Upper Billabong
Land and Water Management Plan

A plan for the management of natural resources
in the
Upper Billabong Catchment, NSW.

Produced by the efforts of community members in the Upper Billabong Catchment and presented in this document by the LWMP Working Group, whose members are grateful for the assistance of the Natural Heritage Trust.

Natural Heritage Trust
Helping Communities Helping Australia

Holbrook Landcare

To be read in conjunction with the attached appendices.

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Designed by Advision, Wagga Wagga

Upper Billabong Land & Water Management

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EXECUTIVE SUMMARY

The *Upper Billabong Land & Water Management Plan* provides for the management of natural resources in the Upper Billabong Catchment. It was developed by a Working Group with representatives from Holbrook and Culcairn Shire Councils, Holbrook Landcare, as well as the local rural and urban communities. Throughout the development of the Plan, the Working Group emphasised involvement of the community, through community meetings, surveys, newsletters and media releases. The Upper Billabong community will continue to determine the values, vision, aims, objectives, issues, actions, targets, cost-sharing arrangements, monitoring and evaluation of the Plan.

The Plan is based on the realisation that landscape change and knowledge is required. It will act as a catalyst to prioritise resources to ensure that the community can acquire knowledge and instigate these landscape changes.

Primary responsibility for developing and implementing the plan rests with the Holbrook Landcare Group Ltd, which is a non-profit community group, founded in 1988 and now incorporated as a company limited by guarantee. The Holbrook Landcare area corresponds with the boundaries of the Upper Billabong Catchment.

A SHARED VISION

The 30 year vision for the catchment developed by the community is:

> To improve the economic, social and physical environment of the Upper Billabong Catchment by the implementation of a viable Land and Water Management Plan through education, participation and community ownership.

IDENTIFYING THE ISSUES

The Upper Billabong community identified and ranked a total of 42 issues that were of significance to their vision for the catchment's future.

The highest ranked issues are:

- Declining economic viability of both the rural and urban sectors in the catchment
- Lack of knowledge, understanding and skills on natural resource management both within and outside the catchment
- Increasing tree decline and dieback
- Increasing soil acidity
- Increasing soil erosion
- Increasing weeds
- Increasing dryland salinity
- Lack of government vision and understanding, and ineffective policy making
- Loss of services in town, declining rural population
- Decline in water quality
- Biodiversity decline
- Lifestyles, desires, attitudes, old habits and stereotypes

ACTIONS

The goal of developing and implementing a plan is to reverse the negative effects of these issues. That goal can be realised by implementing actions that will further the community's vision for their catchment. Proposed actions have been ranked in importance, target outcomes have been identified, and costings have been analysed to show both the public and private benefits that will flow from the achievement of these outcomes.

Holbrook Landcare's strategic planning process has identified the organisational structures and personnel who will implement the Plan. Provision has been made at all points in the process for the monitoring and evaluation of actions and the subsequent modification of the Plan if required.

An extensive series of appendices contain the detailed information and analyses on which the Plan is based.

"To improve the economic, social and physical environment of the Upper Billabong Catchment by the implementation of a viable Land and Water Management Plan through education, participation and community ownership."

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INTRODUCTION TO APPENDICES

These appendices provide more detailed information on the matters dealt with in the Plan. The table below sets out a description of each of the appendices.

Appendix 1 sets out some background material on the genesis of the LWMP, as well as the processes adopted during development. It also discusses the Holbrook Landcare Group, which will assume primary responsibility for implementation of the Plan.

The issues are dealt with in the appendices titled People, The Natural Environment (Flora and Fauna), Land and Water (Appendices 2 to 5). These appendices provide:

- some background or baseline material on the current status of the Upper Billabong Catchment; and
- an analysis of the issues, including causes and the "Do-Nothing" outlook.

There is always a dilemma in categorising issues. On the one hand, categorisation allows indexing and assists readers to search for materials on related matters. However, categorisation obscures the fact that the issues are the subject of complex interrelationships. For example, loss of biodiversity results in less shrubs and less insectivorous birds, more insects, more dieback, more tree deaths, more erosion and rising groundwaters, which result in more tree deaths and more loss of biodiversity. Therefore, each issue cannot be viewed in isolation.

The relationship between these issues and the proposed actions is summarised at the end of Appendix 6 (The Actions). Only Issue L (Attitudes etc) is not discussed in detail, as attitudes are expected to change in the course of addressing the other issues. The benefits of the actions in ameliorating the issues is looked at in Part 2 of Appendix 7 (The Costs and Benefits). That Part looks at all benefits together rather than dividing the benefits into their issue-related categories.

Appendix 8 (Monitoring and Evaluation) is an attempt to design a system to check whether we are 'on the right track'. Appendix 9 contains references and maps.

1. ACKNOWLEDGMENTS

Special thanks go to everyone involved to date in the development of the Upper Billabong Land & Water Management Plan (LWMP). This has included:

The Natural Heritage Trust for provision of funds.

The Upper Billabong LWMP Working Group
(past and present members):
Joy Wearn, Barbara Ross, John Cox, Noel Passalaqua, Bruce Beard, Andrew Hicks, Bob Parr, David Lieschke, Danny O'Flanagan, Mandy Locke, Peter Heriot, Michael Elvins, Philip Julian, Catherine Hulm, Brett McInnes and Emmo Willinck.

Members of the original steering committee:
Peter Trescowthick, Reis Bulle, Andrew Cumming, Desley Kendall, Leanne Wheaton and Rob Peardon.

Holbrook Landcare Group Executive and Committee (past and present):
Neil Ross, David Pugh, Rob Chatfield, David Geddes, Andrew Mathie, Michael Bulle, Andrew Hicks, Jacinta and Chris Mirams, Philip Locke, Karen Pitson, Joy Wearn, Catherine Moore, Stephen Bunyan, Roger Geddes, Barbara Hawkins, Noel Passalaqua, Sue Pugh, Ian Meiklejohn, Craig Rowe, James McNaughton, Desley Kendall and Karen Schulz.

The Working Group and the Holbrook Landcare Group Committee have been the driving forces behind "their" plan.

Technical Specialists:
Anthony Fanning, Louise Bull, Fleur Stelling, Murray Brown, Sue Brunskill, Martin Driver, Ian Davidson, Graham Carter, Helen Wilson, Tony Dawson, Lisa Cary-Castleman, Jack Chubb, Mark Sheahan, Stuart Lucas, Nimal Kulatunga, Tony Watson, Peter Huhta, Margie Parmenter, Tony Dawson, Jill Landsberg, James McNaughton, Neil Hibberson, John Powell, Julie Burke, Tony Sharley, Ros Chivers, Geoff Burrows, Warren Meyers, Kate Browning, Natalie O'Connell, Danielle Hopman, Tim Paramore, Ray Evans, Anna Ridley, Geoff Beale, John Sykes, Stuart Collard, Clare Purtle, Siobhan Bland, Lucy Anderson, John Whittington, Ashley Bastock, Claudia Marchesi, Bill Currans and the Murray Catchment Management Committee, Cec Grant and the Wiradjuri people.

Consultants:
Hakai Tane, Baden Williams, Michael Clarke, Michelle Ward, Anthony Fanning.

Historians:
Cec Grant, Beverley Geddes, Ross Allworth, Max Meiklejohn, Norm McLaurin, King Shearer, Malcolm Ross and Dudley Ross.

Field Naturalists:
Sue Pugh, Sandy O'Flanagan, Margaret Geddes, Gail Geddes, Beverley Geddes and Stuart Collard.

Work experience student:
Sascha Kerb.

Bore Monitors:
Ian Lister and Alison Jowett.

Members of the media:
Rowan Reid, Paul McSweeney, Jenny Kane, Di Thomas, David Thorpe and Kim Woods

Facilitators:
Helen Wilson, Cathy McGowan.

Holbrook Shire Council Staff:
Geoff Piese, Laurel Whitley, Mark Lister, Cathy MacKinlay, Angela Pearce, Brian Frana, Barb Hawkins, Marlene Fleming, Eveonne Byatt, Peter Brasier, Ray Hosken, Geoff Wheeler, Bob Parr and Brett McInnes.

Editors:
Annelies Willinck, Stuart Collard, Jenny Parer and Mary Feodoroff.

Artists:
Graeme Clifford and Margaret Castle.

Mappers:
Murray Brown and Anthony Fanning.

Members of the Community within the Upper Billabong Catchment, Particularly those of you whotook part in the community workshops and meetings, financial survey, field investigations, bore monitoring program, acid soils project, stream watch program, catchment surveys, dieback studies and bird surveys.

Emmo Willinck, Project Officer for the Plan, wrote the bulk of this plan, with directions from the Working Group. The Plan was finalised by Andrew Lawson, Implementation Officer, with directions from the Working Group.

2. THE DEVELOPMENT PROCESS

Emphasis throughout the development of the Upper Billabong Land & Water Management Plan (LWMP) has been on the "involve me and I'll understand" process, as opposed to the completion of "a plan". The community has been kept involved and informed throughout the development of the Plan via community meetings, surveys, newsletters and media releases.

Members of the Working Group and of the Holbrook Landcare Group have been at the forefront of development and promotion of their Plan. The community of the Upper Billabong will continue to be involved in determining their values, vision, aims, objectives, issues, actions, targets, cost sharing arrangements, and monitoring and evaluation requirements.

The Plan is dynamic - always open to change. The vision, aims, objectives and issues within the Plan will act as a foundation for the actions and targets being set. Keeping the Plan alive is a long-term, cyclical process involving continual monitoring, evaluation and revision.

The Plan is dynamic - always open to change

The Plan's Working Group has been responsible for ensuring that community involvement was maintained. The Working Group has Holbrook Shire, Culcairn Shire, farmer, Landcare and urban representation. The Working Group deliberately did not appoint no chairperson to ensure that responsibility and knowledge would be shared throughout the group.

As part of the planning process there were:

- 16 community meetings conducted throughout the catchment attended by 370 community members. These meetings endorsed the development of an Upper Billabong LWMP and its objectives; elected a working group representative of the community; determined Values, a Vision, Priority Issues and Actions; and reviewed consultancy works
- 35 Working Group/steering committee meetings
- 2 joint Holbrook Landcare Group and Upper Billabong LWMP Working Group meetings
- 6 Holbrook Landcare meetings addressing specific LWMP issues
- a logo competition
- 7 formal surveys conducted of senior citizens, historians and an aboriginal elder
- 7 presentations to local community groups and councils
- 8 presentations to community groups outside the catchment
- 7 newsletters produced (a joint Upper Billabong LWMP and Holbrook Landcare production). Sent to 450 stakeholders inside and outside the catchment. Local community members were the main contributors to this newsletter
- numerous (~60) newspaper articles and radio interviews
- 3 written surveys to gain feedback from community members
- 31 landholders interviewed for a financial study for the catchment
- 55 landholders involved in having land degradation or soil investigations undertaken on their properties
- 59 landholders involved in an on-going bore/piezometer monitoring program throughout the catchment
- Over 50 landholders participated in a soil acidity project sampling 326 paddocks throughout the catchment, organised by the South West Slopes Community Acid Soils Group
- Numerous (~35 over three years) farm walks, seminars, field days, work shops, sub-catchment and property planning days - in the main organised by the Holbrook Landcare Group, Greening Australia, Farming for the Future, Acid Soils Group and the Department of Land and Water Conservation.

3. HOLBROOK LANDCARE GROUP (pers. comm. Hulm 1999, 2000)

As the Holbrook Landcare Group is charged with the major responsibilities for implementing the Upper Billabong Land & Water Management Plan, it is appropriate to outline the history and role of the Group in the management of natural resources.

In 1988, the *Holbrook Trees On Farms Group* was founded to address the growing land degradation problems within the Holbrook district. When the Landcare movement began in 1990, the *Holbrook Trees On Farms Group* was quick to see that the Landcare ethos complemented the Group's objectives. Hence, a name change, with the *Holbrook Trees On Farms Landcare Group* being incorporated in 1990.

The Group defined their boundary to be the 171,000 hectares that encompass the area now known as the Upper Billabong Catchment (the same area covered by the Upper Billabong LWMP). Upon incorporation, there were five sub-catchment groups represented within the defined boundary of the Landcare Group. As support for landcare grew, new sub-catchment groups formed within the areas that were not covered by the existing groups. Today there are 13 sub-catchment groups and an urban Landcare Group (see map below), with a majority of landholders in the area being members.

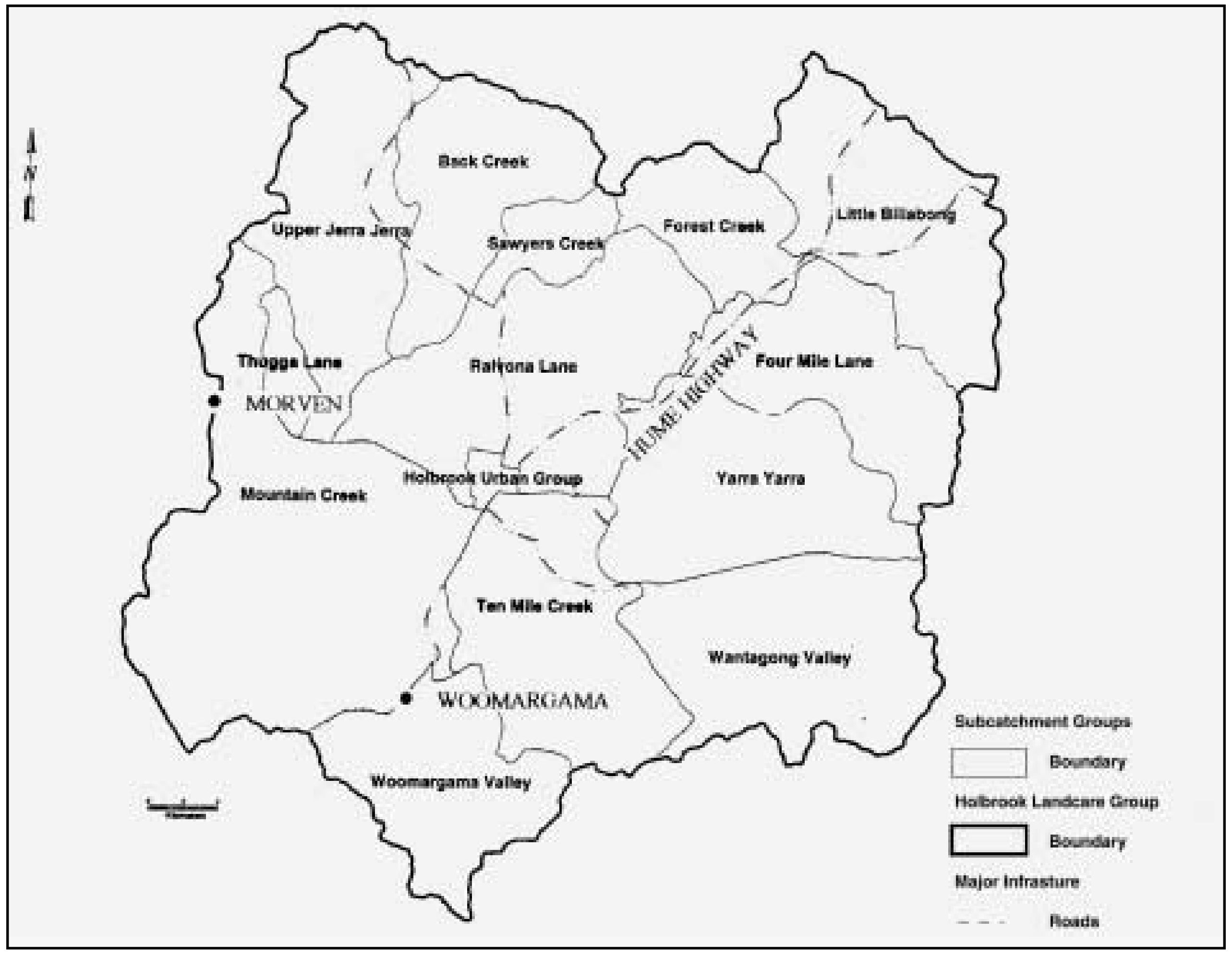
As the *Holbrook Trees On Farms Landcare Group* grew, its achievements also went from strength to strength. The first funded project that the Group undertook was the 10 Mile Creek Reserve Project, which received $2000 under the Greening Australia initiative 'Trees by the Million'. Since then the group has undertaken more than 60 projects and has been funded more than $3.2m (see Table 1.1, pg 5).

The projects show the shifting trends of best practice for landcare, with the early 1990s seeing projects concentrating on salinity demonstration sites, pasture trials, concrete flumes and tree establishment for shelter belts and habitat improvement. In the mid-1990s, a number of the sub-catchment groups completed sub-catchment plans and the direction of projects changed accordingly. Rising watertables were now the main issue and recharge plantings were required. So a number of the sub-catchment groups undertook large-scale plantings to address the issue.

In 1994, it was realised by the Landcare Group that something was drastically wrong with the ecosystem within the catchment. A self-funded survey revealed that 41% of trees within the catchment were suffering severe dieback with a further 22% showing dieback symptoms. The Landcare Group subsequently began a research project into dieback over the next three years.

In the late 1990s, project emphasis shifted to biodiversity, with wetlands being created, creek lines being fenced and still more recharge plantings being undertaken. Whilst acknowledging that all this activity was beneficial to the catchment, the Landcare Group realised that a more co-ordinated catchment approach was required to address the ever-present problem of environmental decline in the area. The answer, the group felt, was to undertake a Land & Water Management Plan.

Figure 1.1 Upper Billabong Catchment showing Holbrook Landcare subcatchment boundaries



In 1997 the Federal Government's "National Heritage Trust" funded the *Upper Billabong Land & Water Management Plan*. The Landcare Group opened up the development of the plan to the entire Holbrook community, with the Working Group members being local business people, landholders and shire representatives.

Since then the Landcare Group has maintained an increasing level of activity. For example, it is currently undertaking a major 'rebirding' project which aims to combine fauna surveys, education programs, revegetation and remnant protection across 2000 hectares of grassy woodland. The primary aim of the project is to mitigate tree dieback, by providing improved habitat for insectivorous birds.

Having outgrown the structure of an incorporated association, in 2000 the Group reorganised as a company limited by guarantee. This structure is especially designed for non-profit community groups, with formal requirements for decision-making and accountability.

Table 1.1 Summary of Holbrook Landcare Projects 1989-2000
(pers. comm. Hulm 1999, 2000)

Year	Funding Received	No. of new projects	Continuing Projects	Total No. of Projects Operating
1989/90	$2000	1	0	1
1990/91	$60283	3	0	3
1991/92	$14300	7	1	8
1992/93	$106153	5	3	8
1993/94	$51238	4	2	6
1994/95	$202583	13	1	14
1995/96	$102912	5	2	7
1996/97	$164436	8	2	10
1997/98	$455423	10	2	12
1998/99	$306309	8	5	14
1999/00	$652583	3	6	9
2000/01	$954569	3	6	9
TOTAL	$3,201,589	66	-	-

Project details are available from the Holbrook Landcare Group. Some of the achievements to date include: more than 200 ha of gully erosion repaired, 70 km of creekline fenced out, more than a million trees and shrubs planted, several wetlands created, a high percentage of landholders as Landcare members, 50 field days, 163 hectares of remnant native vegetation fenced, 89 bores/piezometers throughout the catchment monitored quarterly, an urban Landcare Group established, several endemic native seed production sites being established, 13 sub-catchment groups established, 6 sub-catchment plans completed and development of the Upper Billabong LWMP.

4. ORGANISATIONAL FRAMEWORK FOR IMPLEMENTING THE LWMP

To enable the findings of the LWMP to be implemented, an appropriate organisational structure and clear lines of responsibility are needed. The Working Group developed the following framework for the various groups and positions, as well as the main roles they will undertake. Figure 1.2 shows how the various committees and positions relate to each other.

Holbrook Landcare Committee:

- Operates under the structure of a Company Limited by Guarantee
- Comprises Directors (elected by members at AGM) and Subcatchment Leaders (elected by subcatchment members)
- Responsible for ensuring that the activities conducted by the Holbrook Landcare Group are in accordance with the Group's Constitution
- Responsible for endorsing new initiatives to be undertaken by the Holbrook Landcare Group
- Meets every month
- Responsible for the implementation of the Upper Billabong LWMP
- In conjunction with the Upper Billabong LWMP Working Group, responsible for reporting back to the community on the Plan's progress and developments

> "Members of the Working Group and of the Holbrook Landcare Group have been at the forefront of development and promotion of their Plan."

