocks may support only a few species.

Box 2. The importance of habitat size for wildlife conservation

Studies of wildlife in remnants of native vegetation have shown that habitat size is a particularly important influence on nature conservation values. Points to note include:

- larger areas generally provide a greater variety of habitat types for the fauna than do small areas;
- the number of species increases with habitat size. This *species-area relationship* (see diagram) has been shown repeatedly for studies of birds, mammals and reptiles in Australia;
- population size of a species is larger in large blocks, and consequently the species has greater capacity to cope with varying seasonal conditions or disturbance;
- large areas are more likely to include species that are rare or have specialised requirements. Small habitats may be dominated by common species or those from surrounding land uses.



Species-area relationship for a) the number of forest bird species in forest remnants in Gippsland, Victoria (Loyn 1987) and b) the number of native mammals in forest remnants in western Victoria (Bennett 1990). In each case, the number of species increases rapidly with increasing patch size, then approaches an asymptote (flattens out).

What does this mean for revegetation?

1. Wherever possible, identify the types of species intended to benefit from revegetation actions and match the size of the plot to their requirements (see Box 3).

2. In rural environments, 10-20ha appears to be a useful goal for revegetation for wildlife habitat. This is because:

- species-area curves for remnant vegetation in farmland suggest that the rate of increase of additional species with increasing habitat size slows at around 20ha (see diagram);
- surveys of birds and mammals have shown that many species (but not all) are able to occur in fragments of about 20ha, especially where they form part of a connected system of vegetation; and
- revegetated plots of only a few hectares (< 5ha) are likely to be dominated by introduced species or common native species. For example, a native bird, the noisy miner, dominates small open eucalypt remnants and aggressively excludes many insectivorous bird species.

3. Planting blocks of 10-20ha of new vegetation may be a large task for a single landholder, but habitats of this size can also be achieved by *building onto* existing vegetation. There are many remnants of 5ha or less that could be increased to blocks of 10-20ha, and have great benefit for local wildlife.

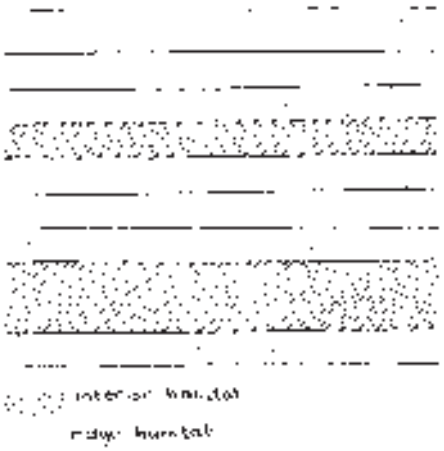
Shape

The shape of a block of vegetation determines the ratio between the perimeter (or edge length) and area. Long thin areas of revegetation, or those with a convoluted boundary, have a high ratio of edge to area; whereas patches that are square, circular or other compact shapes have a low ratio of edge to area. Edges are where revegetated blocks interact with the surrounding environment, and consequently the vegetation (and habitat) at edges often differs from that of the 'interior' of a block. Some of the processes that may occur at the edge of a revegetated plot include:

- an increased exposure to wind and light, with consequent changes in temperature and humidity;
- changes in vegetation structure (such as size and growth form of trees and shrubs) in response to the altered microclimate;
- invasion of exotic plant species (grasses, weeds) from surrounding land;
- exposure to pesticides, fertilizers, and other chemicals from surrounding land uses;
- incursions from animals such as domestic stock, rabbits, cats and foxes; and
- disturbance from humans.

Increase width to reduce 'edge effects'

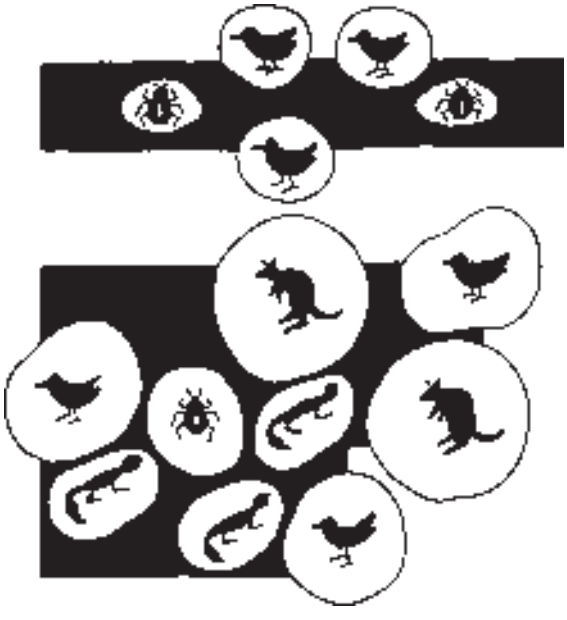
A large percentage of current revegetation activities are in the form of linear strips (shelterbelts, tree rows, wildlife corridors). Depending on their width, such strips may be entirely edge and exposed to a range of 'edge effects' (noted above). Increasing the width of linear strips has multiple conservation benefits:



- it reduces the proportion of vegetation directly exposed to edge effects;
- it offers a greater area of habitat per unit length;
- it increases the chance of restoring natural ecological processes; and
- the strip will support a wider range of wildlife species.