Holbrook Landcare Employment Subcommittee:

- Responsible for job specifications, staff employment, evaluation and conditions

Holbrook Landcare Sponsorship Group:

- Identify and actively seek potential sponsors for the Holbrook Landcare Group
- Develop and uphold ethics associated with sponsorship

Subcatchment Groups:

- Meet on a needs basis
- Determine their own levels of activity
- Each has a Subcatchment Leader, who is eligible to be a part of the Holbrook Landcare Committee. The Subcatchment Leader has the responsibility of informing subcatchment members of any new Landcare initiatives
- Activities include: subcatchment and property planning, farm walks/drives across the subcatchment to integrate works
- On-ground activities include: revegetation, fencing of remnant native vegetation, erosion and salinity control works, co-ordinated fox baiting and water quality monitoring

Community:

- The urban and rural community within the Upper Billabong Catchment
- It is vital the community be kept informed and involved in the developments within Holbrook Landcare and the Upper Billabong LWMP. This will provide opportunities for members of the community to be educated, involved and have their say
- A series of community meetings will be held once a year within the catchment. Input from stakeholders outside the catchment will also be encouraged at these meetings

Upper Billabong Land and Water Management Plan Implementation Working Group:

- Has representation from Holbrook and Culcairn Shires, Landcare, local businesses and the urban and rural sectors. Further representation can evolve if desired by the group
- Oversees amendments and additions to the Plan - to ensure it remains a dynamic and community based document
- Internally reviews the marketing, actions, monitoring and evaluation associated with the Plan
- Ensures the wider community is being kept informed and involved
- Ensures the actions desired within the Plan are being equitably undertaken
- Meets on a needs basis approximately every three to six months

Rebirding Project Steering Committee:

- Composed of local landholders, Holbrook Landcare Support Officer and representatives from Greening Australia, CSIRO, Birds Australia, Charles Sturt University, Environment Australia and Hume Rural Lands Protection Board
- Oversees the methodology of the Rebirding Project
- The committee will be responsible for ensuring that the Biologist and Rebirding Project Officer are working effectively and that the project is on schedule and meeting targets
- The committee will meet on a needs basis
- Is responsible for reporting back to the Holbrook Landcare Group the progress of the Rebirding Project

Biologist - "Rebirding" Project (already completed):

- Responsible for undertaking bird surveys and habitat assessments at all bird survey sites
- Full time position for 12 months
- Responsible for conducting workshops to inform/educate the community on the issues of dieback and the methods involved in undertaking bird surveys
- Responsible for producing a report which will assist in providing direction for revegetation works
- Will convey the results of the investigations through journals, media, seminars and workshops to the Holbrook Community and beyond
- Reports to the Rebirding Steering Committee, Holbrook Landcare Committee and Holbrook Landcare Support Officer

Land and Water Management Plan Implementation Project Officer:

- Full time position
- Directly responsible to the Upper Billabong LWMP Implementation Working Group and the Landcare Support Officer. Indirectly responsible to the Holbrook Landcare Group
- Education and extension (bus trips, field days, workshops, farm walks, seminars, brochures, media, newsletters etc), seeking of expressions of interest for incentives
- Establish a data base of Plan on-ground actions
- Facilitation of Implementation Working Group, issue-based sub-groups and Plan actions and targets
- Maintain links and works with Farming for the Future, Greening Australia, Department of Land and Water Conservation, CSIRO, NSW Agriculture, Murray Farm Forestry, State Forests, Murray Catchment Management Board, Murray Darling Basin Commission
- Preparation of assessment forms and property agreements
- Assessment, prioritisation and integration of applications for incentives; administration of incentives
- Ensure the desired monitoring and evaluation associated with the Plan is being undertaken. This would include the bore monitoring program and streamwatch

Funds Manager:

- Part-time position (1-4 days/week)
- Administer accounts associated with: staff employment, subcatchment projects, catchment projects
- Pay approved incentives to landholders

Landcare Support Officer:

- Full time position
- Responsible to the Holbrook Landcare Committee
- Publicise all incentives available to landholders
- Put into place the organisational structure of the Holbrook Landcare Group

- Oversee all projects within the catchment
- Oversee other Landcare employees and ensure that all employment conditions are being met. This would include the Implementation Officer, Rebirding Officer, Funds Manager, Works Team Leader, Works Team Crew and Consultants
- Develop marketing and sponsorship strategies for Holbrook Landcare and the Plan
- Actively seek out corporate support for Landcare and Plan activities, in particular funds for a shopfront and the current and proposed incentives
- Setting up of a technical review/reference group
- Maintain links and works with Farming for the Future, Greening Australia, Department of Land and Water Conservation, CSIRO, NSW Agriculture, Murray Farm Forestry, State Forests, Murray Catchment Management Committee, Murray Darling Basin Commission
- Develop the Holbrook Landcare Internet site
- Seek and maintain the funding and structural requirements of Holbrook Landcare and the Plan
- Encourage research organisations to undertake studies in the Holbrook Landcare area
- Maintain report and newsletter writing requirements particularly to funding bodies and corporate sponsors
- Oversee and develop education packages

Rebirding Project Officer:

- Part-time position (3 days/week) for two years from January 2000 to December 2001
- Responsible for undertaking site inspections to allocate ‘rebirding’ revegetation funds to landholders within the Catchment
- Responsible for promotion of the Rebirding Project to the Catchment and beyond
- Responsible for co-ordinating priority sites for the Holbrook works team
- Reports to the Rebirding Steering Committee, Holbrook Landcare Committee and Holbrook Landcare Support Officer

Holbrook Works Team Leader (being developed):

- Full time position for a minimum of two years
- Responsible for the day-to-day operations of the of the Holbrook works team
- Ensures the training obligations for the works team are met
- Liases on a regular basis with the Rebirding Project Officer
- Reports to the Rebirding Steering Committee, Holbrook Landcare Committee and Holbrook Landcare Support Officer

Holbrook Works Crew (being developed):

- Six-member crew employed on a full-time basis for a minimum of two years
- Responsible for undertaking revegetation and fencing works associated with the Rebirding Project, seeking to accelerate implementation rates
- Potential to extend works to include seed collecting and works associated with other Holbrook Landcare Projects
- Directly responsible to works team leader

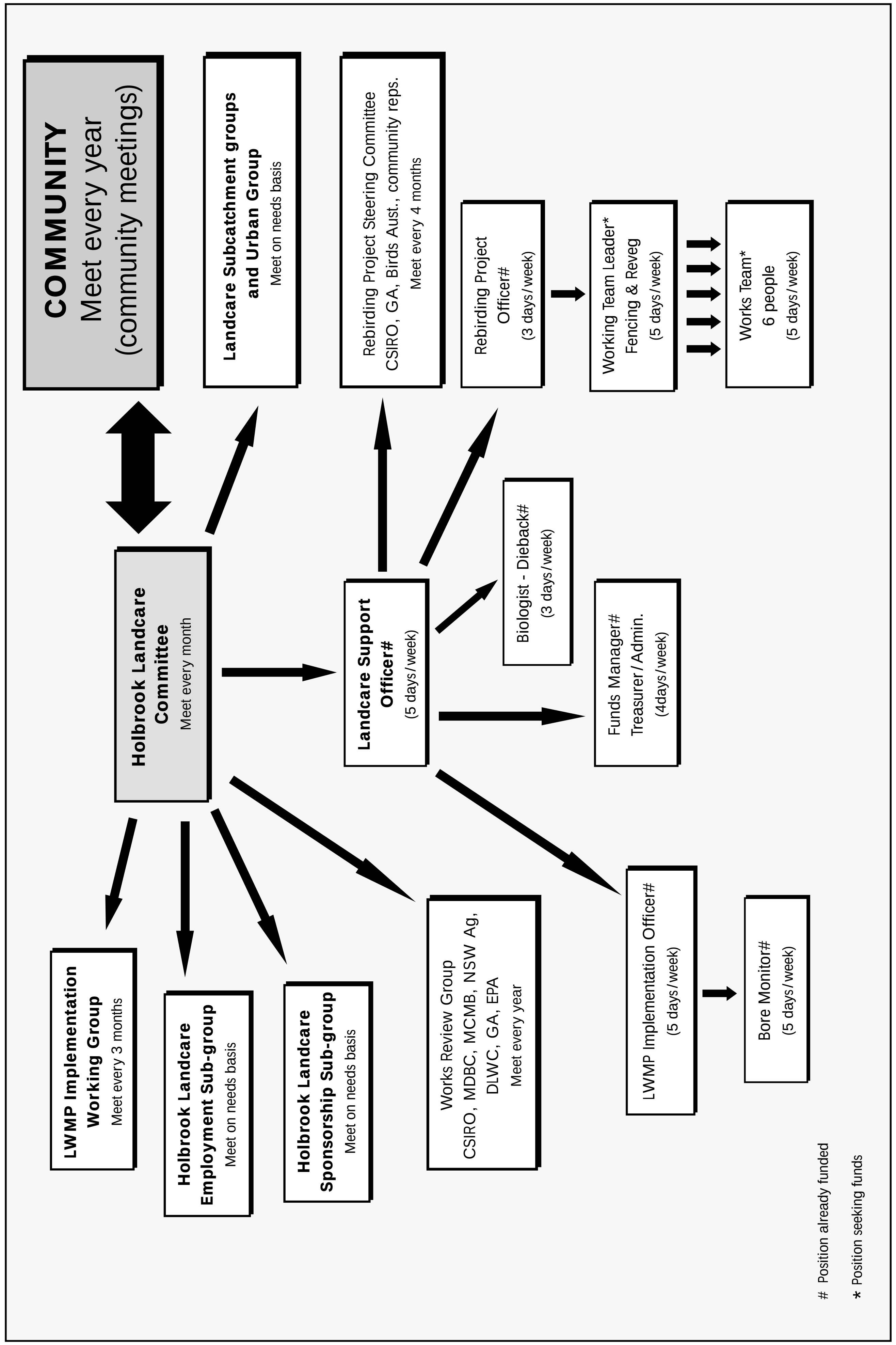


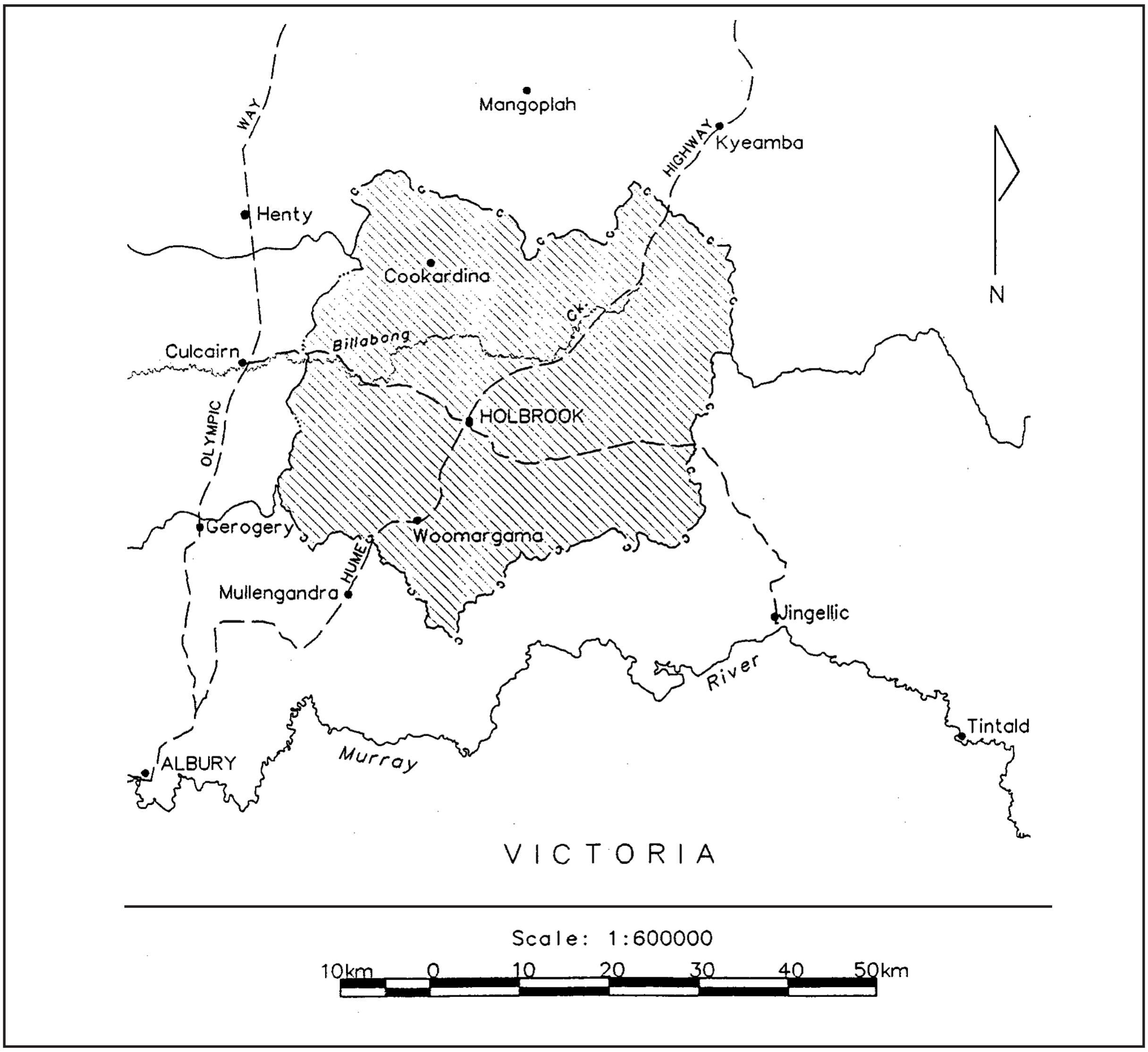
Figure 1.2 Organisational Structure for Implementation of *Upper Billabong* LWMP

1. USEFUL BACKGROUND MATERIAL

(a) Location and Brief History

The Upper Billabong Catchment (Figure 2.1) covers an area of 171,000 hectares. It lies on the eastern part of the Murray-Riverina Region of NSW (50 kilometres north west of Albury). It includes 22,000 hectares within the Culcairn Shire in the west of the catchment. The remainder of the catchment lies within Holbrook Shire. The township of Holbrook is centrally located within the catchment. The catchment is the headwaters of the Billabong Creek. Ridge lines or the watershed act as the natural boundary for the catchment. The lowest point within the catchment is the Billabong Creek at Morven.

Figure 2.1 Upper Billabong Catchment



The Upper Billabong Catchment covers an area of 171,000ha

Aborigines – Wiradjuri

The whole Upper Billabong Catchment comes within the lands that traditionally were cared for by the Wiradjuri peoples. Wiradjuri recollections of traditional life recall the harvesting of local plants and animals (pers. comm. Grant 1998). Aboriginal people actively engaged in land management, for example through the use of fire, digging stick farming (primarily of yams) and the construction of dams and fish traps. European records indicate that the Wiradjuri were active in the country between the Murray River and Murrumbidgee in their thousands (Carnegie 1973). Much Aboriginal activity was along the creeks and billabongs. They had an intimate relationship with the land - "the land owned them" - and had a spiritual relationship with animals through totem. They did not exploit the land and were not materialistic. They were necessity-minded and appreciated that their survival depended on the survival of the land and its natural resources. They saw themselves as part of the system of native animals and plants, but not superior to them (pers. comm. Grant 1998). Aboriginal culture and motivation operated through religion, spirituality and a system of belief. A system of belief and not questioning: "you believe everything or you will learn nothing" (pers. comm. Grant 1998).

Like all humans, they modified the environment to improve their own well being, mainly through the use of fire. European academics at various times debate the extent to which humans helped to create and maintain eucalypt dominated forests before European settlement. There are arguments that fire caused the decline of forest diversity - rainforest trees, casuarinas, cypress and pine were not able to compete with the fire resistant eucalypts (Barr & Cary 1992). Some academics raise the possibility that continuous hunting brought many larger animal species (macrofauna) to extinction. However, extinctions could have resulted from climate change, or use of fire, or a combination of all three (CSIRO 1996b). Suffice to say that the debate is inconclusive.

Aboriginal oral traditions, as well as early European diaries and accounts, indicate that European occupation and its consequences (smallpox, dislocation and killings) caused the decline of the Aboriginal population. "The last great corroboree was in 1851 when the gold diggings started and the influx of Europeans and Chinese began. The [A]borigines died out rapidly after this" (Carnegie 1973). Senior Wiradjuri Elder Cec Grant feels denigration of the Aboriginal people was the major factor leading to their dispossession from the land and these circumstances constituted the worst form of conflict.

Cec Grant provides this environmental statement for the Wiradjuri tribal land in the Wiradjuri language as follows:

WIRADJURI
kaarray binaal billas
Land of many rivers

ngangaana kaarray billas
Look after the land and rivers

dya, kaarray billas
darraay ngangaana ngindu
And the land and rivers will look after you

Early European Settlement & Landuse Impacts

The explorers Hume and Hovell were the first Europeans to travel through the catchment in November 1824. They described the catchment as having "the best of the cow pastures ... excellent coat of grass ... soil of an excellent dry quality" and timber varying from "string bark, gums and the trees something like the cow box pasture tree". These qualities were quickly appreciated by the first settlers to the catchment with one of the first official licences for the "depasturising of stock" going to Reverend J.J. Therry in 1837 including "twelve acres in cultivation, eight hundred head of cattle and three stockhorses" (Carnegie 1973).

The first resident of Ten Mile Creek (later Holbrook) and first recorded sheep grazier was German born Johann Pabst, a sheep expert for the Australian Agricultural Company. He worked for two years in charge of the sheep owned by Thomas Mate (Lynch 1988). The "beautiful water" was one of the main reasons for Ten Mile Creek becoming a popular rendezvous for stockmen on the Sydney Road (Carnegie 1973). In 1871 a flourmill was opened in Holbrook, and in 1895 prospecting for gold occurred between Holbrook and Mullengandra and in the Four Mile sub-catchment. In 1897 share farming began in the district (Lynch 1988).

As a condition of retaining land granted by the government, the government required that the leaseholder undertake annual capital improvement to the land. These improvements were based on 10% of the value of the land. Theimprovements included buildings, sheds, fencing, roads and clearing (pers. comm. Ross 1999).

Native vegetation was cleared for crops and pastures and to obtain structural timber for housing, stabilising mine shafts and fence posts. Teams of labourers undertook most clearing prior to the Second World War. Gangs of Chinese were used until the early 1900s after they finished in the mines. It was common practice to put arsenic in the 'frill' to stop regrowth. A reduced labour force during the Second World War resulted in large areas of cleared country regenerating. The early settlers used to be able to ride a cart through a lot of the timber as there was far more open woodland - particularly on the gilgai wetlands (eg: Yarra Yarra and Wantagong sub-catchments). Hence these areas were initially favoured for early settlement (pers. comm. Ross 1999 and Meiklejohn 1997). Regrowth from clearing and particularly the fire of 1952 in the stringybark hill country has resulted in much thicker stands of timber (pers. comm. Meiklejohn 1997).

The initial clearing of trees removed the suppression effect of the big trees on seedlings, therefore allowing dense stands of regrowth or coppicing to occur.

Now there is the paradoxical situation of too many trees growing on some hilly sites and too few throughout the majority of fertile areas (pers. comm. Davidson 1998), where grazing and cultivation have resulted in a lack of regeneration.

In 1902 the Culcairn to Holbrook railway line was established. In 1908 a tin mine was opened in the area, and traces of copper were also found. In 1909 a telephone line to Holbrook was completed, and in 1911 a butter works and freezing factory were opened. In 1914 electric lighting started to be installed in Holbrook (Lynch 1988).

Rabbits were introduced into Victoria in 1859 and first appeared in the Albury area in 1884 where they quickly established. Heavy infestations, particularly in the rocky hills caused extensive sheet erosion (SCS 1978). Rabbits became a major problem in the 1940s and 50s, as a result of a reduced labour force during the War (pers. comm. McLaurin 1998). "You used to be able to crack a whip and see the whole hill moving" (pers. comm. Ross 1999). The rabbits were trapped, poisoned and dug out (pers. comm. Shearer 1997). Local football clubs would have rabbit drives as fundraisers; it was common to get 500 to 600 pairs (pers. comm. Meiklejohn 1997). In 1951 the virus myxomatosis was introduced, which has since controlled rabbit populations, in combination with poisons such as 1080 (SCS 1978).

Cereal farming up until the 1940s was a minimal wheat-fallow rotation. Stubble was burnt. Much of the accelerated erosion of drainage lines and the general depletion of soils is attributed to these farming methods. Many of the district farmers refer to a major event in 1939, when two prolonged droughts were followed by 1204 mm of rain for the year. The consequential severe erosion caused many farmers to reduce cultivation areas (SC, 1978). The erosion decades of the 1930s and 40s spawned the first wide-spread community concern about land degradation and the establishment of soil conservation agencies by state governments (Campbell 1994).

Fertilisers first started being applied in the late 1940s making a significant difference to both pasture and crop production (pers. comm. Meiklejohn 1997; Shearer 1997 and Geddes 1997). After the Second World War, the combination of superphosphate and clover allowed for dramatically increased pasture growth particularly in the spring. In the 1950s, hay-baling machinery and efficient tractors simplified the task of storing fodder for drought. Also in the 1950s, the Soil Conservation Service promoted the planting of grasses to stabilise the soil against erosion; these were generally introduced annual grasses such as ryegrass, or perennial grasses with shallow roots. Annual aerial applications of superphosphate, particularly in the steeper grazing country significantly improved the stability of the land (SCS 1978).

Conservation farming practices began in the early 1960s when herbicides that could potentially replace cultivation as a form of weed control started to become available. Using herbicides instead of cultivation for weed management reduced the structural degradation of the soil that resulted from repeat tillage. However, it was not until the early 1970s that conservation farming, in the form of reduced tillage, started to become a common practice. This change was triggered by increased fuel costs rather than a desire to preserve the soil structure. Reduced tillage was seen as a means of cutting costs (Charles Sturt University 1999). The success of many minimum till crops and the availability of knockdown herbicides containing paraquat and diquat, for controlling weeds before sowing, encouraged many producers to direct drill crops without any cultivation. This practice was boosted in 1980 when the knockdown herbicide glyphosate was released (Charles Sturt University 1999).

Up until the 1970s, erosion was the main subject of efforts to reverse land degradation. By the 1980s, soil salinity was being recognised as a growing concern; more emphasis then was placed on deeper rooted perennial pasture species such as phalaris and lucerne. In the early 1970s, soil acidity and the associated aluminium and manganese toxicity were first identified as problems within the region. Clover was found to be getting smaller and stunted. Prior to this the main soil deficiency was regarded to be phosphorus. In 1980, major wheat crop yellowing was found to be occurring due to soil acidity. Since 1980 there has been crop breeding for acidity tolerance and the application of lime to soils to increase soil pH (pers. comm. Scott 1998).

(b) Demographics

Population Distribution

An estimated 2717 people live in the Upper Billabong Catchment. Table 2.1 shows:

- 41% live within the rural sector
- 59% live within the town and villages of Holbrook, Woomargama and Morven.

Table 2.1 Population Distribution Estimates (ABS 1996b)

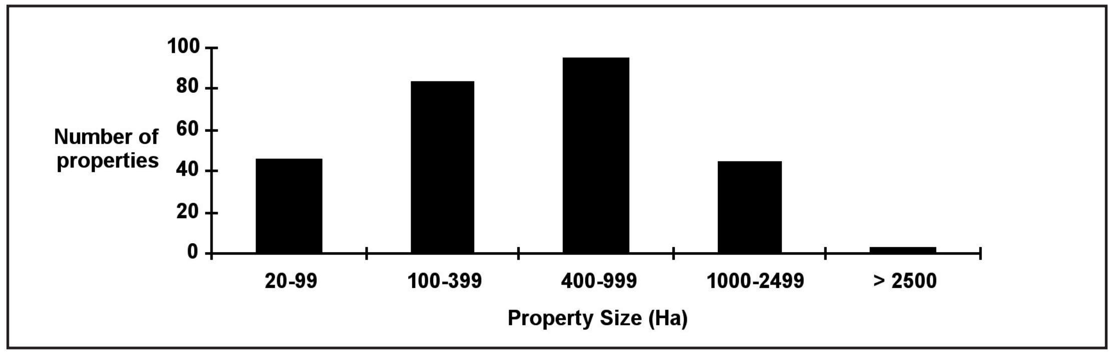
Area	Population
Holbrook	1,400
Woomargama	102
Morven	75
Rural	1,140
Total	**2,717**

"You believe everything or you will learn nothing."

Number of Farms and Size

Within the Upper Billabong Catchment there are 270 independent property owners with properties greater than 20 hectares in size (Figure 2.2 based on Culcairn and Holbrook Shire records). It is estimated there are 188 farms within the catchment that earn greater than $5,000 per annum from agriculture (ABS 1996a).

Figure 2.2 Comparison of farm size in the Upper Billabong catchment (Culcairn and Holbrook Shire property records 1997)

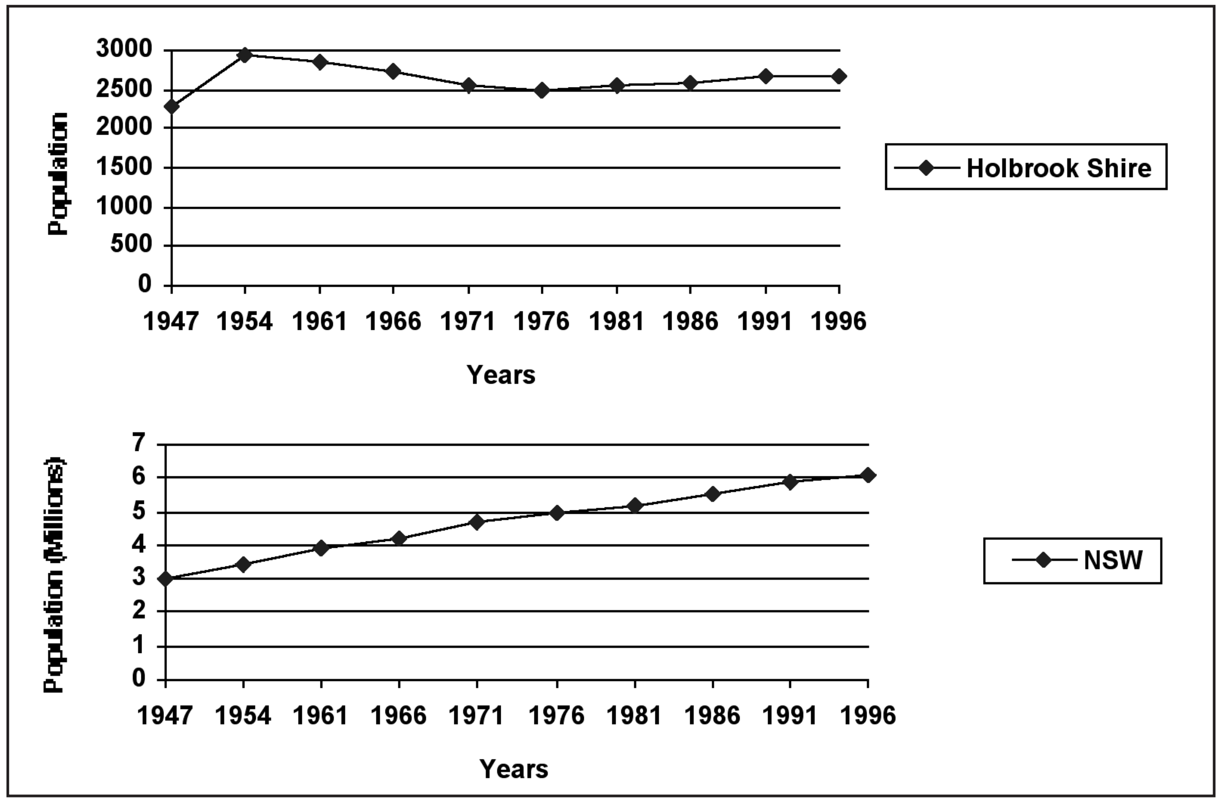


Population Over Time

Indicative figures on residential population growth/decline within the Upper Billabong Catchment can be obtained by looking at historical figures for Holbrook Shire. The graph (Figure 2.3) shows that within Holbrook Shire between 1947 and 1954 there was a jump in population size; it is assumed this was due to post-war soldier-settler blocks being provided. From 1954 to 1976 there was a gradual decline in the population, but since 1976 it has remained stable.

If we compare population growth of Holbrook Shire with the state of NSW from 1947 to 1996 (Figure 2.3), we see a population increase within Holbrook Shire of only14% compared with 103% within NSW (ABS 1963 - 1996).

Figure 2.3 Estimated resident population figures for Holbrook Shire and NSW (ABS 1963 - 1996)



Age by Sex

Indicative figures on age by sex for the Upper Billabong Catchment have been derived from 1996 ABS census data for Holbrook Shire (Table 2.2).

Age Distribution

Figure 2.4 shows a marked decline in persons found in the 15 - 29 year age bracket within Holbrook Shire, when compared to the state of NSW. It is assumed this would be primarily due to the young adults seeking employment and education outside of the catchment. There is also a relatively higher percentage of elderly within the catchment. It is assumed this is due to the relatively low cost of living, good services and lifestyle available.

Weekly Individual Income

Figure 2.5 shows that of the individuals aged 20 and over within Holbrook Shire, 64% earn less than $400 per week compared with 55% for the state of NSW. This is a reflection of rural incomes being at the lower end of the income scale and highlights the impact of low agricultural commodity prices on farmers' incomes.

Table 2.2 Age by sex figures for Holbrook Shire (ABS 1996c)

Age	Male	Female	Persons	Age	Male	Female	Persons
0-4	110	89	**199**	55-59	73	65	138
5-9	111	109	**220**	60-64	45	62	107
10-14	108	112	**220**	65-69	70	68	138
15-19	78	64	**142**	70-74	57	51	108
20-24	40	39	**79**	75-79	33	31	64
25-29	66	73	**139**	80-84	15	28	43
30-34	89	83	**172**	85-89	14	21	35
35-39	87	106	**193**	90-94	4	4	8
40-44	92	90	**182**	95-over	3	4	7
45-49	92	87	**179**	overseas	3	5	8
50-54	78	72	**150**	**Totals**	**1,268**	**1,263**	**2,531**

Figure 2.4 Age Distribution within Holbrook Shire and NSW (ABS 1996c)

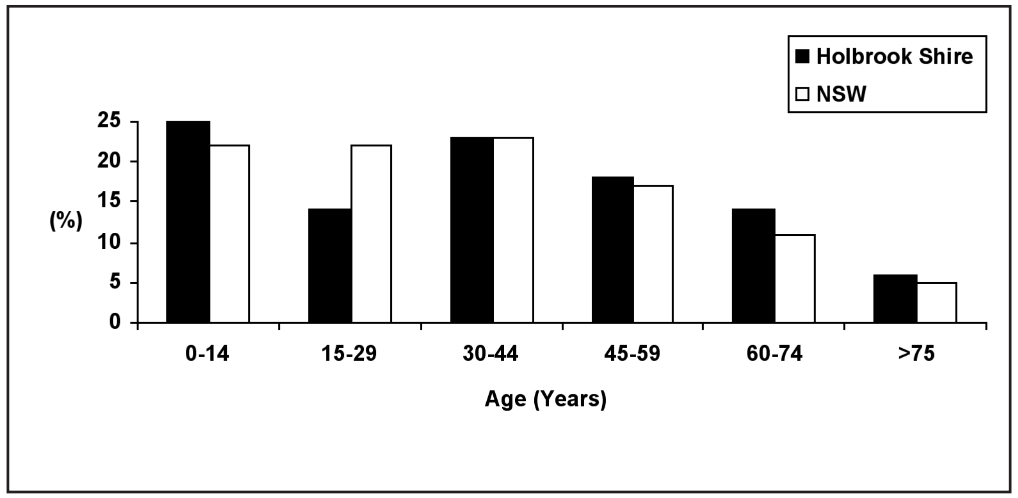
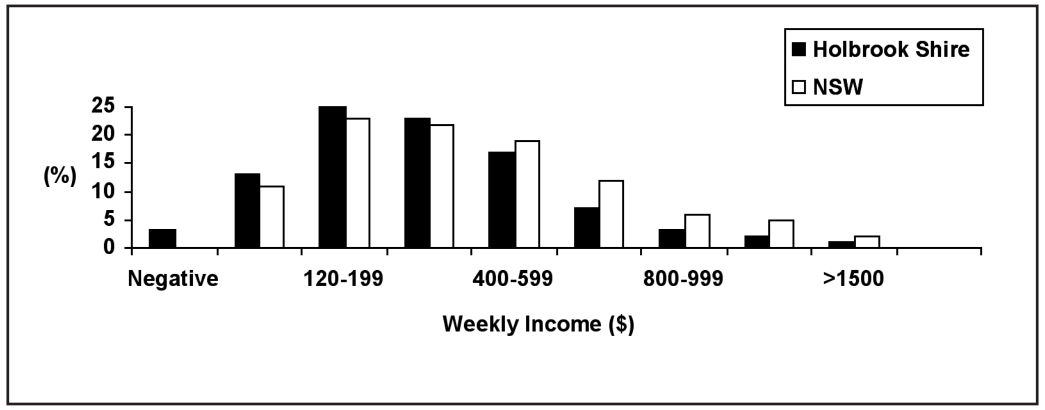


Figure 2.5 Weekly Incomes for Holbrook Shire and the State of NSW for individuals aged 20 and over (ABS 1996c)



Employment

Figures on employed persons, unemployed persons and those in, and not in, the labour force show very little difference between Holbrook Shire, Albury and the state of NSW (Table 2.3). When we look at the unemployment rate - which is the percentage of unemployed in the labour force - it shows Holbrook Shire to have an unemployment rate less than Albury and NSW (Table 2.4).

Table 2.3 Employment and labour force percentages for Holbrook Shire, Albury and NSW (ABS 1996c)

Employment Status (% of the total population)	Holbrook Shire (%)	Albury (%)	NSW (%)
Employed	40	43	42
Unemployed	4	5	4
In labour force	44	48	46
Not in the labour force	30	28	29

Table 2.4 Unemployment percentages for Holbrook Shire, Albury and NSW (ABS 1996c)

Employment Status	Holbrook Shire	Albury	NSW
Unemployment rate %	8.4	10.9	8.8

Employment by Industry

Employment by industry figures show agriculture to be the strongest area of employment (37%) within Holbrook Shire (Table 2.5).

Table 2.5 Employment by Industry within Holbrook Shire and NSW
(ABS 1996c)

Industry	Holbrook Shire (%)	NSW (%)
Agriculture	37	4
Manufacturing	4	12
Construction	6	6
Wholesale Trade	3	6
Retail Trade	12	13
Accom, Cafes and Restaurant	5	5
Transport and Storage	7	5
Communication Services	1	2
Finance and Insurances	1	5
Property and Business Services	2	11
Government Admin. and Defence	7	4
Education	4	7
Health and Community Services	7	9
Cultural and Recreational Services	1	2
Personal and Other Services	2	4

The arrival of Austral Softwoods Pty Ltd in Holbrook since the last census has brought about a dramatic change in the number of people from Holbrook employed in the timber milling industry. Austral employs 104 people, mostly in timber processing but this figure includes management (4), supervisory (5) and administrative staff (2).

Social Security Payments

Indicative figures on the Upper Billabong's reliance on social security payments can be obtained by looking at the main types of social security payments for the 2644 postcode area. These statistics are available for postcode districts only (which are different from shire or LWMP boundaries). Comparison of the 2644 (Holbrook), 2640 (Albury) and NSW figures shows there is low reliance on social security payment within Holbrook Shire (Table 2.6).

Table 2.6 Proportion of the population receiving different types of social security payments – comparison of the Holbrook and Albury postal code areas, as well as NSW
(supplied by Centrelink June 1998)
Based on June quarter social security figures and 1996/97 census total population figures. (supplied by Centrelink June 1998)

Payment Type	2644 (Holbrook) (%)	2640 (Albury) (%)	NSW (%)
Age Pension	8	10	10
Disability Support Pension	2	3	3
Family Payment Allowance	8	11	10
Newstart Allowance	3	5	5
Parenting Payment (single)	1	3	2
Parenting Allowance	3	3	4
Rent Assistance	3	6	6
Other	2	3	2
Total Percentages	**30**	**44**	**42**

(c) Infrastructure and Services

Private Dwellings

It is estimated there are 1,112 private dwellings within the Upper Billabong Catchment. Of these, 15% (146) are unoccupied compared with 9% for the state of NSW.

Roads, Bridges and Railway

The catchment is bisected by the Hume Highway. There are 23 sealed roads and 34 unsealed roads within the catchment. Table 2.7 summarises their lengths and shows the estimated length of these potentially affected by seepage from shallow watertables.

Table 2.7 Roads within the Upper Billabong Catchment and those influenced by locally raised watertables/seeps
(pers. comm. Hoskins 1997 and Spokes 1998)

Road Type	Total Length in Upper Billabong Catchment (km)	Length influenced by locally raised watertables/seeps (km)
Hume Highway	55	4
Other sealed roads	254	4
Unsealed roads	138	
Total	**447**	**8**

There are 27 bridges within the catchment. Of these, the bridges on Thugga Creek, Back Creek and Wantagong Creek require works to address erosion and sedimentation (pers. comm. Beard and Brasier 1998). An abandoned railway line runs between Holbrook and Culcairn.

Community Services

Community services available in the township of Holbrook include: hospital, police, Post Office, Rural Lands Protection Board, banking facilities, primary schools and pre school, Community Education Centre, Bushfire Control Centre, swimming pool, library.

Tourism

Holbrook is situated in the heart of a diverse and rich agricultural region and is ideally placed between Melbourne, Sydney and Canberra on the Hume Highway. As a direct result of the Commonwealth Government's long-term plans to provide a four lane carriageway from Sydney to Melbourne, the Holbrook Shire Council has been pro-active in providing travellers with excellent facilities to make overnight stops in Holbrook convenient, comfortable and interesting. Motel accommodation to suit all budgets, a new caravan park, and beautiful parks and gardens along with a bush walk and a variety of eating establishments and cottage industries, provide the amenities to stop, revive and survive.

> "Holbrook is situated in the heart of a diverse and rich agricultural region and is ideally placed between Melbourne, Sydney and Canberra on the Hume Highway."

The construction of an above-waterline casing from the decommissioned submarine HMAS Otway has proven to be a great traffic stopper. Given the history of Holbrook's connection to submarines through the naming of the town after First World War submariner Commander Norman Holbrook, it is a natural progression to establish a museum and interpretative centre focusing on the history and workings of Australian submarines. Still in the planning stages, this will be a facility of national importance and a first for country Australia (pers. comm. Parker 1998).

2. ISSUE A: DECLINING ECONOMIC VIABILITY AND ISSUE I: LOSS OF SERVICES

(a) Declining Economic Viability – some major themes

It should be noted that most of these issues interrelate and pertain directly to the agricultural sector. The quoted 1969 booklet called "Small Farmers in Trouble" produced by the Australian Broadcasting Commission, further highlights that the economic and social trends within rural communities have been with us for some time.

Below is a summary of the major themes relating to declining economic viability:

- Cost Price Squeeze - increasing costs associated with decreasing commodity prices
- Decreased returns on agricultural assets
- Increasing reliance/demand on higher inputs and outputs, farming technology and reduced labour
- The influence of world prices, markets and subsidies
- Increasing reliance/demand on larger farms to maintain an adequate standard of living. "The small income farm of this generation was the viable farm of the last generation". "A small farm today is one that has 3000 sheep or less than 200 beef breeders" (Australian Broadcasting Commission 1969). Today, in 1998, you could possibly double those figures
- "Farmers tend to hang on." "Farmers are occupationally immobile… Humans being humans are reluctant to change their way of life, especially those of advanced years" (Australian Broadcasting Commission 1969)
- Continuing degradation of the land (eg: salinity, soil acidity, erosion, biodiversity decline and weeds)
- Landholders' limited market, economic and technical ability to structurally adjust and value-add. "Inadequate training and specialisation of many farmers as managers… Farmers are not managing and operating their properties as a business enterprise within a large industry" (Australian Broadcasting Commission 1969)
- Agriculture is high risk. "A run of bad fortune ... two or three years of drought followed by reduced market prices" (Australian Broadcasting Commission 1969)
- Increasing reliance on off-farm income. Fewer jobs. Greater competition for those jobs
- Younger people are tending to leave the farm and seeking employment away from agriculture

(b) The Current Economic and Social Situation

Summary

From the background material in Part 1, we can deduce the following:

- Figures on employment (Table 2.3) show very little difference between Holbrook Shire, Albury and state of NSW. When you compare the unemployment rate (Table 2.4) - which is the percentage of unemployed in the labour force - it shows Holbrook Shire (8.4%) to have an unemployment rate less than Albury (10.9%) and NSW (8.8%).
- Welfare benefit figures show there is a low reliance on welfare benefits within the Holbrook area (30%) when compared with the Albury area (44%) and the state of NSW (42%) (Table 2.6).
- There is a marked decline in the number of persons found in the 15 - 29 year age bracket within Holbrook Shire (14%) when compared to the state of NSW (22%) (Table 2.3). It is assumed this would be primarily due to the young adults seeking employment and education outside of the catchment and a movement away from agriculture as a source of income.
- An estimated 15% of all dwellings within the catchment are unoccupied - this compares with 9% for the state of NSW. This is another reflection of rural decline.
- Individual weekly income figures show of the individuals aged 20 and over, within Holbrook Shire, 64% earn less than $400 per week compared with 55% for the state of NSW (Figure 2.5). This is a reflection of rural incomes being at the lower end of the income scale and highlights the impact of low agricultural commodity prices and increasing costs on farmers' incomes.
- Comparing population growth between Holbrook Shire and NSW from 1947 to 1996 (Figure 2.3) shows a population increase within Holbrook Shire of only 14% (6% if you look at the last 20 years) compared to 103% within NSW. These graphs highlight the population trend away from rural areas into urban centres.

Chronically Poor Families

A study headed by Dr Bob Birrell at Monash University found that within Holbrook Shire, 48% of children up to the age of 15 lived in chronically poor families. This compared with a figure of 41% in Albury and 39% in both Corowa and Wodonga. The study classified chronically poor families as those receiving an unemployment benefit or pension of some kind. The category also covers the working poor who earn less than $24,000 a year - who are eligible for welfare by way of family allowance payments (Border Morning Mail 1997).