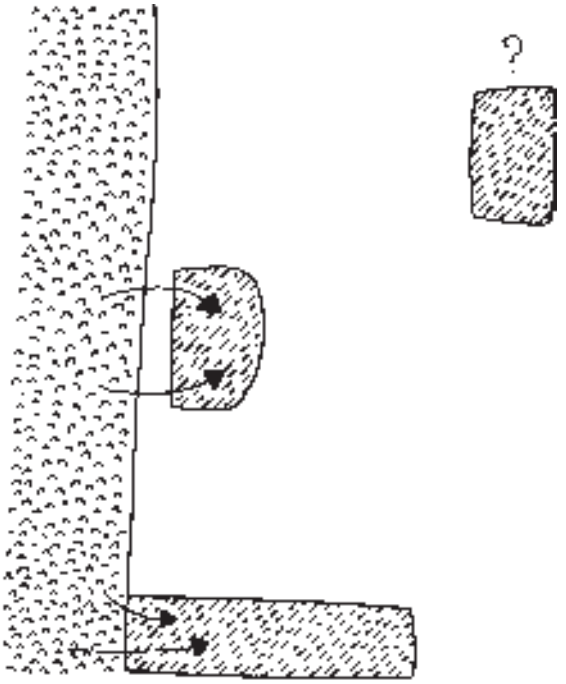
Design the shape and width of revegetation to meet species' requirements

Blocks that have a high proportion of 'edge' favour species that readily use both the block vegetation and adjoining land, or species that prefer open habitats. Consequently, the fauna of narrow revegetated strips differs from that of large natural areas, and is often dominated by 'edge' species (e.g. birds that shelter in vegetation and forage in farmland). To provide habitat for species that depend on natural environments, it is more effective to establish very wide strips or large compact blocks of revegetation.



Location of blocks

The location of a habitat influences its value for wildlife. First, its position in relation to other habitats influences the ability of animals to move to and from neighbouring populations. Such movements are essential for plants and animals to colonise newly revegetated habitats or to recolonise if local extinction occurs. Second, where revegetation 'builds onto' other vegetation, the size of the combined habitats is much larger. Third, the location of a revegetated block determines its exposure to disturbance processes such as weed invasion, introduced predators, grazing stock, pesticides and chemicals, and waterlogging.



Position revegetation to increase opportunities for colonisation from other habitats

The potential for a newly established block of vegetation to be colonised by plants and animals depends on the ability of species to move from nearby habitats. This capacity to colonise new habitats depends on:

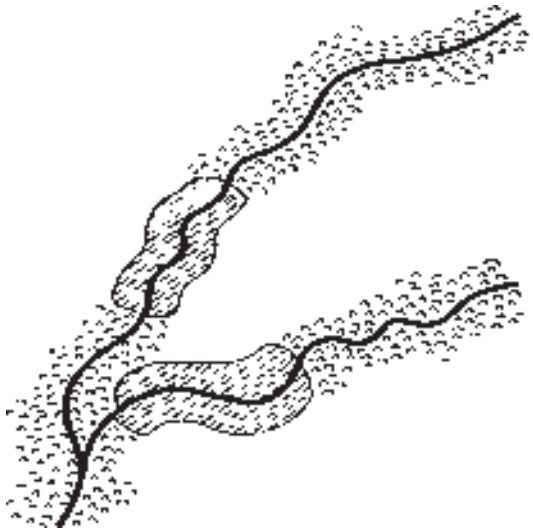
- the distance from existing populations;
- the relative mobility of each species; and
- the 'resistance' to movement from interven ing land uses or other factors.

Birds, bats and large mammals, for example, may easily move hundreds of metres between blocks of habitat. Less mobile species, such as many insects, spiders, reptiles and small mammals, are unlikely to readily cross such gaps. Revegetation close to 'source' areas is more likely to be colonised than isolated plots.

Build onto existing natural vegetation

Planting new vegetation close to, or 'building onto', existing vegetation has particular benefits:

- it increases the opportunity for biological components such as soil fungi, ground invertebrates and understorey plants to establish in the revegetation;
- it creates a larger combined area of habitat;
- when revegetation is used to fill 'gaps' in remnant vegetation (such as along drainage lines, streams and roadsides) it enhances the continuity and connectivity of the habitat; and
- by planting in appropriate locations, the new vegetation may act as a buffer to natural vegetation, reducing impacts from adjacent land uses.

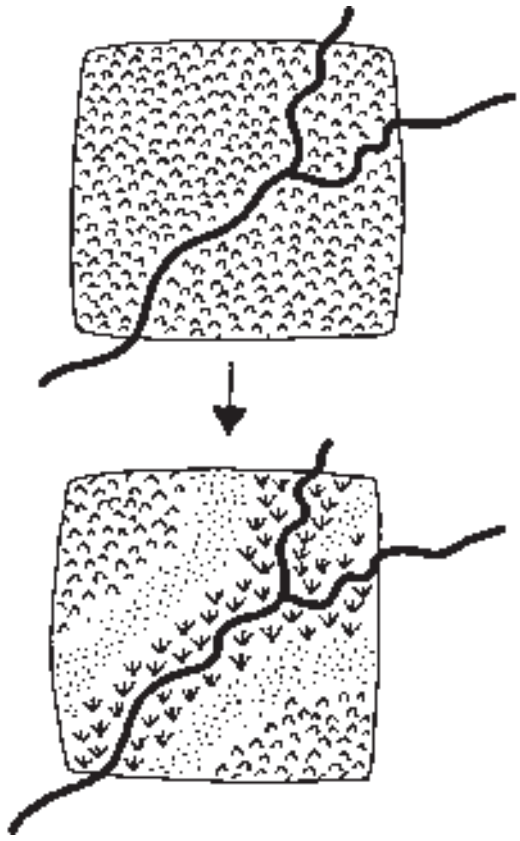


Locate new habitats away from known sources of disturbance

The location of a revegetated area directly influences its vulnerability to disturbance processes that may have detrimental effects (e.g. recreational pressure, domestic stock, introduced predators, pesticides and fertilisers). When nature conservation is an important goal, possible sources of disturbance to the vegetation and wildlife need to be carefully considered. However, *natural disturbance processes*, such as treefall or fire, can be important in creating patchiness and structure in vegetation.