This high occurrence of chronically poor families for Holbrook Shire does not coincide with the figures for unemployment and welfare benefits (Tables 2.3, 2.4 and 2.6). In this regard, Holbrook Shire has tended to have a reduced reliance on welfare when compared with other areas. Dr Birrell agreed with this, explaining that people in the Holbrook area do not seem to be as accepting of welfare benefits, 'making-do' without. According to Centrelink (pers. comm 1998), high asset levels (eg: land, machinery, stock) should not affect the landholders' ability to receive welfare benefits. The Community meetings conducted by the LWMP in 1999 revealed that many community members within the catchment disagree with Centrelink's comment.

The Economic Status of Properties within the Upper Billabong Catchment

A financial study of properties within the Upper Billabong Catchment was undertaken by Hassall & Associates (1998) based on 1996/97 financial data. Hassall and Associates undertook the study via on-property face-to-face surveys with 31 landholders. This study found the catchment to be not dissimilar and possibly slightly healthier than other beef/sheep farming areas within the state. However, it should be noted that the average property size surveyed was 897ha, whereas the more realistic farm business size within the catchment is 769ha. It could also be assumed that those properties experiencing financial difficulties may have been more reluctant to participate.

It should also be noted that in 1997/98, commodity prices have been less than 1996/97 and most landholders experienced a negative return on assets (pers. comm. Working Group 1998).

The major findings of note from the financial study were:

- The average return on capital was 2%, whilst the average return for the top 20% of landholders was 5% and -2% for the bottom 20% surveyed. ABARE statistics for return on capital in the sheep beef industry indicate slightly negative results for the three years from 1994 to 1997.
- The average farm results indicated a surplus after cash expenses, interest and depreciation of $35,625, with the surplus available for reinvestment being $1,225 after recognising an allowance of $34,400 for operator labour and the farm family.
- It was estimated that for a farm to be financially viable in this region, the property would need to carry at least 5,000 DSE, with the minimum viable farm size being somewhere between 535 to 700ha. These figures on viable farm size should be noted with caution as there is no simple relationship between farm size and viability - a multitude of factors can impact upon this figure (eg: high value enterprises, management, debt levels and off farm income). More than 50% of properties within the catchment are smaller than this minimum viable farm size.
- The total asset value, comprising plant and equipment, land and livestock for those surveyed averaged $1.8 million. In 1995 ABARE found the average asset value to be $1.1 million for the sheep/beef industry (no figures are available for 1996/97). A higher figure is to be expected in the Upper Billabong catchment due to the higher rainfall, productive farming and land values.
- The 1997 ABARE farm surveys report estimates average liabilities at $80,500. Liabilities are significantly higher in the Upper Billabong catchment - exceeding $208,000 but when equity levels are examined, the landholders surveyed had an average farm business equity of 89%. Hassall & Associates' experience, working with rural businesses, indicates that banks consider businesses with equity below 80% to be at risk. The Upper Billabong catchment is therefore reasonably healthy compared with other NSW sheep/beef producing regions, with respect to banking industry standards for asset and equity levels.

(c) The Bigger Picture and Trends associated with Economic Viability in the Rural Sector

The above summary, highlighting the current economic and social status of the Upper Billabong catchment, is a snapshot in time and it is important to understand the environment within which the catchment is operating.

A discussion paper called "The Role of Agriculture" made the following observations:

> **"Global information is driving the changes taking place in Australia and overseas...the real cost of operating a farming enterprise in the future will increase....additional skills and or services will be needed.... the farmers' use of external sources of information, which is already high, will increase even further."**

Highlights from ABARE's "Farm Surveys Report" (1994):

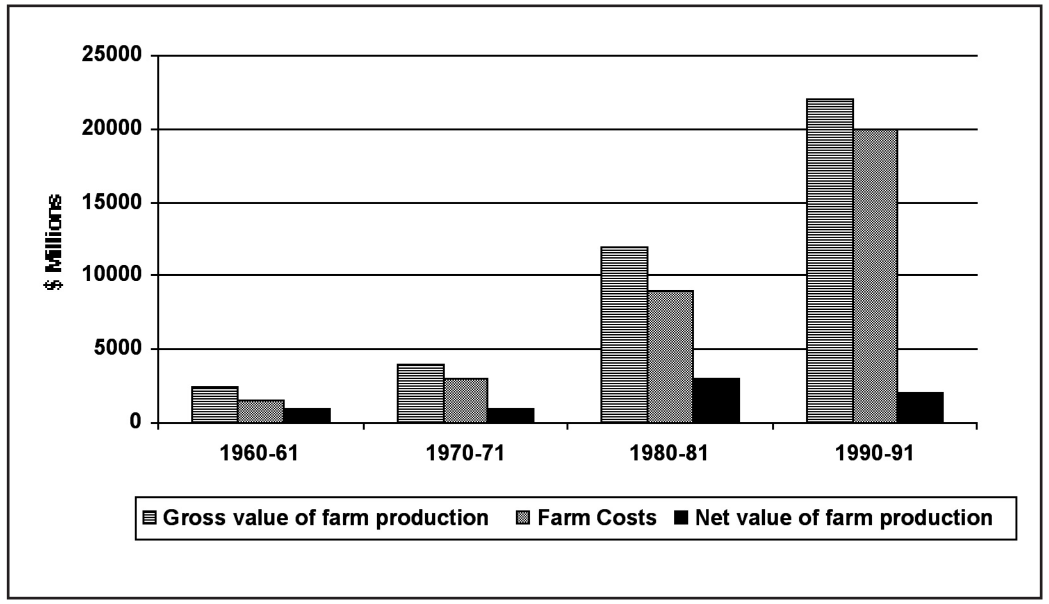
- The single operator farm, a current characteristic of Australia's farm base, will disappear. The minimum size farm will be a multi-person operator, supported by a wide range of off-farm marketing, business and financial services.
- Agricultural producers whose farms have not experienced significant changes to the production base over the last 20 years will find the 1990s very difficult indeed. Whilst profit margins on annual turnover have fallen from 26% to 9% and farm numbers have decreased by 34%, numbers employed in agriculture have only fallen 4% over the same 30 year period - there appears to be a pent-up reluctance toward structural adjustment in this area.
- Commercial pressures and the need to increase real earnings for both operators and employees will drive massive change in agriculture over the 1990s. It is expected the number of farms in Australia will fall to below 75,000 by the end of this decade.
- The consequence of this new style of farming will be a wider spread of agricultural efficiency. Much larger, more efficient farms will emerge. Most alarmingly, an underprivileged group of landholders not seen previously - real rural poverty - will emerge.
- All farms will need to be more adaptive. For instance, smaller farms will be under more pressure to seek out specialty markets to generate higher levels of income to compensate for relatively higher farm overhead costs.
- Even on the fewer larger farms there will be a pressure to join in co-operative programs to enlarge effective farm areas. Inevitably, even co-operative programs will not prevent many of these farmers from working in off-farm employment.
- The change in nature of farming in Australia is a real threat both to the well-being of regional economies and the management of Australia's more fragile environmental areas.

Figures 2.6 to 2.8 highlight these statements. The Upper Billabong Catchment, being reliant primarily on traditional agriculture as an industry, is not insulated from the problems highlighted above - the trends are expected to continue into the future.

> **"Tell me and I'll forget: Show me and I may remember: Involve me and I'll understand."**

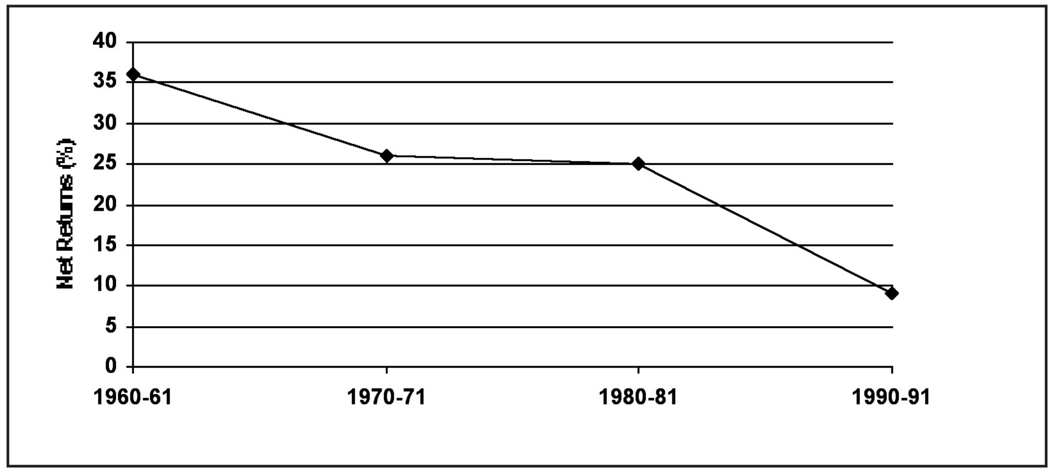
Figure 2.6 Australian Farm Returns Costs and Prices (ABARE, 1994)

Another way of illustrating that the costs of inputs are continuing to rise, is through a simple comparison:



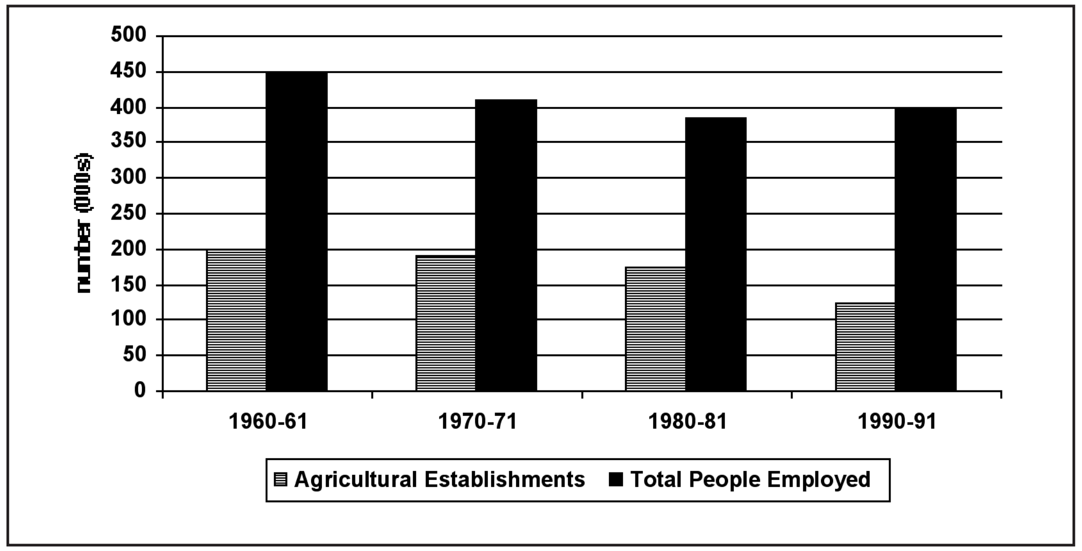
In 1973, one tonne of wheat would buy 4.92 tonnes of superphosphate or 2,644 litres of fuel, whilst in 1992 it would buy 0.46 tonnes of superphosphate or 166 litres of fuel (Thorne 1992).

Figure 2.7 Net returns as a percentage of the gross value of production (ABARE 1994)



In 1973, one tonne of wheat would buy 4.92 tonnes of superphosphate or 2,644 litres of fuel in 1992 it would buy 0.46 tonnes of superphosphate or 166 litres of fuel.

Figure 2.8 Agricultural Establishments and Total People Employed (ABARE 1994)



3. ISSUE B: LACK OF KNOWLEDGE, UNDERSTANDING AND SKILLS OF NATURAL RESOURCE MANAGEMENT

Lack of education on natural resource management was determined to be a high priority issue of concern by the community of the Upper Billabong. It was felt this lack of education extended beyond the rural sector to include the urban and larger city sectors. No formal work to date within the catchment has been undertaken to qualify, quantify or benchmark this concern.

Natural resource decline may be attributed to the lack of access to information regarding the importance of conservation. Landholders will not take preventative or rehabilitative action if they do not see their land threatened by problems of natural resource decline.

A survey of landholders attitudes toward native vegetation in the wheatbelt of Western Australia highlighted that the greatest factor retarding bushland management was a lack of available information on appropriate management practices, for example managing degraded areas of bush, or the role of fire in different vegetation types (Jenkins 1996).

Information that has been used to increase knowledge and raise awareness has not always been the most accurate. Until very recently there has been limited national publicity on the need to protect biodiversity, with the focus largely on tree-planting rather than managing remnants in a landscape context (Alexander 1995).

Campbell (1994) believed that people will change voluntarily if they have the required knowledge, capacity and motivation, and if the change is socially acceptable. Involvement and ownership are far more motivating and educating than being told what to do (Campbell 1994). The process of sharing experiences and collectively solving problems will help landholders become aware of the value and application of local knowledge (Millar & Curtis 1997). "Tell me and I'll forget; Show me and I may remember; Involve me and I'll understand".

Monitoring the public's acceptance and undertaking of improved land management practices could be used as one gauge of education on natural resource management. For example, within the Upper Billabong catchment prior to the 1960s, there would have been a broad acceptance of clearing. In the late 1980s the Holbrook Trees on Farms Group commenced with a few members. That group became a Landcare group that now boasts a membership of the majority of landholders within the catchment. Almost one million trees have been planted within the catchment. From an original focus on trees the group now has a more holistic focus which involves the wider community.

4. ISSUE H: INEFFECTIVE GOVERNMENT POLICY

Government policy has had a major impact on land and water issues and this has been noted by the by the community of the Upper Billabong when prioritising issues. In Australia, landuse policies were generally set by states and were, to an extent, sanctioned by both the urban and rural communities. Therefore, it is not constructive to simply blame governments, because in some cases they have merely reflected the views of their own rural voters.

A list of questionable government policies include the following:

- Early government "Selection Acts" during the 1860s required selectors to "improve their runs". Improvement meant clearing and fencing.
- Tax incentives for land clearing. These were not abolished until 1983. There are now tax incentives for planting, and there is the *Native Vegetation Conservation Act* (1997) controlling clearing.
- In 1963 the Commonwealth Government introduced a subsidy for superphosphate. Fertilisers such as these indirectly induce soil acidity and often pollute waterways.
- Bounties were introduced for the slaughter of animals such as the Wedge-tailed Eagle and Tasmanian Tiger. We now have the *Threatened Species Conservation Act* (1995) controlling developments in areas known to be inhabited by threatened species.
- The provision of irrigation water, licences, allocations and subsidised water prices within areas of naturally low rainfall and naturally high soil salt loads. This has now been followed by a water cap and water reform program (1998).
- Prior to 1989 there were drought relief programs that provided short term financial assistance to landholders with the highest stocking rates, not those with drought management programs.

There is now a tendency toward some government policy being augmented or replaced by a community based voluntary approach. This is being done through the Total Catchment Management and Landcare movements and Land and Water Management Plans.

1. USEFUL BACKGROUND MATERIAL - FLORA AND FAUNA OF THE UPPER BILLABONG

To date, there have only been limited systematic surveys of both flora and fauna within the catchment. There are many species yet to be found.

Fauna

Table 3.1 lists the species that have been found and should occur within the Upper Billabong Catchment. This is a collation of various fauna surveys undertaken by the Geddes families on their farms within the Four Mile sub-catchment (pers. comm. Geddes 1998); Charles Sturt University (Bos & Lockwood 1996); State Forests (Howard 1993; Lemckert 1996); Forest Creek sub-catchment group (pers. comm. Pugh 1998); and the Holbrook Landcare Group (pers. comm. Hulm 1998). It also includes fauna noted by Davidson (1998) in his travels throughout the Catchment.

The fish species list is based on fish surveys undertaken by NSW fisheries at Walbundrie, restocking work, and fish that should occur within the catchment (pers. comm. Schiller 1998; Hulm 1998; and Lindement 1998).

This list in no way represents all fauna within the catchment. There are also thousands of lesser-known animals such as spiders, insects, millipedes, worms, nematodes and centipedes. To put this in some perspective, comparing the number of species of different groups of living things, world wide, animals provide three-quarters of the species, and insects provide almost three-quarters of the number of species of animals. Spiders and their relatives comprise approximately one-quarter of the remainder (Shield 1999).

Threatened Fauna

Table 3.2 gives a threatened species list for fauna found, or potentially found, within the Holbrook (1:100 000) Map Sheet area (NPWS 1997). Habitat loss and reduced structural diversity (eg: loss of shrubs), through clearing and grazing, introduced flora and fox and cat predation, have been the major contributors to fauna decline.

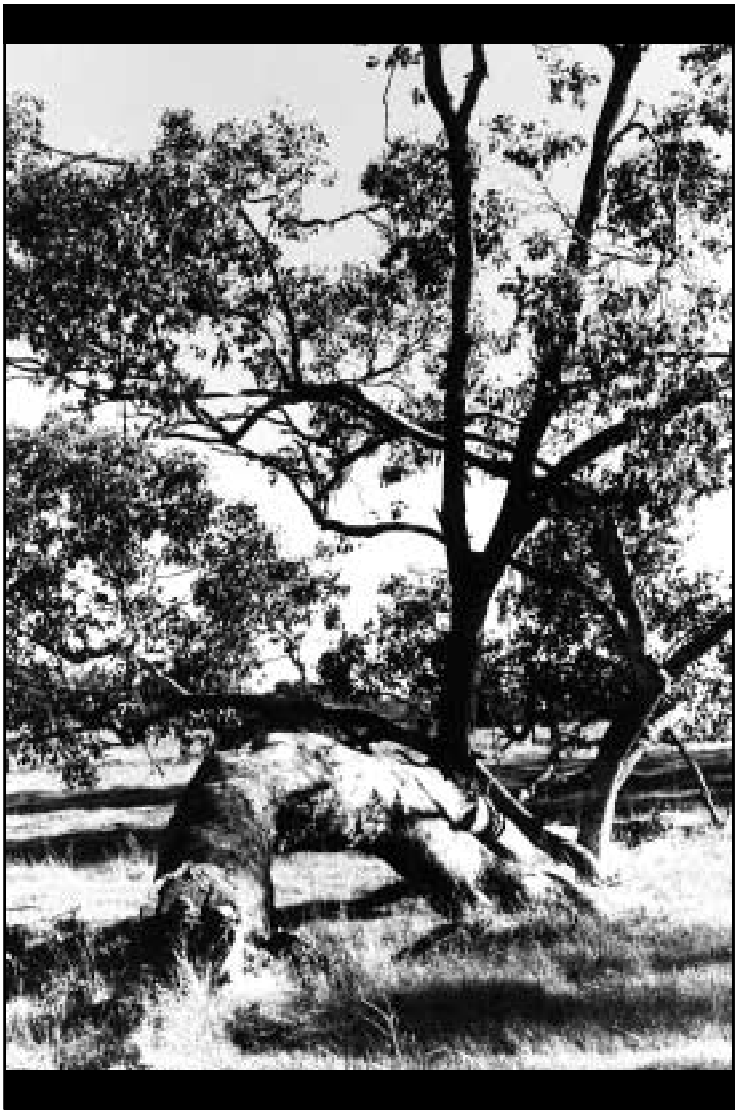


Table 3.1 Species of Fauna found in the Upper Billabong Catchment

* indicates introduced species

\# indicates should occur within the catchment but no formal record/siting has been obtained.

For "*status and threats*" - (pers. comm. Davidson (birds, mammals), Hulm (bats), Lindement and Schiller (fish) 1998)

LC locally common where habitat present.

U uncommon, only occasionally found in some remnants.

LT locally threatened, facing local extinction.

IP increased population, more common than expected in pre European times.

Vul Vulnerable E - Endangered (NPWS 1997)

For the Birds and Bats:

M - Migrant V - Vagrant
R - Resident N - Nomad

Major (present) threats:

1 Loss of shrub layer
2 Loss of litter
3 Predation by cats/foxes
4 Competition
5 Loss of hollow bearing trees
6 Weediness
7 Isolation

Common Name	Scientific Name	Status and Threats	Common Name	Scientific Name	Status and Threats
			Brown Hare *	*Lepus capensis*	
Mammals			Rabbit *	*Oryctolagus cuniculus*	
Platypus	*Ornithorhynchus anatinus*	LT	Fox *	*Vulpes vulpes*	
Echidna	*Tachyglossus aculeatus*	LC,7	Feral cat *	*Felis catus*	
Spotted-tailed Quoll	*Dasyurus maculatus #*	Vul	Feral Pig *	*Sus scrofa*	
Yellow-footed Antichinus	*Antechinus flavipes #*		Feral Goat *	*Capra hircus*	
Brown Antichinus	*Antechinus stuatii*	LC,3,7			
Dusky Antichinus	*Antechinus swainsonii #*		Bats		
Brush-tailed Phascogale	*Phascogale tapootafa #*	Vul	Tasmanian Pipestrell	*Falsistrellus tasmaniense*	(N?) U 5,6,7
Long-nosed Bandicoot	*Perameles nasuta*	LT,3,1	Large Bent-Wing Bat	*Miniopterus schreibersii*	U
Koala	*Phascolarctos cinreus*	LT,Vul	Large Footed Myotis	*Myotis adversus #*	1,6
Common Wombat	*Vombatus ursanus*	LC	White-striped Mastiff Bat	*Nyctinnomous australis*	(MN) LC 5,6,7
Common Ringtail Possum	*Pseudocheirus peregrinus*	LC,1,3,7	Little Mastiff Bat	*Mormopterus planiceps*	5
Greater Glider	*Petauroides volans*	LC 5,7	Gould's Long Eared Bat	*Nyctophilus gouldi*	LC 1,5,6,7

Common Name	Scientific Name	Status and Threats	Common Name	Scientific Name	Status and Threats
Yellow-bellied Glider	*Petaurus australis #*		Lesser Long-eared Bat	*Nyctophilus geoffroyi*	LC 1,5,6,7
Sugar Glider	*Petaurus breviceps*	LC,1,5,7	Gould's Wattled Bat	*Chalinolobus gouldii*	
Squirrel Glider	*Petaurus norfolcensis*	LT,Vul,1,3,5,7	Chocolate Wattled Bat	*Chalinolobus morio*	1,5,7
Common Brushtail Possum	*Trichosurus vulpecula*	LC/IP	Western Broad-nosed Bat	*Scotorepens balstoni*	
Eastern Pigmy Possum	*Ceracartetus nanus*		King River Bat	*Vespadelus regulus*	1,5,7
Feathertail Glider	*Acrobates pygmaeus*	LC	Little Forest Bat	*Vespadelus vulternus*	1,5,6,7
Red-Necked Wallaby	*Macropus rufogriseus*		Large Forest Bat	*Vespadelus darlingtoni*	5,6,7
Black Wallaby	*Wallabia bicolor*	LC			
Eastern Grey Kangaroo	*Macropus giganteus*	LC/IP	Birds		
Water-rat	*Hydromys chrysogaster*	LC	Hoary-headed Grebe	*Poliocephalus poliocephalus*	N,LC
Black Rat *	*Rattus rattus*		Australasian Grebe	*Tachybaptus novaehollandiae*	R,LC
House Mouse *	*Mus musculus*		Australian Pelican	*Pelecanus conspicillatus*	N,U
Birds Continued			Brolga	*Grus rubicundus #*	
Darter	*Anhinga melanogaster*		Bush Thick-Knee	*Burhinus grallarius*	R,LT,E
Pied Cormorant	*Phalacrocorax varius*		Eurasian Coot	*Fulica atra*	
Little Pied Cormorant	*Phalacrocorax melanoleucos*	R,LC	Masked Lapwing (Plover)	*Vanellus miles*	R,LC
Great (Black) Cormorant	*Phalacrocorax carbo*	R,LC	Banded Lapwing (Plover)	*Vanellus tricolor*	R,LT
Little Black Cormorant	*Phalacrocorax sulcirostris*	R,LC	Black-fronted Plover	*Charadrius melanops*	R,LC
Pacific (White-necked) Heron	*Ardea pacifica*	M,LC	Peaceful Dove	*Geopelia placida*	R,LC
White-faced Heron	*Ardea novaehollandiae*	R,LC	Common Bronzewing	*Phaps chalcoptera*	R,LC,1
Cattle Egret	*Ardea ibis*	V,U	Brush Bronzewing	*Phaps elegans*	
Great Egret	*Ardea alba #*		Crested Pigeon	*Geophaps lophotes*	R,LC/IP
Rufous Night Heron	*Nycticorax caledonicus #*		Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus #*	
Australian White Ibis	*Threskiornis molucca*	R,LC	Gang-gang Cockatoo	*Callocephalon fimbriatum*	R,U,5

Table 3.1 Species of Fauna found in the Upper Billabong Catchment cont...

CommonScientific Name	Status and Name	Common Threats	Scientific Name	Status and Name	Threats
Straw-necked Ibis	*Threskiornis spinicollis*	M,LC	Galah	*Cacatua roseicapilla*	R,LC/IP
Yellow-billed Spoonbill	*Platalea flavipes*	R,LC	Sulphur Crested Cockatoo	*Cacatua galerita*	R,LC/IP
Black Swan	*Cynus atratus*	R,LC	Musk Lorikeet	*Glossopsitta concinna #*	
Australian Shelduck	*Tadorna tadornoides*	R,LC	Little Lorikeet	*Glossopsitta pusilla #*	
Pacific Black Duck	*Anas superciliosa*	R,LC	Australian King Parrot	*Alisterus scapularis*	R,U,5
Grey Teal	*Anas gibberifrons*	N,LC	Swift Parrot	*Lathamus discolor*	Vul
Hardhead	*Aythya australis*	N,U	Crimson Rosella	*Platycercus elegans*	R,LC
Maned (Wood) Duck	*Chenonetta jubata*	R,LC/IP	Eastern Rosella	*Platycercus eximius*	R,LC/IP
Blue-billed Duck	*Oxyura australis*	N,U	Red-rumped Parrot	*Psephotus haematonotus*	R,LC/IP
Musk Duck	*Biziura lobata*	N,U	Turquoise Parrot	*Neophema pulchella*	R,LT,Vul,5,6
Black-shouldered Kite	*Elanus notatus*	M,U	Pallid Cuckoo	*Cuculus pallidus*	M,U
Letter-winged Kite	*Elanus scriptus*	N,U	Fan-tailed Cuckoo	*Cuculus flabelliformis*	M,LC
Whistling Kite	*Milvus sphenurus*	M,U	Black-eared Cuckoo	*Chrysococcyx osculans #*	
Square-tailed Kite	*Lophoictinia isura*	M,LT,Vul	Horsfield's Cuckoo	*Chrysococcyx basalis*	M,LC
Brown Goshawk	*Accipiter fasciatus*	R,U	Shining Bronze-cuckoo	*Chrysococcyx lucidus*	M,LC
Collared Sparrowhawk	*Accipiter cirrhocephalus*	R,LT	Powerful Owl	*Ninox strenua*	R,LT,Vul,5
Grey Goshawk	*Accipiter novaehollandiae #*		Southern Boobook	*Ninox novaeseelandiae*	R,LC
White-bellied Sea-Eagle	*Haliaeetus leucogaster #*	V,U	Barking Owl	*Ninox connivens*	R,LT,5,7
Wedge-tailed Eagle	*Aquila audax*	R,LC	Barn Owl	*Tyto alba*	R,LC
Peregrine Falcon	*Falco peregrinus #*	R,LC	Tawny Frogmouth	*Podargus strigoides*	R,LC
Australian Hobby	*Falco longipennis*	R,U	Australian Owlet-nigtjar	*Aegotheles cristatus*	R,LC
Brown Falcon	*Falco-berigora*	R,LC	White-throated Nightjar	*Caprimulgus mystacalis*	R,U
Australian Kestrel	*Falco cenchroids*	R,LC	Spotted Nightjar	*Eurostpodus argus*	R,U
Stubble Quail	*Coturnix pectoralis*	R,LC	White-throated Needletail	*Hirundapus caudacutus*	N,U

CommonScientific Name	Status and Name	Common Threats	Scientific Name	Status and Name	Threats
Brown Quail	*Coturnix ypsilophora #*		Azure Kingfisher	*Alcedo azurea #*	
Painted Button-quail	*Turnix varia #*		Laughing Kookaburra	*Dacelo novaeguineae*	R,LC
Land Rail ????			Sacred Kingfisher	*Todiramphus sanctus*	R,LC,4
Lewin's Rail	*Dryolimnas pectoralis*	R,LC	Rainbow Bee-eater	*Merops ornatus*	M,LC
Dusky Moorhen	*Gallinula tenebrosa*	M,U	Dollarbird	*Eurystomus orientalis*	M,LC
Purple Swamphen	*Porphyrio porphyrio*	R,LC	Welcome Swallow	*Hirundo neoxena*	R,LC
Birds Continued			Inland Thornbill	*Acanthiza apicalis*	
Tree Martin	*Hirundo nigricans #*		Chestnut-rumped Thornbill	*Acanthiza uropygialis #*	
Fairy Martin	*Hirundo ariel*	R,U	Buff Rumped Thornbill	*Acanthiza reguloides*	R,LC,1,4,7
Richard's Pipit	*Anthus novaseelandiae*	R,LC/IP	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	R,LC,1
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	M,LC	Yellow (Little) Thornbill	*Acanthiza nana*	R,U,1,4,7
White-winged Triller	*Lalage sueurii*	M,U	Striated Thornbill	*Acanthiza linetata*	R,LC,1,4,7
Blackbird*	*Tardus merula*	R,LC/IP	Southern Whiteface	*Aphelocephala leucopsis*	R,U,1,4,7
Rose Robin	*Petroica rosea #*		Varied Sitella	*Daphoenositta chrysoptera*	N,U,4,7
Pink Robin	*Petroica rodinogaster #*		White-throated Treecreeper	*Cormobates leucophaeus*	R,LC,4,7
Flame Robin	*Pertoica phoenicea*	M,LC	White-browed Treecreeper	*Climacteris affinis #*	
Scarlet Robin	*Petroica multicolor*	M,U,4	Brown Treecreeper	*Climacteris picumnus*	R,LC,4,7
Red-capped Robin	*Petroica goodenovii*	R,U,1,4	Red Wattlebird	*Anthochaera carunculata*	M,LC
Hooded Robin	*Melanodryas cucullata*	R,LT,1,4,7	Noisy Friarbird	*Philemon corniculatus*	M,LC
Eastern Yellow Robin	*Eopsaltria australis*	R,U,1,4,7	Little Friarbird	*Philemon citreogularis*	M,LC
Jacky Winter	*Microcea leucophaea*	R,LC,1,4,7	Regent Honeyeater	*Xanthomyza phrygia*	M,LT,E,1,4,7
Crested Shrike-tit	*Falcunculus frontatus*	R,LC,4,7	Blue-faced Honeyeater	*Entomyzon cyanotis*	N,LC
Olive Whistler	*Pachycephala olivacea #*		Noisy Miner	*Manorina melanocephala*	R,LC/IP
Golden Whistler	*Pachycephala pectoralis*	M,U,4	Yellow-faced Honeyeater	*Lichenostomus chrysops*	M,LC

Table 3.1 Species of Fauna found in the Upper Billabong Catchment cont...

Rufous Whistler	*Pachycephala rufiventris*	M,LC,1,4	Singing Honeyeater	*Lichenostomus versicolor*	
Common Name	**Scientific Name**	**Status and Threats**	**Common Name**	**Scientific Name**	**Status and Threats**
Grey Shrike-thrush	*Colluricincla harmonica*	R,LC,1,4	Yellow-tufted Honeyeater	*Lichenostomus melanops*	R,U,1,4
Leaden Flycatcher	*Myiagra rubecula*	M,U,1,4	Yellow-plumed honeyeater	*Lichenostomus ornatus*	
Satin Flycatcher	*Myiagra rubecula #*		Fuscous Honeyeater	*Lichenostomus fuscus*	N,LC,4,7
Restless Flycatcher	*Myiagra inquieta*	R,LC,1,4	White-plumed Honeyeater	*Lichenostomus penicillatus*	R,LC,4
Rufous Fantail	*Rhipidura rufifrons #*		Brown-headed Honeyeater	*Melithreptus brevirostris*	N,LC,4
Grey Fantail	*Rhipidura fuliginosa*	M,LC,1,4	Brown Honeyeater	*Lichmera indistincta*	
Willie Wagtail	*Rhipidura leucophrys*	R,LC/IP	White-napped Honeyeater	*Melithreptus lunatus*	M,LC,4,7
Eastern Whipbird	*Psophodes olivaceus*		Eastern Spinebill	*Acanthorhynchus tenuirostris*	R,LC,4
Grey-crowned Babbler	*Pomatostomus temporalis*	R,LT,1-7	White-fronted Chat	*Epthianura albifrons*	R,LC
White-browed Babbler	*Pomatostomus superciliosus #*		Skylark*	*Alauda arvensis*	
Little Grassbird	*Megalurus gramineus #*		Mistletoebird	*Dicaeum hirundinaceum*	R,LC
Clamorous Reed-warbler	*Acrocephalus stentoreus*	M,U	Spotted Pardalote	*Pardalotus punctatus*	M,U,4,7
Golden-headed Cisticola	*Cisticola exilis*	R,LC	Striated Pardalote	*Pardalotus striatus*	R,LC,4,7
Rufous Songlark	*Cinclorhamphus mathewsi*	M,LC,1,4	Silvereye	*Zosterops lateralis*	M,LC
Brown Songlark	*Cinclorhamphus cruralis*	M,U	European Goldfinch*	*Carduelis carduelis*	
Superb Fairy Wren	*Malurus cyaneus*	R,LC,1,3,4	Tree Sparrow*	*Passer montanus*	R,LC/IP
White-browed Scrubwren	*Sericornis frontalis*	R,LC	Diamond Firetail	*Stagonopleura guttata*	R,U,1
Striated Calamanthus	*Sericornis fuliginosus*		Red-browed Firetail	*Neochmia temporalis*	R,LC
Speckled Warbler	*Sericornis sagittatus*	R,U,1,7	Zebra finch	*Taeniopygia guttata*	R,U
Weebill	*Smicrornis brevirostris*	N,LC,4,7	Common Starling*	*Sturnus vulgaris*	R,LC/IP
Western Gerygone	*Gerygone fusca*	M,U,1,4	Olive-backed Oriole	*Oriolus sagittatus*	M,LC
White-throated Gerygone	*Gerygone olivacea*	M,U,1,4	Satin Bowerbird	*Ptilonorrhynchus violaceus*	R,LC
Brown Thornbill	*Acanthiza pusilla*	R,LC,1,4	White-winged Chough	*Corcorax melanorphamphos*	R,LC

Common Name	Scientific Name	Status and Threats	Common Name	Scientific Name	Status and Threats
Birds Continued			Fish		
Apostle Bird	*Struthidea cinerea #*		Mountain Galaxias	*Galaxias olidus*	
Australian Magpie-lark	*Grallina cyanoleuca*	R,LC	Murray Jollytail	*Galaxias rostratus #*	
White-breasted Woodswallow	*Artamus leucorhynchus #*		Australian Smelt	*Retropina #*	
White-browed Woodswallow	*Artamus superciliosus*	N,LC	Goldfish*	*Carassius auratus*	
Black-faced Woodswallow	*Artanus cinereus*		Carp*	*Cyprinus carpio*	
Dusky Woodswallow	*Artamus cyanopterus*	M,LC	Freshwater Catfish	*Tandannus tandannus*	
Grey Butcherbird	*Cracticus torquatus*	R	Oriental Weatherloach*	*Misgurnis anguillicaudatus*	
Pied Butcherbird	*Cracticus nigrogularis*	R	Golden Perch	*Macquaria ambigua*	
Australian Magpie	*Gymnorhina tibicen*	R,LC/IP	Murray Cod	*Maccullochella peelii peelii*	
Pied Currawong	*Strepera graculina*	M,LC	Silver Perch	*Bidyanus bidyanus*	
Grey Currawong	*Strepera versicolor*	R,U	Southern Pigmy Perch	*Nanoperca australis #*	
Little Raven	*Corvus mellori #*		Redfin Perch*	*Perca fluviatilis*	
Australian Raven	*Corvus coronoides*	R,LC	River Blackfish	*Gadopsis mamoratus*	
			Flathead Gudgeon	*Philypnodon grandiceps #*	
Reptiles			Dwarf Flathead Gudgeon	*Philypnodon sp. #*	
Jacky Lizard	*Amphibolurus muricatus*		Southern Purple Spotted Gudgeon	*Mogurnda adspersa #*	
Dragon Lizard	*Species not known*		Western Carp Gudgeon	*Hypseleotris klunzingeri #*	
Nobby	*Amphibolurus nobbi*				
Wood Gecko	*Diplodactylus vittatus*				
	Carlia vivax				
Copper-tailed Skink	*Ctenotus taeniolatus*				
Tree Skink	*Egernia striolata*				

Table 3.1 Species of Fauna found in the Upper Billabong Catchment cont...

Common Name	Scientific Name	Status and Threats
	Hemiergis decresienis	
Three-toed Skink	*Saiphos equalis*	
Blue-tongued Lizard	*Tiliqua scincoides*	
Goanna	*Varanus gouldii*	R,U
Lace Monitor	*Varanus varius*	R,LC
Carpet Python	*Morelia spilota*	R,LT
Eastern Tiger Snake	*Notechis scutatus*	R
Red-bellied Black Snake	*Pseudechis porphyriacus*	R,LC
Common Brown Snake	*Pseudonaja textilis*	R,LC
Long-necked Tortoise	*Chelodina longicollis*	R,LC
Amphibians		
Brown Froglet	*Crinea signifera*	
Victorian Smooth Froglet	*Geocrinea victoriana*	
Eastern Pobblebonk	*Limnodynastes dumerilii*	
Barking Marsh Frog	*Limnodynastes fletcherii*	
Giant Pobblebonk	*Limnodynastes interioris*	
Spotted Marsh Frog	*Limnodynastes tasmaniensis*	
Peron's Tree Frog	*Litoria peronii*	
Green and Golden Swamp Frog	*Litoria aurea*	
Recent additions Painted Honeyeater	*Grantiella picta*	M,V

Table 3.2 Threatened fauna species list for the Upper Billabong Catchment (NPWS 1997)

Species in bold are those that have been found within the catchment.

Name	Status	Comments (Habitat, Food Type and Range)
Aprasia parapulchella (Pink-tailed worm lizard)	Vulnerable	Prefers open areas with mainly native grass cover. Gravelly Soils. Carnivore - egg larvae and pupae of ants. Often found in tunnels of small ant species. Isolated populations have been found at Tarcutta.
Botaurus poiciloptilus (Australasian Bittern)	Vulnerable	Solitary species. Inhabits wetlands - also feeds in tussocky wet paddocks, drains and rice fields. Carnivore - medium sized aquatic animals
Burhinus magnirostris **(Bush Thick Knee)**	**Endangered**	**Prefers open grassy woodlands - partly cleared woodlands with fallen branches and leaf litter present. Carnivore - insects, molluscs and other small vertebrates. Usually found along water courses. Historically, seen and heard in the Upper Billabong - nothing in the last 10 years.**
Dasyurus maculatus (Tiger Quoll)	Vulnerable	Found in a variety of forest types. Carnivore - birds rats anthropods and small mammals. Found on both sides of the great dividing range.
Delma Impar (Striped Legless Lizard)	Vulnerable	Found in woodlands to grasslands. Found beneath rocks, bark, tussocks etc. Canivore - arthropods. Isolated populations have been found at Tarcutta.
Glossopsitta porphyroceph (Purple crowned lorikeet)	Vulnerable	A scarce inhabitant of Eucalypt woodlands. Herbivore - pollen, nectar and blossoms, insects occasionally eaten. Has been found in Albury area.
Grantiella picta **(Painted Honeyeater)**	**Vulnerable**	**Inhabits open Eucalypt forests. Herbivore - drupes of mistletoe, flowers and nectar of Eucalypts, insects occasionally. Mainly in Eastern NSW. Found on Eastern side of Morgan's ridge (Collard, 1999).**
Grus rubicundus (Brolga)	Vulnerable	Found in wetlands, swamps and floodplains. Also found in paddocks. Omnivore - variety of vegetation, vertebrates and invertebrates. Observed in the Riverina (Henty, Walla).
Lathamus discolor **(Swift Parrot)**	**Vulnerable**	**Inhabits a variety of woodland and dry sclerophyll. Omnivore - mainly nectar and pollen from eucalypts and lerps. Found on the Vic. and NSW border. Doughtys Travelling Stock Reserve (pers. comm. Meyers, 1998)**
Litoria aurea (Green and Golden Bell Frog)	Endangered	Aquatic species - found near permanent water. A voracious cannibalistic frog. West of the Great Dividing Range in Southern NSW - Tumut SF.
Litoria raniformis **(Warty Bell Frog)**	**Endangered**	**Aquatic species - found near permanent water. Unknown diet. Found in cold parts of NSW - Woomargama State Forest (Lemckert 1996)**
Lophoictinia isura **(Square tailed Kite)**	**Vulnerable**	**Inhabits Eucalypt forest and Woodland. Carnivore - feeds mainly on small birds directly from the forest canopy, nestlings, eggs, small mammals and skinks also consumed. Found over most of Aust. - Benambra State Forest.**

Table 3.2 Threatened fauna species list for the Upper Billabong Catchment (NPWS 1997). cont...