Manage for diversity of vegetation

Diversity of vegetation communities is usually a consequence of variation in topography, soil type or moisture regime; and structural diversity is often associated with age of the vegetation. Large blocks of habitat generally offer a greater diversity of vegetation than small areas, and hence a greater range of resources for wildlife. When planting new blocks of vegetation that are large or extend across landforms, diversity of habitats for wildlife can be increased by establishing different vegetation types, varying vegetation structure (such as large and small trees, different growth forms, shrub thickets and open areas), and planting for different age structures.



Planning and design at the landscape level

The term 'landscape' is used here to refer to an area that is 'kilometres wide' and consists of a mosaic of different land uses and habitats. The landscape level is a key level for planning and restoration:

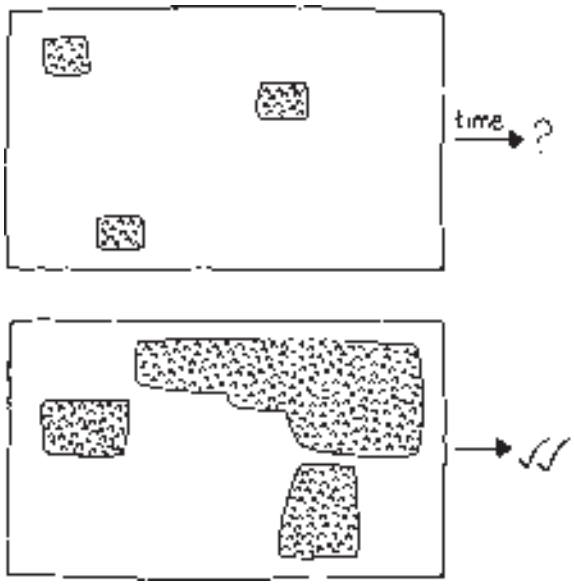
- individual patches of habitat are generally too small to maintain viable populations of most species of wildlife, but viable populations can be maintained by having *systems* of habitat patches across a landscape;
- natural disturbances in the environment, such as wildfire, floods and wind storms, usually occur at a landscape level rather than at the level of single patches;
- stream systems extend throughout entire landscapes (and regions) and therefore their restoration and management must necessarily be at the landscape level; and
- landscape level is an appropriate level at which community groups (e.g. landcare groups), government agencies and local government can plan and work cooperatively.

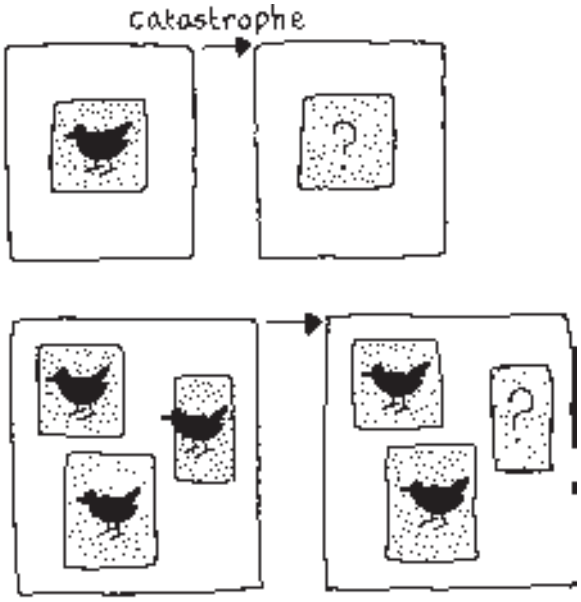
At the landscape level the focus is on understanding interactions between multiple blocks of habitat and how this influences conservation across large areas. Important themes include the total amount of habitat in the landscape, connectivity between habitats, and representation of natural ecosystems.

The amount of suitable habitat in the landscape

Increase the total area of suitable habitat in the landscape

The greater the area of suitable habitat in the landscape, the larger will be the total size of species' populations. In general, large populations are more resilient to environmental fluctuations and disturbance, and more likely to persist in the long term than those that are small and isolated.





Establish multiple populations

Animal species are more likely to survive in an area when they occur as multiple populations rather than a single small population. The presence of a number of populations means that there is:

- a larger population size overall; and
- potential for the species to survive even if one local population is lost through inadvertent (or deliberate) destruction of its habitat.

Provide for species that use different habitats

Wide-ranging species that move between different habitats to obtain resources (such as feeding in one habitat and nesting in another), or that follow flowering or fruiting patterns of plants, are more likely to occur when these different habitats are present and closely adjacent in the landscape. Revegetation activities can enhance the habitat for such species by establishing important vegetation types that may have been depleted or by adding additional habitat in closer proximity.