Name	Status	Comments (Habitat, Food Type and Range)
Myotis adversus (Large footed Mouse eared bat)	Vulnerable	Colonies never far from water - riparian vegetation. Roost in a variety of sites from caves to dense vegetation. Carnivore - insects and small fish. Eastern NSW
Neophema pulchella (Turquoise Parrot)	Vulnerable	Lives on edge of Eucalypt Woodland. Herbivore - mainly seed from native and introduced grasses. Found along Upper reaches of the Murray - Four Mile Lane sub-catchment in early 1980s, Benambra SF and Carabost SF
Ninox strenua (Powerful Owl)	Vulnerable	Roosts in dense foliage. Dense gullies between eucalypt forests. Also pine plantations. Carnivore - birds and particularly arboreal mammals such as possums and birds. Great Dividing Range - Woomargama State Forest.
Nyctophilus timoriensis (Greater Long Eared Bat)	Vulnerable	Dry open woodlands and River Red Gums. Roosts in tree hollows and exfoliating bark. Forages for large moths and beetles. Favours water bodies for hunting. Found in inland NSW.
Petaurus norfolcensis (Squirrel Glider)	Vulnerable	Dry sclerophyll forest to woodland, preferring woodlands on fertile soils with a shrub layer. Omnivore - acacia and eucalypt gum, insects particularly caterpillars - also occasionally lerps and pollen. Found in eastern NSW, Holbrook Common (pers. comm. Small, 1998).
Petroica rodinogaster (Pink Robin)	Vulnerable	Heavily timbered ranges and gullies. Insectivore - terrestrial and flying insects. South Eastern Australia. Breeds in the alps.
Phascogale tapoatafa (Brush tailed Phascogale)	Vulnerable	Dry sclerophyll forest with sparse ground cover of herbaceous plants. Omnivore - insects, spiders, centipedes, also small vertebrates and nectar. Found in south eastern Australia.
Phascolarctos cinereus (Koala)	Vulnerable	Eucalypt forests and woodlands. Favours tree species associated with high nutrient soils. Herbivore - Eucalypts, red gum, manna gum, blue gum, etc. Found in Eastern Australia. Woomargama SF (Lemckert, 1996)
Polytelis swainsonii (Superb Parrot)	Vulnerable	In riverina riparian woodlands. Omnivore - feeds on seeds, nectar, blossom, fruits, insects and larvae. Found in Western Slopes of GDR and Central Murray.
Rostratula benghalensis (Painted Snipe)	Vulnerable	Inhabits fringes of swamps and marshy areas. Feeds on invertebrates (eg molluscs, grasshoppers, earthworms). Found in Murray-Darling Region.
Saccolaimus flaviventris (Yellow bellied Sheathtailed Bat)	Vulnerable	Wide range of habitat from woodland to rainforest. Forage on airborne insects largely beetles and moths. Found in eastern and northern Australia.
Xanthomyza phrygia (Regent Honeyeater)	Endangered	Inhabits Eucalypt woodland and open forest. Follows the flowering of Eucalypt species for supply of food, particularly box/ ironbark woodland. Omnivore - insects and nectar. Inland NSW - Holbrook.

Flora

A list of native plant species that have been found within the Upper Billabong Catchment is provided in Table 3.3. The list is based on the native plants found by Stelling in the subcatchments of the Upper Billabong during her development of "Revegetation Guides for the South West Slopes" in 1997/98 and studies by Burrows (1996) of the flora in Pulletop and Benambra National Parks (formerly State Forests)

Table3.3 General Local Native Vegetation Profile: Upper Billabong Catchment

Derived from general native vegetation profiles for: Mountain, Native Dog & Sandy Creek, Four Mile Upper Jerra Jerra, Upper Back, Scent Bottle, Serpentine, Wantagong, Yarra Yarra, Ten Mile, Mountain Tunnel, Sawyers, Forest, Four Post and Little Billabong and Holbrook District sub catchment. (Stelling 1998)

Profile drawing from Stelling 1998

LANDFORM	Creeks, flats and low country.	Rising and Hill Country.
VEGETATION TYPE	River Red Gum Woodland; Blakely's Red Gum & Yellow Box Woodlands; Grey Box Woodland.	White Box Woodland, Dry Sclerophyll Forest, Moist Open Forest (>500m).
GEOLOGY & SOILS	Alluvium – sand, silt, gravel and clay. Sandy alluvials; Red and yellow earths; Sandy yellow earths.	Quartzite, slate, phyllite, greywacke, hornfels and schist. Granite, gneissic granite, gneiss. Red and yellow earths, sandy granite soils; red & yellow loams.
LOCATION EXAMPLE	Elevation of approximately 200 – 500mt.	Ridge country surrounding the catchment. Elevation of approximately 500 – 900mt.
TREES > 8 m	*Acacia dealbata* – Silver Wattle *A. implexa* – Lightwood *A. melanoxylon* – Blackwood * *Brachychiton populneus* - Kurrajong *Callitris glaucophylla* – White Cypress Pine	*Acacia dealbata* – Silver Wattle *A. doratoxylon* – Currawang (mainly rocky outcrops) *A. implexa* – Lightwood *A. melanoxylon* – Blackwood (upper reaches) *Allocasuarina verticillata* – Drooping Sheoak

* Mainly N and NW aspect
\+ Mainly S and SE aspect
\# not on granite
~ creeklines and soaks

Table3.3 General Local Native Vegetation Profile: Upper Billabong Catchment cont...

	Eucalyptus blakelyi – Blakely's Red Gum *E. bridgesiana* – Apple Box *E. camaldulensis* – River Red Gum # *E. mannifera* – Brittle Gum *E. melliodora* – Yellow Box *E. microcarpa* – Grey Box *E. nortonii* – Silver Bundy *E. polyanthemos* – Red Box # *E. rubida* – Candlebark *Exocarpos cupressiformis* – Native Cherry # these species are usually found in higher rainfall areas * not on clay soils	*Brachychiton populneus* – Kurrajong *Callitris glaucophylla* – White Cypress Pine *C. endlicheri* – Black Cypress Pine *Eucalyptus albens* – White Box *E. bicostata* – Eurabbie (upper reaches) *E. blakelyi* – Blakely's Red Gum ~ *E. camphora* – Mountain Swamp Gum (upper reaches) * *E. dealbata* – Tumbledown Gum +~ *E. dives* – Broad-leaved Peppermint *E. dwyeri* – Dwyer's Red Gum *E. goniocalyx* – Long-leaf Box *E. macrorhyncha* – Red Stringybark +~ *E. mannifera* – Brittle Gum (upper reaches) *E. microcarpa* – Grey Box (lower slopes) *E. melliodora* – Yellow Box *E. nortonii* – Silver Bundy *E. polyanthemos* – Red Box *E. robertsonii* – Robertson's Peppermint (upper reaches) +# *E. rossii* – Scribbly Gum *E. rubida* – Candlebark *E. viminalis* – Manna Gum (upper reaches) *Exocarpos cupressiformis* – Native Cherry	
SHRUBS 1.5 – 8 m	*Acacia acinacea* – Gold Dust Wattle *A. deanei* – Dean's Wattle *A. genistifolia* – Spreading Wattle *A. paradoxa* – Kangaroo Thorn *A. pycnantha* – Golden Wattle *A. rubida* – Red-stemmed Wattle *Bursaria lasiophylla* – Hairy Bursaria *B. spinosa* – Sweet Bursaria ~ *Callistemon sieberi* – River Bottlebrush *Dodonea viscosa subsp. angustissima* – Narrow-leaf Hop-bush *D. viscosa subsp. cuneata* – Wedge-leaf Hop-bush *Grevillea floribunda* – Seven Dwarf's Grevillea *Hymenanthera dentata* – Tree Violet *Indigofera adesmiifolia* – Tick Indigo	*Acacia acinacea* – Golddust Wattle *A. buxifolia* – Box-leaf Wattle *A. deanei* – Dean's Wattle *A. deanei subsp. paucijuga* – Dean's Wattle *A. decora* – Western Golden Wattle *A. buxifolia* – Box-leaf Wattle *A. genistifolia* – Spreading Wattle *A. gunni* – Ploughshare Wattle *A. lanigera* – Woolly Wattle *A. paradoxa* – Kangaroo Thorn *A. pycnantha* – Golden Wattle *A. rubida* – Red-stemmed Wattle *A. verniciflua* – Varnish Wattle *Bursaria lasiophylla* – Hairy Bursaria	*Daviesia latifolia* – Hop Bitter-pea *Daviesia leptophylla* – Slender Bitter-pea *Dillwynia phylicoides spp. complex* – Parrot-pea *D. retorta spp. complex* – Small-leaf Parrot-pea *Dodonaea viscosa subsp. angustissima* - Narrow-leaf Hop-Bush *D. viscosa subsp. cuneata* – Wedge-leaf Hop-bush *Grevillea polybractea* – Crimson Grevillea *Hymenethera dentata* – Tree Violet *Indigofera australis* – Austral Indigo *Kunzea ericoides* – Burgan *K. parvifolia* – Violet Kunzea ~ *Leptospermum continentale* – Prickly Tea-tree *L. multicaule* – Silver Tea-tree
	Kunzea ericoides – Burgan + *Leptospermum continentale* – Prickly Tea-tree *Pultenaea cunninghamii* – Grey Bush Pea *P. foliolosa* – Bush Pea ~ creeklines only + soaks/poorly drained sites	*B. spinosa* – Sweet Bursaria *Calytrix tetragona* – Common Fringe Myrtle *Cassinia aculeata* – Common Cassinia *C. arcuata* – Chinese Shrub ~ soaks/poorly drained sites	*Persoonia rigida* – Hairy Geebung *Platylobium formosum* – Handsome Flat-pea *Pultenaea cunninghamii* – Grey Bush-pea *P. daphnoides* – Bush-pea *P. foliolosa* – Bush-pea *P. procumbens* – Heathy Bush-pea
GROUND COVERS	*Amphibromus neesii* – Swamp Wallaby Grass *Atriplex semibaccata* – Creeping Saltbush *Austrostipa spp.* – Spear Grass ~ *Blechnum nudum* – Fishbone Water Fern *Bothriochloa macra* – Red Leg Grass *Carex spp.* – Sedges *Chloris truncata* – Windmill Grass ~ *Cyperus lucidus* – Sedge *Danthonia spp.* – Wallaby Grass *Dianella longifolia* – Smooth Flax-lily *D. revoluta* – Spreading Flax-lily *Dillwynia sericea* – Parrot Pea *Elymus scaber* – Common Wheat Grass *Juncus spp.* – Rush *Lissanthe strigosa* – Peach Heath *Lomandra spp.* – Mat-rush *Microlaena stipoides* – Weeping Grass *Poa spp.* – Tussock Grass ~ *Phragmites australia* – Common Reed *Templetonia stenophylla* – Templetonia *Themeda triandra* – Kangaroo Grass ~ *Typha spp.* – Cumbungi *Sporobolus creber* – Rat's Tail Grass *Xanthorrhoea spp.* Grass Tree ~ creeklines/soaks/poorly drained sites	*Adiantum aethiopicum* – Common Maidenhair *Astroloma humifusum* – Native Cranberry *Aristida ramosa* – Purple Wire Grass *Austrostipa spp.* – Spear Grass *Blechnum nudum* – Water Fern *Bothriochloa macra* – Red Leg Grass *Brachyloma daphnoides* – Daphne Heath *Bracteantha spp.* – Everlasting Daisy *Brunonia australis* – Blue Pincushion *Bulbine bulbosa* – Bulbine Lily *Cheiranthera linearis* – Finger Flower *Chloris truncata* – Windmill Grass *Chrysocephalum apiculatum* – Yellow Buttons *Clematis aristata* – Old Man's Beard *Danthonia spp.* – Wallaby Grass *Dianella longifolia* – Smooth Flax Lily *D. revoluta* – Spreading Flax Lily *Dichopogon strictus* – Chocolate Lily *Dillwynia sericea* – Showy Parrot-pea *Elymus scaber* – Common Wheat Grass	*Hardenbergia violacea* – Purple Coral-pea *Hibbertia obtusifolia* – Grey Guinea Flower *H. sericea* – Silky Guinea Flower *Geranium spp.* – Cranesbill *Isotoma axillaris* – Rock Isotome *Joycea pallida* – Red-anther Wallaby Grass *Leucopogon virgatus* – Common Beard-heath *Lissanthe strigosa* – Peach Heath *Lomandra spp.* – Mat-rush *Melichrus urceolatus* – Urn Heath *Microlaena stipoides* – Weeping Grass *Pelagonium spp.* – Storksbill *Pimelea spp.* – Rice-flower *Poa sieberiana* – Tussock Grass *Stypandra glauca* – Nodding Blue-lily *Themeda triandra* – Kangaroo Grass *Xanthorrhoea spp.* – Grass Tree

Table3.3 General Local Native Vegetation Profile: Upper Billabong Catchment cont...

OTHER GROUND COVERS (found by Burrows [1996] in Benambra &Pulletop State Forests)	*Ajuga australis* – Australian Bugle	*Limosella australis* – Australian Mudwort
	Arthropodium minus – Small Vanilla Lily	*Luzula densiflora* – Field Woodrush
	Asperula conferta – Common Woodruff	*Lythrum hyssopifolia* – Hyssop Loosestrife
	Asplenium flabellifolium – Necklace Fern	*Microtis unifolia* – Common Onion Orchid
	Bossia prostrata – Creeping Bossiaea	*Microseris lanceolata* – Native Yam
	Calochilus robertsonii – Purplish Beard-orchid	*Montia fontana* – Water-blinks
	Calotis cuneifolia – Purple Burr Daisy	*Oxalis corniculata* – Yellow Wood-sorrel
	Caladenia caerulea – Blue Fingers	*Parietaria debilis* – Smooth Nettle
	Caladenia carnea – Pink Fingers	*Pellaea falcata* – Sickle Fern
	Cheilanthes austrotenuifolia – Rock Fern	*Plantago varia* – Variable Plantain
	Cheilanthes sieberi – Mulga Fern	*Pleurosorus rutifolius* – Blanket Fern
	Cheiranthera cyanea – Finger-flower	*Podolepis jaceoides* – Showy Copper Wire Daisy
	Chionochloa pallida – Silver top Wallaby Grass	*Poranthera microphylla* – Small Poranthera
	Convulvulus erubescens – Australian Bindweed	*Pteridium esculentum* – Common Bracken
	Correa reflexa – Common Correa	*Pterostylis curta*
	Cotula australis – Common Cotula	*Pterostylis hispidula*
	Crassula decumbens – Spreading Stonecrop	*Pterostylis mutica* – Midget Greenhood
	Crassula sieberiana – Australian Stonecrop	*Pterostylis nutans* – Greenhood
	Cymbonotus lawsonianus – Bear's Ear	*Pterostylis pedunculata*
	Cynoglossum australe – Australian Hound's Tongue	*Ranunculus lappaceus* – Common Buttercup
	Cynoglossum suaveolens – Sweet Hound's Tongue	*Ranunculus sessiliflorus* – Small Australian Buttercup
	Daucus glochidiatus – Australian Carrot	*Rumex brownii* – Slender Dock
	Deyeuxia quadriseta – Reed Bent Grass	*Rutidosis multiflora* – Small Wrinklewort
	Dillwynia juniperina – Prickly Parrot Pea	*Sebaea ovata* – Yellow Centaury
	Dillwynia phylicoides – Small Leaf Parrot Pea	*Schoenus apogon* – Common Bog Rush
	Diuris sulphurea – Tiger Orchid	*Scutellaria humilus* – Dwarf Skullcap
	Drosera peltata – Pale Sundew	*Senecio garlandii* – Woolly Ragwort
	Galium gaudichaudii – Rough Bedstraw	*Senecio hispidulus* – Hill Fireweed
	Glossodia major – Wax Lip Orchid	*Senecio lautus* – Variable Groundsel
	Glycine spp.	*Senecio quadridentatus* – Cotton Fireweed
	Gnaphalium gymnocephalum – Creeping Cudweed	*Sigesbeckia australiensis* – Pale Indian Weed
	Gnaphalium indutum – Tiny Cudweed	*Solenogyne dominii*
	Gonocarpus tetragynus – Common Raspwort	*Spyridium parvifolium* – Australian Dusty Miller
	Goodenia hederacea – Forest Goodenia	*Stackhousia monogyna* – Creamy Candles
	Goodenia pinnatifida – Scrambled Eggs	*Stylidium despectum* – Dwarf Triggerplant
	Gompholobium huegelii – Common Wedge Pea	*Stylidium graminifolium* – Grass Triggerplant

	Grevillea alpina – Cat's Claws	*Stuartina muelleri* – Spoon Cudweed
	Grevillea lanigera – Woolly Grevillea	*Thysanotus patersonii* – Twinning Fringe Lily
	Helichrysum semipapposum – Clustered Everlasting	*Thysanotus tuberosus* – Common Fringe Lily
	Hydrocotyle laxiflora – Stinking Pennywort	*Tricoryne elatior* – Yellow Rush-lily
	Hypolepus rugusula – Ground Fern	*Triptilodiscus pygmaeus* – Common Sunray
	Hypoxis glabella – Tiny Star	*Wahlenbergia gracilenta* – Annual Bluebell
	Indigofera adesmifolia – Leafless Indigo	*Wahlenbergia stricta* – Tall Bluebell
	Isolepis inundata	*Wurmbea dioica* – Early Nancy
	Isotama fluviatilis – Swamp Isotome	*Xanthorrhoea glauca* – Grass Tree
	Juncus holoschoenus – Jointed-leaf Rush	
	Juncus subsecundus – Finger Rush	
	Leptorhynchus squamatus – Scaly Buttons	
	Levenhookia dubia – Hairy Stylewort	

Main Vegetation Communities

The estimated areas represented by the main vegetation communities found within the catchment prior to European settlement and in 1998 are shown in Table 3.4.

Table 3.4 Estimated areas of vegetation communities prior to European Settlement and in 1998.

Based on aerial photographic interpretation, personal observations (pers. comm., Bull, Davidson and Sheahan 1998), habitat and regolith mapping of the catchment (Woodward-Clyde 1998c). Percentages are as a percentage of the entire 171,000ha of the catchment.

Vegetation Communities and their signature species (in bold)	Estimated area pre-European settlement	Estimated area in 1998 (uncleared)
Riparian Communities: River Red Gum (*E. camaldulensis*). (Watercourses)	8,700ha (5% of Upper Billabong catchment)	<1,000 ha. (0.6% of Upper Billabong catchment)
Grassy Woodland Communities: Yellow Box (*E. melliodora*)/ Blakely's Red Gum (*E. Blakelyi*)/ Apple Box (*E. bridgesiana*)/ White Box (*E. albens*)/ River Red Gum (*E. camaldulensis*). (Floodplains)	18,900ha (11%)	0 ha. (0%)
Woodland Communities: Yellow Box (*E. melliodora*)/ Blakely's Red Gum (*E. Blakelyi*)/ White Box (*E. albens*)/ Long-leaf Box (*E. goniocalyx*)/ Red Stringybark (*E. macrorhyncha*)/ White Cypress Pine (*C. glaucophylla*). (Slopes and Downs)	78,000ha (45%)	<500 ha. (0.3%)
Woodland and Forest communities: Red Box (*E. polyanthymus*) Red Stringybark (*E. macrorhyncha*), Broad-leafed Peppermint (*E. dives*), White Gum (*E. rosii*), Brittle Gum (*E. mannifera*), Long-leaf Box (*E. goniocalyx*), Black Cypress Pine (*C. endlicheri*) (Hills, Mountains).	67,100 ha (39%)	20,200 ha (11.8%)

Vegetation Management Status

The Murray Catchment Management Committee Nature Conservation Working Group has determined, based on several references, the "Vegetation Management Status" for vegetation within the South West Slopes, which includes the Upper Billabong Catchment (Table 3.5). Within the paper it is noted that
"a vegetation community may consist of several layers of vegetation, which may include an overstorey and understorey, and a variety of plant species. In many cases only the overstorey component of the vegetation community remains as remnants with little or no regeneration or diversity in age or species" (MCMC 1997).

Estimated area of Grassy Box Woodland Communities: pre-European - 11% of catchment; now - 0%

It was found that within the South West Slopes all vegetation communities lay within the categories
of either:

> Extensively Cleared (EC): "These vegetation communities have been largely removed from their entire pre-European extent, and only very small remnant areas remain. It is recommended that no further clearing take place, and that any remnants of these communities, no matter how degraded or fragmented, be retained. Any decision relating to their future management must prioritise their restoration and regeneration."

or

> Significantly Cleared (SC): "Significant areas of these vegetation communities have been cleared. Most of the areas that remain are fragmented and degraded, and it is important these areas be restored and regenerated. Further clearing is unwise, and certainly no clearing or further fragmentation of large remnants should occur. Nevertheless, further clearing of highly fragmented and degraded areas is possible in order to regenerate viable management areas for plantations or pasture. Such clearing would be carried out in accordance with an accredited Vegetation Management Plan, which also addresses restoration and regeneration of larger remnants of these communities. All relevant matters should be considered in an assessment under the appropriate regulatory instrument." (MCMC 1997)

Threatened Flora

Table 3.6 gives a threatened species list for flora found, or potentially found, within the Holbrook (1:100,000) Map Sheet area (NPWS 1997). Clearing, agriculture, fire and rabbits have been the major contributors to flora decline (Moore 1953).