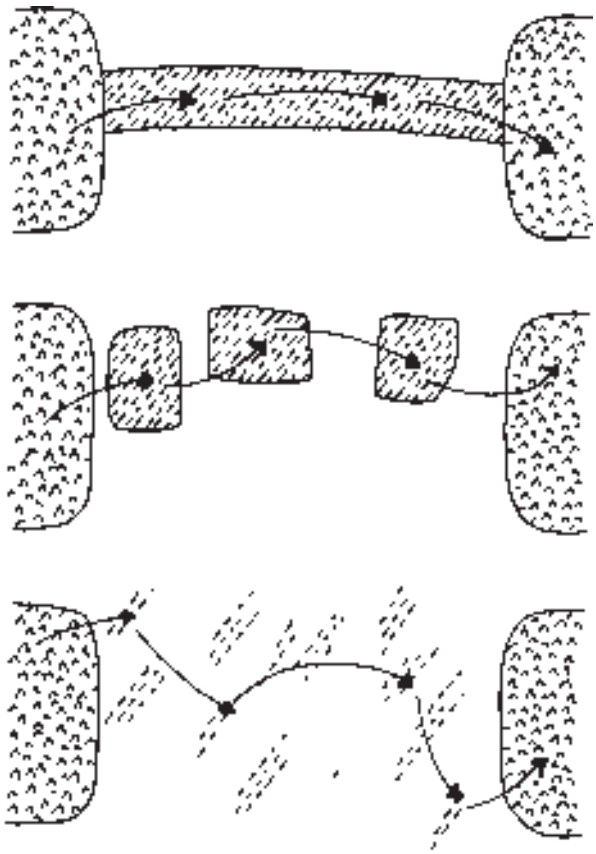
Enhance connectivity in the landscape

'Connectivity' relates to the capacity of a species to move through the landscape between suitable habitats. It is influenced by physical features such as the distance to move, presence of connecting habitats, and extent of barriers to movement. Connectivity is also influenced by behavioural features for a species, such as the size of its regular movements, ability to tolerate altered habitats, and response to land uses in the surrounding environment. A landscape with high connectivity is one in which a particular species can move readily between areas of its habitat. Conversely, a landscape with low connectivity is one in which a species has difficulty moving between habitats, so that populations are largely isolated.

Achieve connectivity by different habitat configurations

Animal species have differing levels of mobility, differing habitat requirements and differing responses to habitat change.

- C*orridors* of favoured habitat that form a continuous link between two vegetation patches are needed by wildlife species that cannot live in, or have difficulty moving through, the surrounding developed land.
- A series of one or more *stepping stones* of favoured habitat may be sufficient to allow movements by species that have limited tolerance of surrounding developed land.
- A *mosaic* of natural and modified vegetation (such as scattered trees in paddocks) may be adequate for species that are tolerant of land uses in the surrounding environment.

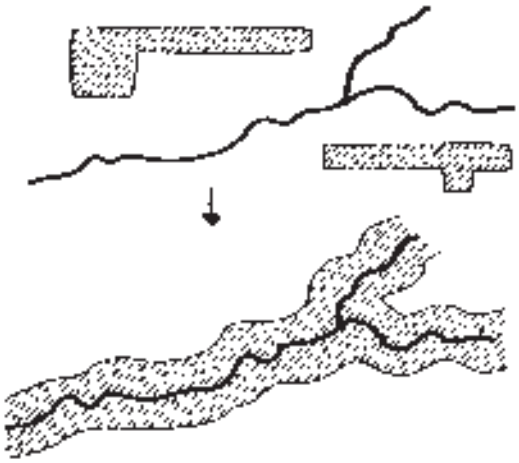


Revegetation activities have great potential for promoting landscape connectivity by establishing or enhancing stepping stones and corridors. However, it is critical that the planned revegetation is *actually capable* of serving in this way. A single line of trees, for example, has little chance of being an effective corridor for any but a few generalist species. A useful goal is to aim for a linear strip from 20 – 50m in width, or wider where possible.

Give priority to streams and watercourses as 'natural' corridors

Gullies, creeks, streams and rivers should receive high priority for revegetation to enhance connectivity because:

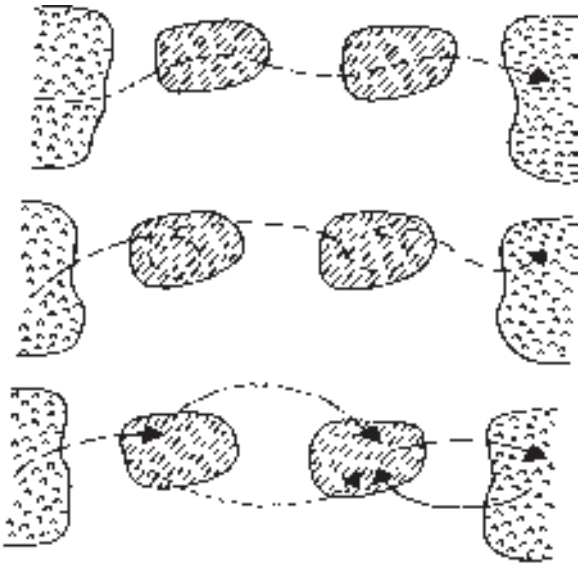
- they form an interconnected system of natural corridors throughout a catchment;
- they often provide rich habitats for wildlife; and
- revegetation along streams has multiple *other* benefits for water quality, aquatic environments and reduction of soil erosion.



Recognise different kinds of movements through links

Links such as corridors or stepping stones may be used by wildlife in several ways:

- single direct movements by animals using corridors or stepping stones as a pathway;
- movements by an individual with one or more 'pauses' along the way; and
- combined movements of a number of animals living within the link, resulting in overall movement and interchange between two habitats but not necessarily by a single individual.



The type and quality of revegetation needed to support these movements differs. For single direct movements, animals may require only shelter or refuge; whereas to *live* within a link animals need food, shelter and breeding sites. The most effective way to enhance connectivity is to provide links of sufficient quality for animals to be able to live within them.

Ensure representation of ecosystems

Clearing of native vegetation for agriculture has been highly selective, removing most wooded vegetation on the fertile soils of plains and lower slopes in rural environments. Not surprisingly, the fauna of these habitat types have been severely affected and are over-represented in lists of threatened species. In many rural environments, remaining vegetation primarily occurs in areas with less-fertile soils, the upper slopes of hills and ranges, rocky outcrops, or regularly flooding margins of major rivers.

Re-establish poorly represented habitats

To achieve adequate representation of all habitats in the landscape, it will be necessary to undertake large-scale re-establishment of poorly represented vegetation types. This cannot be achieved by planting only in degraded areas or areas of low productivity on farms. Planning for such revegetation activities across the landscape must deliberately identify landforms and soil types where depleted vegetation communities occur and include these in a long-term strategy.

Restore remnants of depleted vegetation types

Remnants of native vegetation on fertile soils are frequently small and degraded. Revegetation can improve the quality of such habitats by:

- replacing plant species that are scarce or have been lost, and which provide resources for wildlife;
- re-establishing structural components (such as a shrub layer) that have been degraded; and
- expanding the size of the habitat to increase its ecological value.

Strategic planning at the regional level

'Operational' plans for revegetation activities are best developed at the landscape scale, but the regional level is critical for strategic planning for nature conservation and sustainable land management. Strategic planning at this level can provide a 'big-picture' vision to guide planning for more localised activities, identify key issues to be addressed through revegetation, assess the relative priorities for action across a broad area, and bring together land managers and other stakeholders in a coordinated way.

Develop a long-term vision for the region

Plans for revegetation and land management require goals so that revegetation activities are carried out in a purposeful rather than *ad hoc* manner. However, in many areas the issues to be addressed may seem daunting and beyond the scope of what can be readily achieved. A regional 'vision' of what we want the land to be like in the long term can provide inspiration and direction for planning processes, even while recognizing that the vision cannot be realized immediately. A regional vision could include goals regarding:

- sustainable land use and productive agriculture within the region;
- the level of conservation of the flora and fauna that naturally occur in the region;
- the proportion of the landscape to be revegetated;
- the level of representation of naturally occurring vegetation types across the region; and
- the spatial pattern of vegetation, including the size and connectivity of habitats.

Identify regional ecological priorities for revegetation

A regional perspective is valuable for determining priorities for revegetation because processes affecting the land and the status of the fauna frequently operate at broad scales (such as changes in water tables, water quality and sedimentation throughout a stream system, or selective clearing of a particular vegetation type). Priorities for revegetation need to be considered in two main areas, sustainability of the land and conservation of biodiversity, with particular attention to how actions in these areas can be integrated.

Implement effective monitoring programs

A key element in strategic land use is to monitor activities being undertaken so that their level of success can be determined, and so that lessons can be learned for the future. *Quantitative* monitoring techniques need to be initiated (or maintained) in three main areas:

- to monitor the *outcomes of revegetation actions*, such as the use of revegetated habitats by fauna and the effect on the species' regional status, the change in extent of degraded areas, the improvement in quality of water in streams, and the extent of saline-affected land. These must be long-term monitoring programs because revegetation actions may take many years to achieve their full effect;

- to monitor the *effectiveness of techniques* used in revegetation and restoration in order to continue improving technical procedures for establishing particular vegetation types; and

- to monitor the local and regional *change in land cover* and vegetation patterns so that progress can be followed in achieving regional goals relating to the total extent and distribution of vegetation, representation of vegetation types, and spatial pattern of habitats (such as size, shape and connectivity).

Box 3. Developing a specific landscape plan: the *focal species* approach

How can these principles be applied to a 'real' landscape? How should revegetation be undertaken and what pattern of habitat is needed to ensure that populations of native wildlife are maintained? These are important questions that landholders, community groups and government agencies are facing in developing vegetation plans, catchment strategies and the like, for *their* particular area of concern.

There is no ideal solution or optimum design to suit all areas. Environmental variation between regions, and differences in wildlife and their habitat requirements, mean that what may be well suited for one landscape is not necessarily adequate for nature conservation in another. It is for this reason that the principles developed in this report are generic rather than specific, and need to be carefully applied based on an understanding of a particular area.

A useful approach to landscape planning in rural environments has been developed in Western Australia (Lambeck 1997, 1999) and is now being trialed by scientists, community groups and land managers in several regions (Wallace 1998; Freudenberger 1999; Lambeck 1999). Its aim is to develop specific recommendations for landscape restoration and management in a local area, to provide clear guidance to land managers concerning the actions needed to maintain biodiversity.

The *focal species* approach is based on knowledge of the fauna of a particular study area and the identification of species potentially at risk in that area if no management action is taken. For these species, attention is then given to identifying factors that limit their distribution and abundance. Species that are limited by habitat size, habitat isolation, or insufficient resources require *reconstruction of habitats* in the landscape; while those limited by factors such as predators, stock grazing or inappropriate fire regimes mainly require improved *management of threatening processes*. For each factor (such as size, isolation), the species believed to be *most* limited is referred to as a 'focal' species. If the requirements for these focal species can be met through restoration and changes to land management, it can be assumed that the requirements of all other species should also be fulfilled.

An application of this approach in the Wallatin Creek Catchment in the Kellerberrin area of the Western Australian wheatbelt resulted in the following guidelines (Lambeck 1999):

- the minimum size for habitat patches should be 25ha;
- the distance between remnants should not exceed 2km;
- vegetation linking habitats occupied by dispersal-limited birds should be approx 50m wide;
- other linear strips should be >30m wide for heathland and > 60m for open vegetation types;
- habitat reconstruction in woodland should contain clumps of dense understorey vegetation for some invertebrates and small mammals, and should emphasise the use of plant species that produce nectar over the summer-autumn period;
- feral predators should be reduced to the lowest possible density;
- grazing by stock of remnant vegetation and revegetation should be stopped; and
- inter-fire periods should exceed 50 years unless new evidence suggests otherwise.

These guidelines were used, in conjunction with a consideration of other land uses in the catchment, to draw up a plan for action. A feature of the plan was the identification of specific blocks of remnant vegetation that should be expanded by revegetation or regeneration to meet minimum requirements for the fauna.