Table 3.5 Conservation categories relating to the Upper Billabong Catchment for vegetation communities found within the South West Slopes (MCMC 1997)

Vegetation Community	Conservation Category within the South West Slopes
Dry Sclerophyll Forest	Significantly Cleared
Black Cypress Communities	Extensively Cleared
Yellow Box and Blakely's Red Gum Communities	Extensively Cleared
Red Box Associations	Extensively Cleared
White Box Communities	Extensively Cleared
She-oak Communities	Extensively Cleared
Grey Box Communities	Extensively Cleared
White Cypress Communities	Extensively Cleared
River Red Gum Communities	Extensively Cleared
Other Riparian Communities	Extensively Cleared

Table 3.6 Endangered, Vulnerable and Threatened Flora Species (NPWS 1997)

Name	Status	Comments (Habitat, Range and Form)
Acacia phasmoides (Phantom wattle)	Vulnerable	Damp granite derived soils/rocks. Shrub (1-4m). Yellow flowers Sept. - Nov. Only known on a few rocky parts of Pine Mt. and Woomargama SF.
Ammobium craspedioides	Vulnerable	Occurs in grassy understorey of woodland dominated by *E. blakelyi* and *E. melliodora* in gently undulating terrain. Between Burrinjuck dam and Yass. 30-60 cm perennial. Yellow flower in summer
Brachycome muelleroides	Vulnerable	Damp areas on margins of clay pans. South of Wagga Wagga. Ascending herb. 14cm annual. White floret Sept-Oct.
Caladenia concolor	Vulnerable	On clay loams or gravel beds. South from Bethungra. Terrestrial herb. Flower dark purplish red Oct-Nov.
Senecio garlandii (Woolly ragwort)	Vulnerable	Sheltered slopes of rocky outcrops. Perennial herb or shrub 50-120cm high, much branched, stems woolly. Leaves obovate to elliptic (8-15cm long) From West Wylong to Albury. Benambra State Forest (Burrows, 1996)
Swainsona recta (Mountain Swainsona-pea)	Endangered	Often on Stony Hillsides Found in woodland dominated by *E. blakelyi, E. goniocalyx* and *E. melliodora*. Now only known in six very localised sites in Wellington, Mudgee, Mumbil, Queanbeyan, Williamsdale and Canberra. Erect and ascending. 20cm perennial. Flower purple.

Forests and areas of high conservation value

Woomargama (32,649 ha), Benambra (1,445 ha) and Pulletop (809 ha) are National Parks (formerly State Forests) "that contain the highest quality of vegetation, in comparison to other State Forests in the South West Slopes". These Reserves are all found within the Upper Billabong Catchment and "support floristic wealth of high habitat potential" (Howard 1993). Benambra is particularly significant having a high diversity of fauna and flora associated with it, including threatened and vulnerable species. All of these National Parks adjoin areas of forested private land. Another area of significant native vegetation cover is Morgan's Ridge to the east of Holbrook, which is predominantly privately owned.

2. ISSUE C: TREE DECLINE AND DIEBACK

Causes of Tree Decline

The main causes of tree decline include clearing for agricultural development, competition by introduced flora and predation of seedlings by rabbits. Premature death of trees (dieback) is exacerbating the incidence tree decline in rural areas.

To further understand this decline it is important to understand the historical events that have occurred within the catchment and what the native vegetation cover looked like prior to European settlement.
These historical events also relate to the other physical issues of concern within the catchment, including biodiversity decline, salinity and erosion.

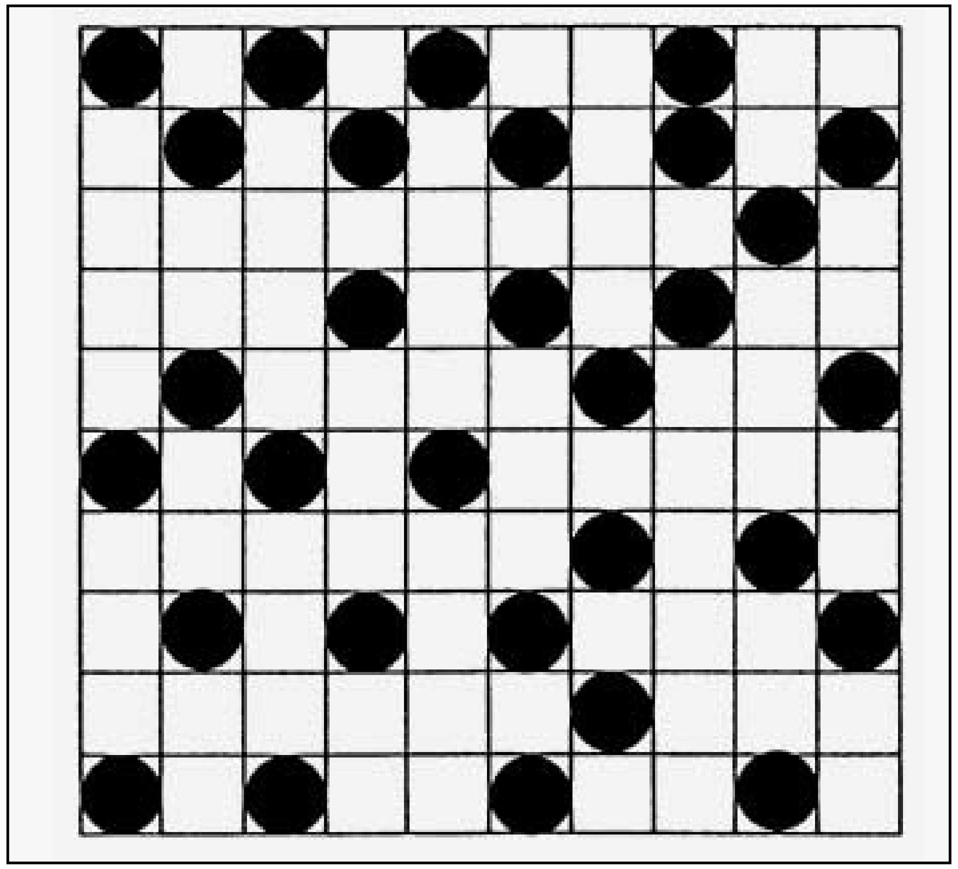
Pre-European and European Settlement

Through human intervention, there have been major changes to the natural flora of the catchment. There is still debate over what the landscape really looked like prior to European settlement. In a literature review on native vegetation cover, Benson and Redpath (1997), found that the pre-European tree densities of grassy woodland formations of south-eastern Australia were, on average, 30 trees per hectare (Figure 3.1). It is assumed that the trees were mature and the width of their crown would have been approximately 10m.

> "These grassy woodlands were much denser than a modern rural scene of a farm paddock with a scatter of ageing trees. However they were less dense than many remnant regrowth forests that will take decades to self-thin....Eucalypt forests with touching crowns would have been present in wetter regions, as they are today."

A similar example of this canopy cover is the easement on the northern end of the Holbrook common.

Figure 3.1 Diagrammatic interpretation of the spacing of trees in a typical grassy woodland of south-eastern Australia prior to European settlement (Benson & Redpath 1997)



Taller trees with a grassier understorey would have been associated with the more fertile soils (flats), whilst a shorter tree with sparse grasses would have been associated with the shallow soils (slopes) (pers. comm. Davidson 1998).

There is limited historical information on what the shrub layer might have looked like. "Early explorers indicate that the woodlands were open communities with a well developed herbaceous stratum in which the dominant species were almost certainly palatable native grasses including Themeda australis (Kangaroo Grass)" (Moore 1953). Extrapolating from a historical analysis of forest and woodland cover in the central western slopes region of New South Wales (an area of similar soils, climate, and remaining native vegetation type to the Holbrook area), the woodland areas were found to contain a predominantly grassy understorey. There were, however, patches with a relatively dense shrub layer. In general there were more observations of shrubs on less fertile soils in hilly areas than on areas classified as being more fertile (Croft *et al.* 1997).

13% of the Upper Billabong still has remnant or existing native vegetation cover

Based on a combination of historical evidence and extrapolation from other areas, shrubs would have been common on shallow soils and along water courses but more scattered and patchy on fertile soils, unless recently disturbed (eg: fire, flood, dead tree) in which circumstances shrubs proliferate. Over time, the system would have been quite dynamic (pers. comm. Davidson 1998 and Sheahan 1998).

Shrub density in the hill country of the catchment is still reasonably well represented in the areas of Benambra, Pulletop and Woomargama Reserves where the density is on average in the high hundreds to thousands per hectare.

Current Status of Tree Decline

Moore, in a study in the early 1950s of the vegetation of the southeastern Riverina, stated

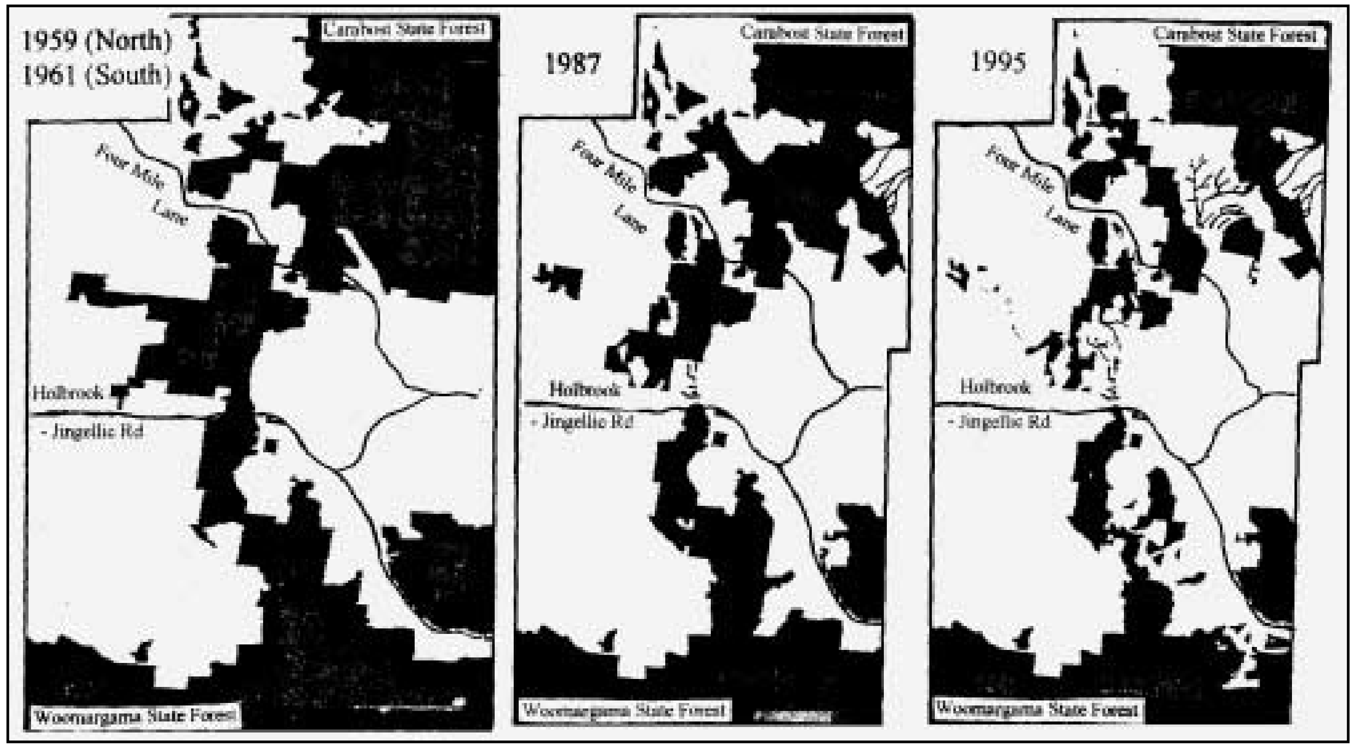
> "there are few, if any, relic areas in which the original conditions have been preserved. Even in communities which do not provide useful timber, and in which there is not a sufficient depth of soil to warrant clearing for grazing or cultivation, the original shrub and herbaceous strata have been modified by fire and rabbits."

Thirteen percent of the Upper Billabong catchment still has remnant or existing native vegetation cover. Approximately eight percent (13,500 ha) of this is on private land, roads and reserves the remaining five percent is State Forest or National Park. Most of the native vegetation cover that remains is on the hills and is dry sclerophyll woodland or forest dominated by species such as Red Stringybark (*E. macrorhyncha*), Broad-leafed Peppermint (*E. dives*), White Gum (*E. rosii*), Brittle Gum (*E. mannifera*), and Long-leaf Box (*E. goniocalyx*).

Good (1996) conducted a study of the Tumut forest area (which includes the eastern sector of the Upper Billabong catchment). He found that 94% of the Yellow Box (*E. melliodora*)/ Blakely's Red Gum (*E. Blakelyi*)/ White Box (*E. albens*) communities found in the flats and lower slopes had been cleared. This figure would be closer to over 99% for the Upper Billabong catchment where clearing has been more prevalent. The areas that do provide a reasonable representation of these communities are some of the uncleared gullies in the upper reaches (slopes) of the catchment and the uncleared slopes and downs associated with Benambra National Park and Morgan's Ridge.

Figure 3.2 represents aerial photographic interpretation by Sheahan (1998) and shows the rate of remnant native vegetation decline within the Upper Wantagong, Yarra Yarra, Four Mile, and Little Billabong subcatchment areas over a 36-year period (1959 to 1995). The dark patches represent areas of the catchment where good remnant native vegetation cover remains on private land.

Figure 3.2 Decline in area of remnant native vegetation cover from 1959 to 1995 (Sheahan 1998 unpublished)

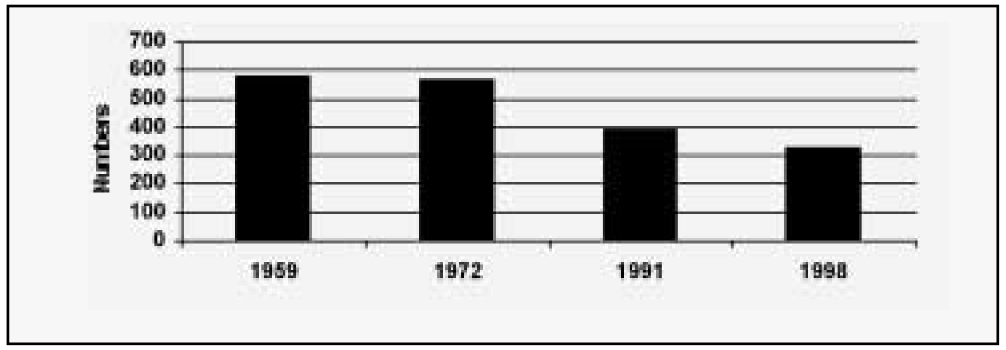


Tree numbers since 1959 in the Upper Billabong Catchment

A study by Kerb (1998) provides indicative figures on tree numbers within farming paddocks between 1959 and 1998 across varying terrains within the catchment. Figure 3.3 shows results for the varying terrains were flat country, ridge country and creek lines. Tree counts were obtained from aerial photographs. The paddocks and creeks where the counts were undertaken were initially "eye-balled" to ensure they were representative of the normal farming area.

Figure 3.3 Tree numbers over time for flat country (Kerb 1998)

Based on results for three blocks varying from 150 to 181 ha

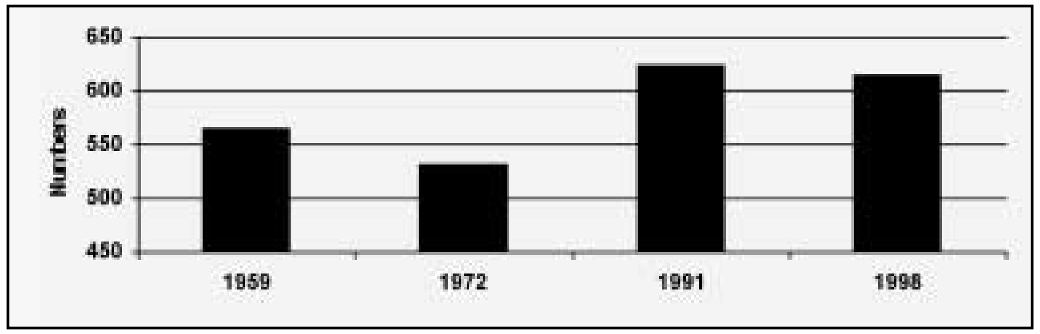


The indicative tree density in the flat country has reduced from 1.2 (1959) to 0.7 (1998) trees per hectare, showing a 44% decline in tree numbers over that time. Compare this with the tree density prior to European settlement: on average 30 trees per hectare (Benson & Redpath 1998).

The indicative results for ridge country showed a variable trend. In the two blocks that were counted, one block showed a decrease from 1.5 to 0.5 trees per hectare, whilst in the other block there was an increase from 1.5 to 2.5 trees per hectare. It is assumed this relates primarily to the intensity of grazing. Results were only obtained to 1991. The blocks were 153 and 172 ha in size.

The results along three creek lines (each 3km in length) showed an increase over time (Figure 3.4).

Figure 3.4 Tree numbers over time for creek lines (Kerb 1998)



The indicative results for tree numbers along creek lines within the catchment show a dramatic increase in tree numbers between 1972 and 1991. It is assumed this increase is due to a regeneration event associated with the 1973/74 floods.

Tree Planting, Protection of Remnant Native Vegetation and Creekline Fencing

Catchment estimates for tree planting (Table 3.7) have been obtained from Jayfields' Nursery (pers. comm. Passalaqua 1999) and the Holbrook Landcare Coordinator (pers. comm. Hulm 1999) based on projects funded and nursery sales. Estimates for the area of remnant native vegetation protected (Table 3.8) have been obtained through a combination of ABARE figures for the period before 1996 and through the remnant native vegetation fencing scheme administered by Greening Australia (pers. comm. Davidson 1998). Creekline fencing estimates (Table 3.9) are based on projects funded (pers. comm. Hulm 1999).

The area of commercial plantations (Table 3.10) has been determined from aerial photography (May, 1998). Collation of the different sources of estimates shows that by January 2000:

- 60 % of farm businesses in the Upper Billabong had undertaken some form of tree planting
- 1.1 % of the catchment (1895 ha) planted to trees
- 976,412 trees and shrubs planted within the catchment
- 16% of farm businesses have undertaken fencing to protect remnant native vegetation
- 0.3% of the catchment (476 ha) comprised protected remnant native vegetation
- 67 kilometres of the catchment's creeklines fenced out
- 1.5 % or 2440 ha of the catchment had been planted to pine

Table 3.7 Tree Planting Estimates by 1st January 2000
(pers. comm. Passalaqua 1999 and Hulm 1999)

Item	% of Farms	Number of trees planted	Area (ha)
Trees planted in windbreaks (~650 trees/ha)	60	488,201	751
Trees planted in gullies (~350 trees/ha)		195,282	558
Trees planted in blocks (~500 trees/ha)		292,923	586
Total		976,412	1,895

Table 3.8 Protection of Remnant Native Vegetation
(ABARE 1996 and pers. comm. Davidson 1998)

Item	% of Farms	Area (ha)
Protected Remnant Native Vegetation	16	476

Table 3.9 Estimates of Protection of Creeklines
(pers. comm. Hulm 1999) Based on Projects undertaken.

Item	Length (km)
Length of Creekline Fenced Out	67

Table 3.10 Area of hard wood farm forestry and pine plantations
(May 1998 aerial photography and pers. comm. landholders and Hulm 1999)

Item	Number of Farms	Area (ha)
Hard Wood Farm Forestry	6	<100
Pine Plantations	8	2,440

Dieback is often the most obvious expression of an underlying problem with the way in which the whole system is operating

Dieback

Dieback is the long-term decline in the health and vigour of trees. It is not a specific disease; trees are simply weakened by a combination of factors to the extent that they are not able to survive repeated attack by fungi, viruses, bacteria or insects.

Dieback is often the most obvious expression of an underlying problem with the way in which the whole system is operating - the balance of nature has been upset - the natural resilience of the landscape has been reduced.