This approach has much promise because its outcomes are specific to the needs of a particular area. However, it depends on having a basic knowledge of the status of the fauna of the area, the patterns of distribution of species in remnant vegetation, and the identity of key threatening processes. A challenge is to adapt the specific landscape-level outcomes to a regional level.

5 Integrating wildlife conservation with revegetation for other purposes

To date, most revegetation in rural Australia has been motivated by issues related to agricultural productivity and land rehabilitation (Box 1). Vegetation established to meet these goals (including plant species used, spacing, size and shape of planting), will not necessarily create high quality habitat for the flora and fauna. Shelterbelts in farmland, for example, are designed to be effective at modifying wind flow and providing shelter, but the vegetation structure required for this purpose differs from that naturally found in forest or woodland habitats. Consequently, while a shelterbelt provides habitat for some species, this is usually a secondary benefit that may be entirely incidental. Some potential limitations in achieving conservation goals where revegetation is undertaken for other purposes are listed in Table 3.

For revegetation to have a more effective role in nature conservation, there must be greater recognition of the importance of habitat for plants and animals in rural areas, and greater integration of habitat values in vegetation management. Integrated management to achieve both production and conservation goals in rural environments is becoming more widely accepted, but achieving effective conservation outcomes 'on the ground' is still a formidable challenge.

The extent to which conservation objectives can be integrated into land management varies, depending on the type of revegetation activities being undertaken. Three main categories can be recognized, reflecting the relative 'weight' that is given to nature conservation objectives (Figure 4):

- modification to revegetation practices within the constraints of present management objectives;
- integration of conservation with other management objectives in planning, design and implementation of revegetation; and
- nature conservation as the primary objective for particular revegetation activities.

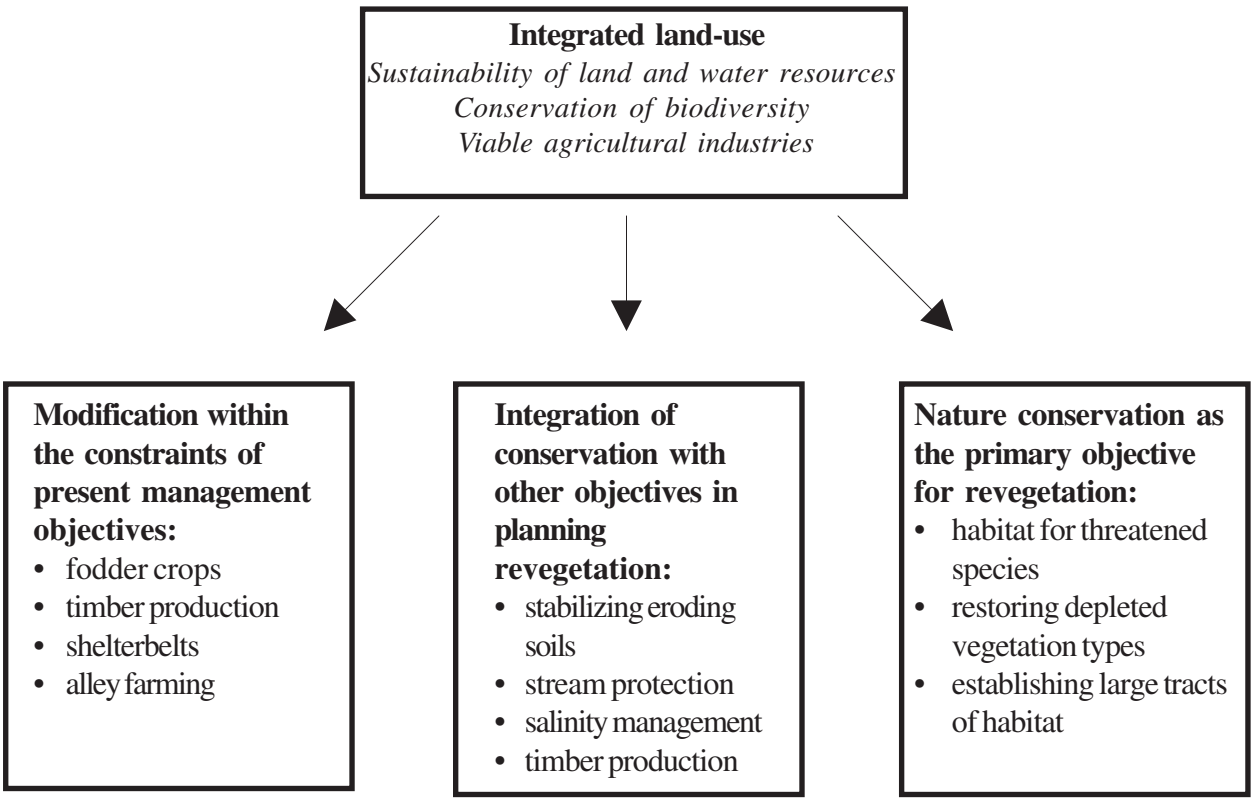


Figure 4. Examples of three approaches to revegetation activities that reflect differing 'weight' given to nature conservation objectives compared with other objectives in land management

Table 3. Approaches to revegetation that potentially limit the achievement of conservation goals in rural environments

Approach	Consequences for wildlife conservation
Types of plant species used	
Use of exotic species	Likely to be unsuitable for many species
Planting of one or only a few native species	Habitat resources (e.g. food, shelter) limited for some species
Planting of canopy tree species only	Few resources for species of the understorey or ground layers
Selective use of plant species (e.g. fast growing species)	May not represent local habitats favoured by the fauna
Size and shape of revegetated areas	
Planting as small blocks (e.g. <2ha)	Number of species present will be reduced
	Size of populations of each species will be relatively small
	Fauna likely to be dominated by common or 'generalist' species
Planting as narrow strips (e.g. <15m width)	Prone to disturbance from adjacent land uses
Planting in evenly spaced straight rows	Total area is small and may be unsuitable for many species Limits the structural diversity and patchiness of the habitat
Pattern in the landscape	
Many small blocks and narrow strips	Landscape dominated by 'edge' habitat, probably unsuitable for species requiring large areas
Little coordination between plantings in different areas	Revegetation less effective, less likely to provide for all species, reduced conservation outcomes
Strong emphasis on 'corridor' plantings	Limited habitat for species that require larger blocks to persist
Revegetation mainly on less-productive areas	Vegetation characteristic of fertile soils remains depleted, lack of balance in representation of wildlife habitats
Strategic planning	
Lack of strategic planning for revegetation	Activities may be poorly coordinated, less effective in integrating nature conservation and sustainable land use
Poorly defined objectives for revegetation	Less cost-effective use of limited resources
No monitoring of revegetation activities	Outcomes of revegetation efforts poorly known; limited capacity to assess success or failure and learn from experience

Modification to revegetation practices within the constraints of present management objectives

In situations where revegetation is driven by specific objectives—such as tree planting for timber products, growth of fodder crops, provision of stock shelter, or establishing perennial vegetation in highly saline conditions—the design of the revegetation may be strongly determined by these objectives. However, within such constraints there are opportunities for minor changes to design and management that will enhance wildlife conservation. The principles pertaining to the *site level* and *block level,* as outlined in Section 4, are particularly relevant.

For example, where the plant species used in revegetation are largely dictated by the management objectives, as with plantations established for timber products (see photo below), there is little opportunity for developing habitats of locally indigenous flora. Habitat values, however, may be enhanced by modification to the size, shape or location of the plantation. Increased size, greater width and closer continuity with other habitats can be expected to enhance the value of the revegetation for those species able to obtain resources among the particular species planted. There may also be opportunities to increase the diversity of habitat structure and habitat resources for the fauna by adding local understorey species between some tree rows, and by planting so that a number of age classes are in close proximity.

Alternatively, in situations where it is the shape of the revegetation that is dictated by the management objectives, as with long narrow shelterbelts or strips in alley farming, there may be opportunities to modify the species planted so that a greater variety of habitat resources are provided. Also, increasing the width of the planted strip wherever possible will not compromise its intended function but has potentially great benefits for wildlife.

Photo: A plantation of fast-growing eucalypts in western Victoria: a typical situation in which opportunities to enhance wildlife habitats must be developed within the constraint of the primary management objective.

Integration of conservation with other management objectives in the planning, design and implementation of revegetation

There are many types of revegetation activities for which there is great scope to integrate nature conservation and other land management objectives in the planning, design and implementation of the work. These include land protection works such as reclamation of eroded gullies, restoration of stream banks, revegetation in groundwater recharge zones and revegetation to reduce waterlogging; as well as plantings for aesthetic purposes and some forms of agroforestry or timber plantations.

Projects in which revegetation is used as a tool to restore degraded rural landscapes are frequently supported by financial incentives, such as through the Natural Heritage Trust. Incentives can be effectively used to influence the *degree* to which nature conservation objectives are incorporated in a project. Revegetation activities likely to have major benefits for both wildlife conservation and environmental restoration could be supported at a high level, while those likely to have limited conservation benefit would attract less support. This approach provides a means to more directly integrate habitat values in revegetation by bringing about changes in the size and shape of revegetated areas, their location in the landscape, and the strategic coordination of restoration activities across the landscape. Table 4 summarises examples of ways in which some different types of revegetation activities can be ranked for their *relative value* for conservation. This is based on the extent to which they incorporate key features such as plant species composition, size or width of area, and its location and connectivity within the landscape. Revegetation along streams and gullies, for example, offers outstanding opportunities for integrating land protection and wildlife conservation objectives in rural environments.

Setting guidelines for revegetation with regard to size, width, and landscape position is difficult given the current scarcity of knowledge about the use of revegetated habitats by wildlife, and the environmental variation that is evident between different regions in Australia. The examples listed in Table 4 are not intended as definitive guidelines or optimum dimensions for wildlife conservation, but rather illustrate the *relative benefits* that are gained in line with the principles outlined in Section 4. For example, a revegetated strip that is 50m in width will offer greater benefits than one of 20m, and likewise a belt of vegetation 100m in width can be expected to have greater benefits than one of 50m width.

Nature conservation as the primary objective for revegetation activities

There are a number of restoration and conservation goals that are unlikely to be achieved, even when conservation objectives are effectively integrated with other purposes. Examples of these include the re-establishment of depleted vegetation types, the restoration of degraded remnants of rare plant communities, provision of habitat for threatened animal species, and the establishment of large tracts of indigenous habitat (e.g. blocks of 100-1000ha). These types of projects generally require nature conservation as the primary objective, with the plant species; the size, shape and location of blocks; and the management of the vegetation all designed to achieve the conservation objective.
There is an urgent need for investment by the wider community in such projects, through generous financial incentives to landholders and community groups prepared to undertake this challenge. The use of 'flagship' species to promote restoration activities for wildlife conservation in rural environments (Box 4) is proving to be a successful model. Species as varied as the southern cassowary, koala and grey-crowned babbler are serving in this way. Large-scale restoration of indigenous vegetation, urgently required in many rural districts, is unlikely to be achieved by relying on the activities of private landholders. There is a role for direct governmental involvement, both to secure large blocks of land (e.g. > 100ha) for revegetation and to ensure that revegetation is carried out in a strategic manner.

Table 4. Examples of ways in which different types of revegetation activities can be ranked for their relative value for wildlife conservation

Conservation value is indicated by asterisks (more asterisks indicates greater value)

Type of revegetation	Attributes for assessing relative conservation value for wildlife			Relative value for conservation
	Site level *Indigenous trees/ shrubs matched to landform*	Block level *Size (ha) or width (m)*	Landscape level *Degree of association with remnant vegetation*	
1. Streams, gullies, natural drainage lines				
filling gaps or widening existing natural vegetation	yes	varies	closely connected	****
strips along streams	yes	> 100 m	connected system	****
strips along drainage lines or streams	yes	50-100 m	connected system	***
strips along drainage lines, gullies	yes	20-50 m	connected system	***
strips along drainage lines, gullies	yes	< 20 m	connected system	**
2. Blocks				
large areas of indigenous vegetation	yes	> 50 ha	not necessarily linked (preferable)	****
medium areas of indigenous vegetation	yes	20-50 ha	adjacent or closely linked	****
small-medium areas of native species	partly	5-20 ha	not necessarily linked	**
small-medium areas added to natural vegetation	yes	5-20 ha	closely linked	***
small areas of native species	partly	< 5 ha	not necessarily linked	*
3. Linear strips and shelterbelts				
filling gaps, widening strips of natural vegetation	yes	varies	well connected	***
new strips	yes	50-100 m	well connected	***
new strips	yes	20-50 m	connected	**
new strips	partly	< 20 m	connected	*

Box 4. 'Flagship species' to encourage revegetation for conservation

It is much easier to generate interest, motivation and commitment to revegetation when there is a specific issue to be addressed or goal to be achieved. The use of 'flagship' species of wildlife as the stimulus for revegetation projects in various rural districts is a good example. 'Flagship' species are animals that may be prominent, attractive or have a symbolic or 'figurehead' appeal to people in a particular area. By using the flagship species to stimulate interest in enhancing or re-establishing habitat, it is hoped that many other species will also benefit. There is a growing number of examples where local groups are undertaking inspiring revegetation and restoration efforts guided by the needs of a local flagship species, often species that are both threatened and visually attractive.

Regent honeyeater
The Lurg Hills near Benalla, Victoria, is one of the key habitats in the state for the regent honeyeater, a nationally threatened species. Over the last four years (1996-1999) there has been a large community effort to fence existing remnant vegetation, replant and regenerate degraded habitats, revegetate new habitat and establish corridors to link isolated habitats. Led by an enthusiastic coordinator,the project has involved some 65 landholders, more than 2000 volunteers, fencing of more than 370ha of habitat, and the planting of more than 80 000 trees and shrubs from 30-40 species (Thomas 1999). There are many other species in this area that will also benefit from this habitat restoration, including other threatened species.

Superb parrot
Growing community involvement to protect and enhance habitats for the beautiful, but declining, superb parrot is contributing to restoration of landscapes in northern Victoria and the inland slopes of New South Wales. Efforts have been mainly directed toward revegetation of gaps in flight paths and feeding corridors of the birds, between their nesting habitats and foraging areas. In the Picola district of northern Victoria, for example, birds nest in old trees in river red gum forest along the Murray River and fly out to feed in dry box woodlands within about 10km. Fencing of remnant box woodlands and revegetation of new habitat close to breeding areas is also undertaken because the box woodlands have been heavily depleted. To date, about 30 farming families together with other community members have planted more than 60 000 trees and shrubs in this area and erected 54km of fencing (Fendley 1999). The community is also involved in regular monitoring to record the numbers of superb parrots and their use of habitats in the district.

Rufous bristlebird
Direct seeding of trees and understorey shrubs to recreate dense shrubby vegetation is the main method being used to revegetate habitats for the rufous bristlebird in south-western Victoria. This ground-dwelling bird is rare nationally, with a limited distribution spanning coastal vegetation from south-eastern South Australia to western Victoria. Corridors of habitat are being established through farmland and along roadside strips to link bushland blocks with each other and with the coastal strip. This revegetation is complemented by fencing bushland remnants to reduce grazing pressure by stock that degrades the essential dense understorey vegetation (Dennis 1994; Du Guesclin *et al.* 1995).

Other species that are presently being used as 'flagships' for revegetation and restoration efforts in rural environments include the koala, squirrel glider, numbat, helmeted honeyeater, grey-crowned babbler and southern cassowary.

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Selected references for each section, including those cited, are listed below. A comprehensive review of literature relating to revegetation and wildlife conservation is also available as a companion to this report (see Kimber *et al.* 1999), available from the Bushcare website at: http://www.environment.gov.au/bg/bushcare/

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Appendix

Common and scientific names of species mentioned in the text

Species are listed in alphabetical order within taxonomic groups

Mammals

Black rat	*Rattus rattus*
Cat	*Felis catus*
European rabbit	*Oryctolagus cuniculus*
House mouse	*Mus musculus*
Koala	*Phascolarctos cinereus*
Numbat	*Myrmecobius fasciatus*
Red fox	*Canis vulpes*
Squirrel glider	*Petaurus norfolcensis*
Sugar glider	*Petaurus breviceps*

Birds

Common starling	*Sturnis vulgaris*
Common mynah	*Acridotheres tristis*
Grey-crowned babbler	*Pomatostomus temporalis*
Noisy miner	*Manorina melanocephala*
Regent honeyeater	*Xanthomyza phrygia*
Rufous bristlebird	*Dasyornis broadbenti*
Southern cassowary	*Casuarius casuarius*
Superb fairy-wren	*Malurus cyaneus*
Superb parrot	*Polytelis swainsonii*

Reptiles

Boulenger's skink	*Morethia boulengeri*

Amphibians

Spotted marsh frog	*Limnodynastes tasmaniensis*

Invertebrates

Huntsman spider	*Isopeda montana*