Many different factors may be involved, some may be primary (eg: clearing) and others more secondary (e.g. pasture improvement). Many factors are likely to interact. For example, dieback may go into remission during drought, because trees can cope with dry conditions better than insects. Chronic insect damage is a classic example of a system out of balance, particularly when it involves native insects on native trees. (Driver *et al.* 1992 and pers. comm. Landsberg 1998)

Dieback symptoms include:

- stunted growth, lack of vigour
- outer branches die leaving dead and protruding twigs
- after considerable decline of the crown, new shoots may be produced directly on the trunk or branches
- there may be several cycles of regrowth and decline associated with some form of attack
- ultimate survival depends on the level and duration of stress (Driver *et al.* 1992)

Causes of Dieback

European settlement has had a major adverse impact on native vegetation throughout the Upper Billabong Catchment. There is usually no single cause, but rather a complex interaction of natural fluctuations and human-induced changes (Figure 3.5). Some of these in the Upper Billabong catchment may be:

- loss of variety in animal and plant species because of clearing, cropping, improved pastures and grazing practices
- lack of regeneration of the remaining species
- changed nutrient balance because of fertilisers, stock camps and cropping systems
- changed water balance due to clearing, damming of waterways, and increased or decreased runoff
- rising watertables and associated salinity
- reduced insect predators, due to habitat degradation
- age of the trees
- mistletoe
- drought
- the use of herbicides
- livestock ringbarking the trees

Role of Insects in Dieback

(Stelling, 1998, particularly information note by I. Davidson)

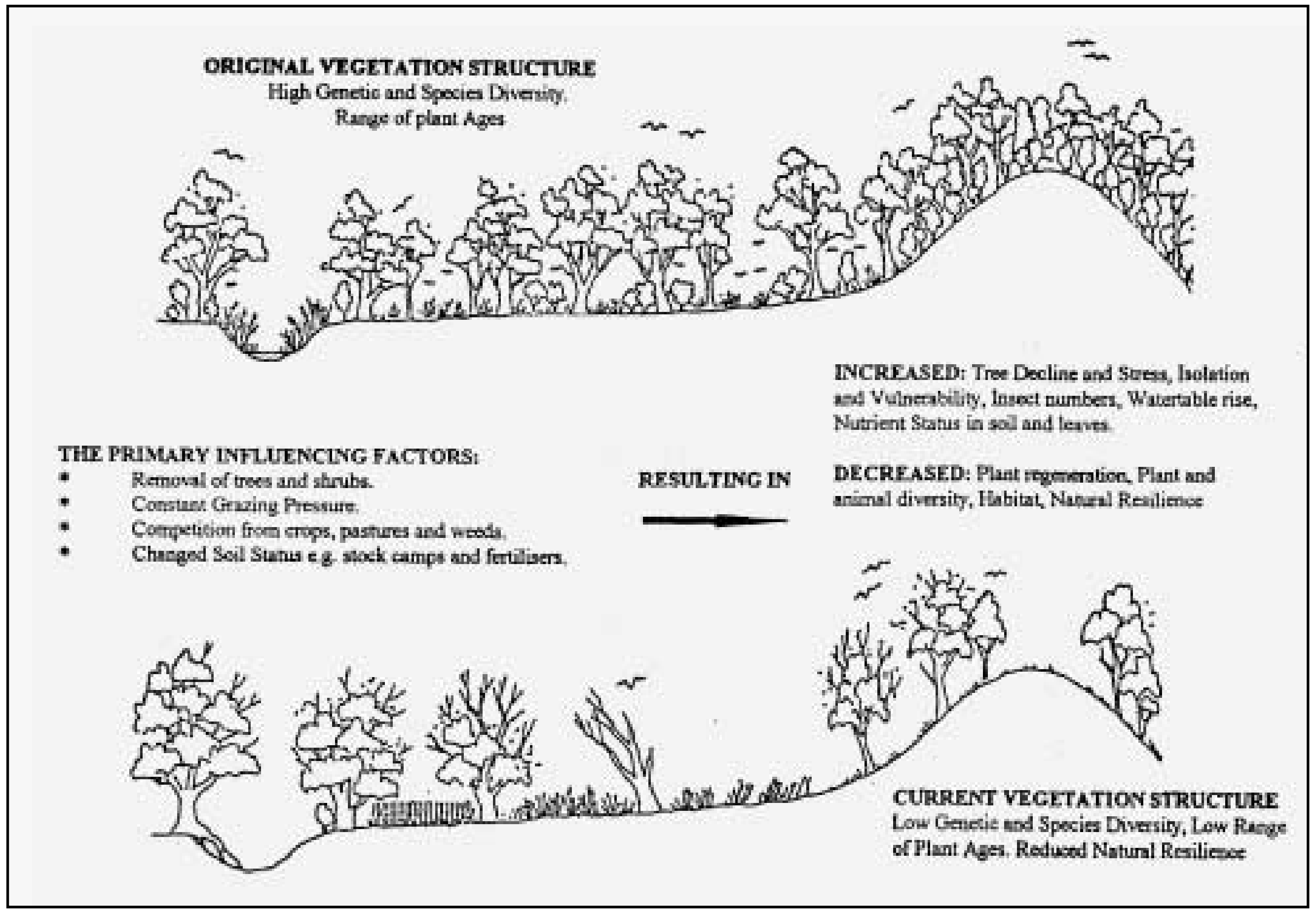
Some insect activity in native vegetation is natural and indeed necessary for sustaining insectivorous birds and other native animals. However, when natural systems are out of balance, insect activity may be so great as to cause serious tree decline. Insect predation often involves the loss of leaves in eucalypts by a variety of insects over consecutive seasons. The main insects involved include psyllids (lerps), scarab beetles, skeletonisers, leaf beetles, leaf hoppers, sawfly larvae, scale, gall forming insects and various caterpillars.

Agricultural development has benefited many insects and adversely impacted upon the remaining eucalypts.

For example:

- there are larger areas of farming. This has resulted in a loss of natural predators
- increased areas of pasture has provided more beetle larval habitat (eg: for Christmas beetles)
- increased soil fertility (from fertilising or stock camps) results in more nutritious eucalypt foliage. This is preferred by both insects and livestock
- there are fewer paddock trees. Those remaining are under increasing pressure, and are not regenerating

Figure 3.5 Interactive processes that cause tree decline / dieback.



Natural predators of insects (eg: birds that feed on insects) may be missing because the habitat is too small, too isolated, or lacking sufficient understorey. Compare a healthy 10-hectare patch of woodland, where there are at least 30 species of native birds, to a typical 10-hectare patch of woodland in farmland, where there are often fewer than 10 species. Such patches usually lack shrubs, regenerating trees and sticks and logs which have been “tidied up”. As native birds are believed to control 50 to 70 per cent of insects in healthy eucalypt woodland, their absence is a major contributing factor in rural tree decline.

Aggressive, larger birds may also drive smaller birds away. For example, colonies of Noisy Miners, are known to reduce the presence of smaller predatory birds by aggressively defending their territories and food sources. Noisy Miners tend to harvest lerps - the protective covering concealing the leaf-sucking psyllids. However, they do not control psyllid populations, unlike the smaller insect eating birds such as Pardalotes, which eat the psyllids.

Mammals such as Sugar Gliders, and native parasitic wasps and flies, also play key roles in controlling beetles and other insects. For example Sugar Gliders will eat 25 scarab beetles a day. Due to the fragmented nature of many rural habitats, however, and the lack of shrubs in farmland, these species are often unable to access isolated patches of native vegetation, or are present in such low numbers as to be ineffectual.

Figure 3.6 Some of the native animal species that have become more dominant in farm woodlands within the Upper Billabong catchment - exacerbating dieback and tree decline
(images from State Forests undated;
and Pizzey & Knight 1997)

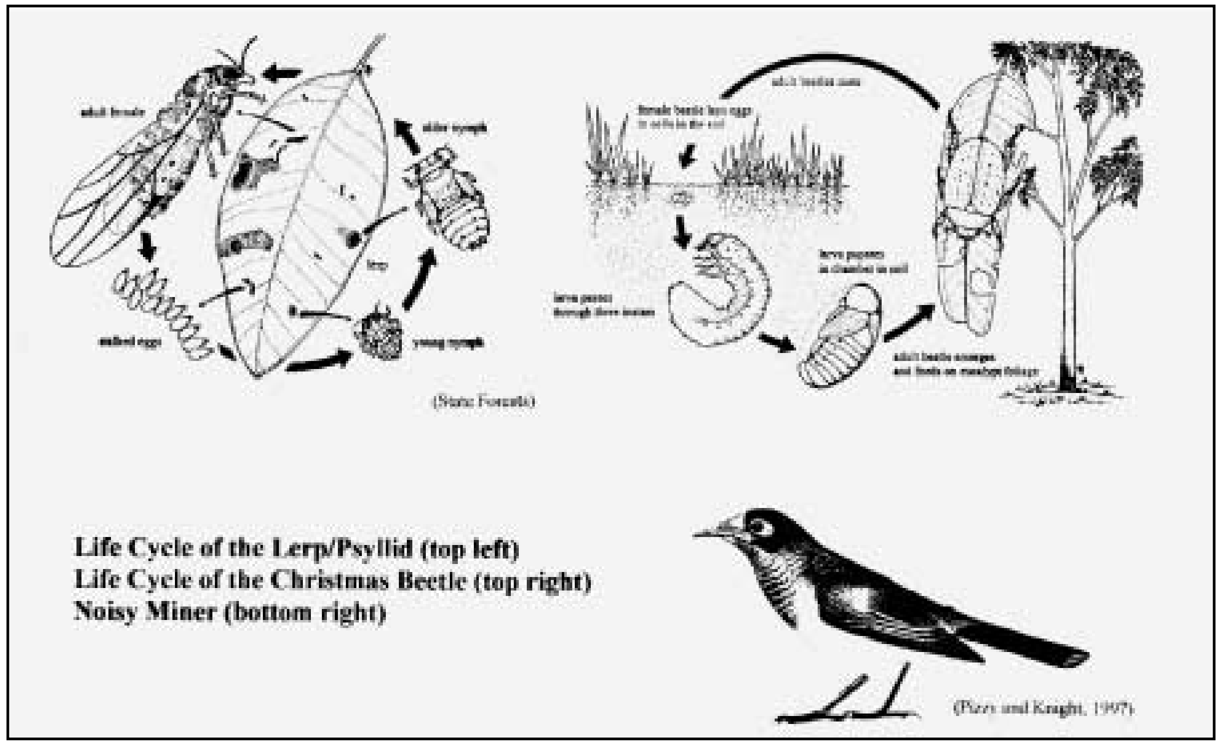
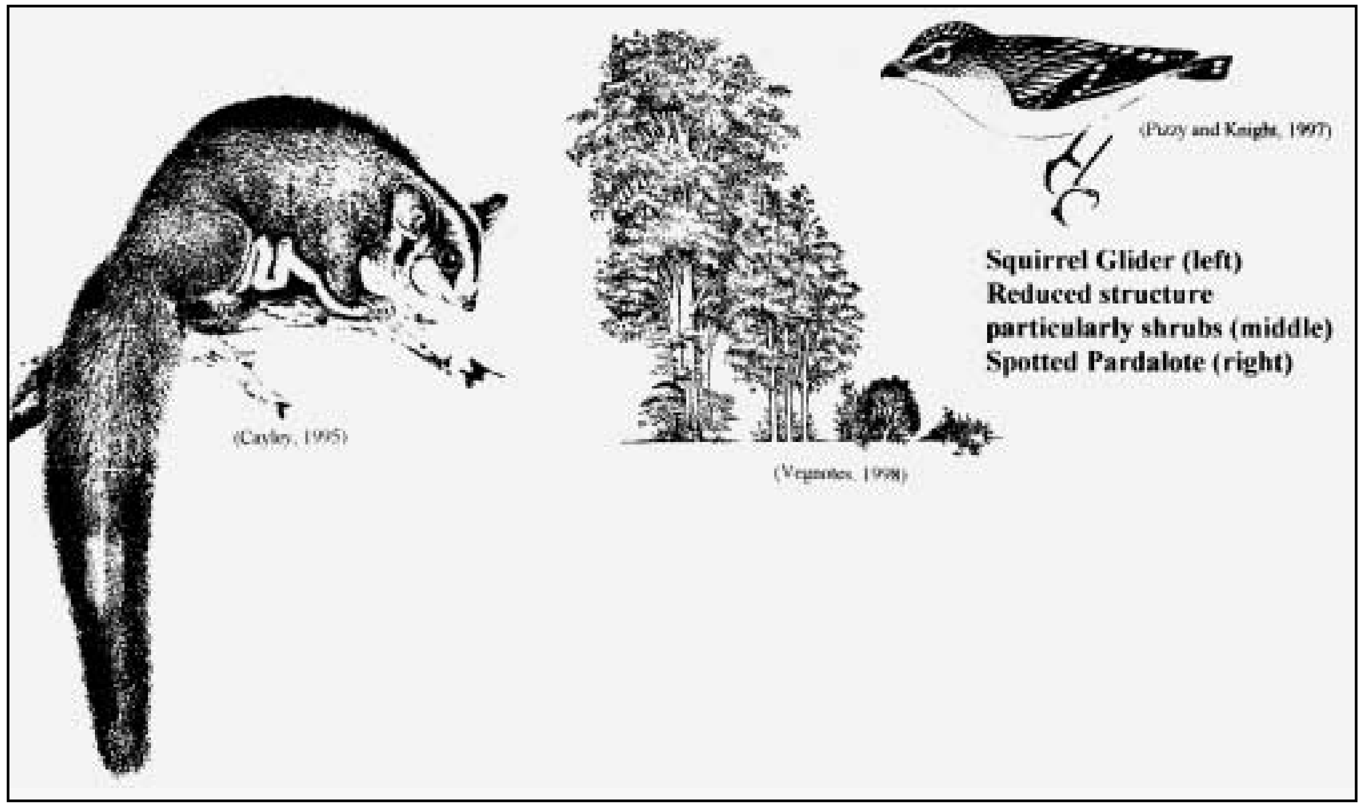


Figure 3.7 Some of the native plant and animal species that have become less dominant in farm woodlands within the Upper Billabong catchment - exacerbating dieback and tree decline
(images from Cayley 1995; Pizzey & Knight 1997;
Vegnotes 1998a).



Current Status of Dieback

Dieback was first noted within the catchment 30 to 50 years ago and has gradually increased since then, with periods of remission (pers. comm. Allworth 1997 and Geddes 1997). Dieback currently predominates on Blakely's Red Gum (*E. blakelyi*) and River Red Gum (*E. camaldulensis*) throughout the catchment. Dieback was particularly prevalent in these species during the summer of 1997/98 with almost complete defoliation occurring in both young and old plants (notable on the January 1998 aerial photography of the catchment, DLWC - Albury). Insect attack (primarily by lerps, and Christmas beetles) has been a major contributor to the symptoms of the disease. Dieback is most prevalent in the more fertile and more intensive agricultural areas where there has been the greatest history of clearing and agriculture.

Dieback associated with insect attack has also been noted in some stands of Red Box (*E. polyanthymus*) and Red Stringybark (*E. macrorhyncha*) particularly in the Jerra Jerra, Sawyers Creek and Forest Creek subcatchment. It has also been noted in Yellow Box (*E. melliodora*), particularly to the west of the catchment.

A survey conducted in the catchment found that 97% of landholders had noticed (the prevalence of) dieback in their farm trees (Bunyan 1998). They noted that dieback was more prevalent in smaller patches of bush (ie: less than 6ha in size). 71% of landholders indicated that a notable presence (eg: too many insects) or absence (eg: too few insectivorous birds) of ecological factors were contributing to their dieback symptoms.

Drought-induced dieback was noted particularly in the Red Stringybark (*E. macrorhyncha*) during an extended dry spell in 1997/98. This was most evident on the northerly aspects and in stands of thick regeneration.

3. ISSUE K: BIODIVERSITY DECLINE

Biological diversity or biodiversity is defined as the variety of life forms, the different plants, animals and micro-organisms, the genes they contain, and the ecosystems they form. It is usually considered at three levels: genetic diversity; species diversity; and ecosystem diversity.

It is estimated there are more than one million species of plants and animals in Australia, but less than 15% of these have been scientifically described (CSIRO 1996a). Over the past 200 years of European, settlement the natural environment has been modified dramatically and in many cases the rate of extinctions and modification of ecosystems is accelerating. Since 1788, more than 100 plant and animal species are known to have become extinct in Australia. In NSW alone about 82 species of plants and animals are extinct and over 600 plant and animal species are considered either endangered or vulnerable (NPWS 1997).

The more diverse a system is, the more stable it will be. Any interference to one component of the system can be compensated for by other components. There is a high probability that with a wide array of components, at least one component will possess the ability to counteract the interference. Conversely, the loss of this diversity reduces the system's stability as it limits its ability to adjust to interference and change (Brinsmead 1998).

Causes of Biodiversity Decline

Habitat loss through clearing and grazing, as well as the introduction of feral plants and animals (eg: fox and cat), have been the major contributors to fauna decline (pers. comm. Davidson 1998). Clearing, agriculture, fire, introduced flora and rabbits have been the major contributors to flora decline (Moore 1953).

"Habitat loss through clearing and grazing, as well as the introduction of feral plants and animals, have been the major contributors to fauna decline."

Biodiversity - the Current Status

261 species of fauna have been listed in the background material earlier in this appendix. Of those:

- 40 are species that should be found within the catchment but have not been formally recorded
- 17 are introduced animals (in addition to domesticated animals that are not regarded as pests)

164 of these 261 species have been provided with a current status. Of these:

- 9% are locally threatened, vulnerable or endangered
- 9% are of increasing population, (this does not include sheep and cattle, being some of the main fauna populations to have increased)

The background material earlier in this appendix lists flora of the Upper Billabong. 206 native plant species have been formally recorded . Stelling (pers. comm. 1998) regarded all native shrub species found in the flats and lower slopes (associated with Blakely's Red Gum and Box Woodlands predominantly) to be locally threatened with only a few relics found to remain, primarily on roads and reserves.

Less than 5% of the Upper Billabong Catchment would be regarded as healthy remnant woodland, primarily the Dry Sclerophyll Forests within National Parks that have had minimal impact through European influences.

A healthy 10 hectare remnant woodland in the Upper Billabong catchment would typically contain:

- Eucalypts of various ages, including hollow-bearing trees and regeneration
- shrub layers (particularly wattle and pea species)
- mostly grassy understorey, with various native herbs
- 60-100 species of vascular plants (ie: plants more highly evolved than mosses and liverworts)
- 30-40 species of birds (mostly insectivores). This includes (*number of species in brackets*): Thornbills (2-5); Robins (1-5); Golden or Rufous Whistlers; Grey Shrike-thrushes; Pardalotes (2); Honeyeaters (2-10); Treecreepers (1-2); Crested Shrike-tits; Sittellas; Jacky Winters; Grey Fantails; Firetails (1-2); Peaceful Doves; Cuckoo Shrikes (1-2); Babblers (1-2); Silvereyes; Restless Flycatchers; Woodswallows (1-5); Owls (1-4); Kingfishers (1-3); White-winged Trillers and birds of prey (2-9)
- over 10 mammals (mostly bats) including: Eastern Grey Kangaroos; Swamp Wallabys; Echidnas; Wombats; Ringtail and Brushtail Possums; Gliders (1-5); Antechinus (1-3) and Bats (1-8)
- up to 10 species of reptile including: Tree Goannas; Snakes (1-3); Skinks (1-4); Blind Snakes (1-2); Geckos (1-2); and Legless Lizards (1-2)
- a diverse range of insects
- a healthy canopy of leaves.

Greater than 80% of the Upper Billabong catchment would be regarded as farmland. Most woodlands of 10 hectares in farmland within the Upper Billabong catchment would contain:

- Eucalypts of one age class (usually old, pre-European)
- no shrubs
- mainly grassy understorey with perennial spring/summer growing native plants mostly replaced by 2 or 3 annual grasses such as Barley Grass and Silver Grass
- less than 10 vascular plants
- branches tidied up and burnt
- less than 10 birds, usually dominated by large aggressive species such as Noisy Miners; Magpies; Eastern Rosellas and Mudlarks
- about five species of mammal: eastern Grey Kangaroos, Brushtail Possums, Ringtail Possums and Bats (1-2);
- 1-2 species of reptile, eg: Brown Snakes
- abundant insects (few species)
- eucalypt dieback common (Stelling 1998, particularly information note by I. Davidson)

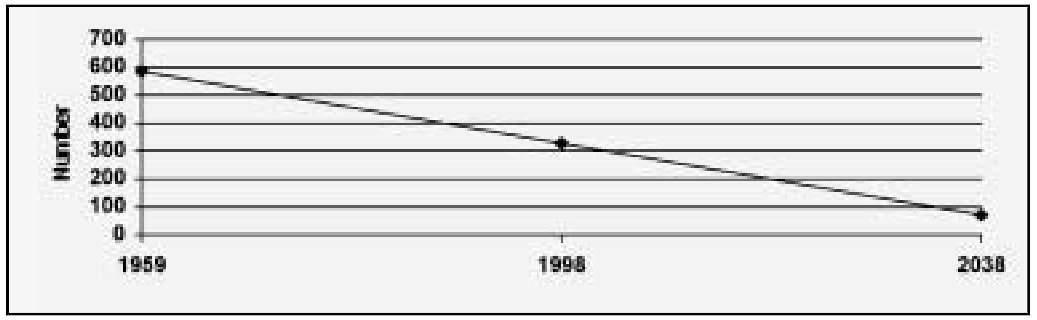
Future Implications and Trends Associated with Tree Decline, Dieback and Biodiversity Decline

There is increasing social and economic pressure to increase agricultural input and output. This places increasing pressure on native flora and fauna.

The greatest pressure on native vegetation has been associated with the more fertile flats within the catchment. In the farming paddocks within these flats, the only native relics generally remaining are signature Eucalypt species. Based on an estimated average tree density of approximately 30 trees per hectare pre-European settlement, indicative tree counts found this density had decreased to 1.2 trees per hectare in 1959. This figure has been further reduced to 0.7 trees per hectare in 1998.

Figure 3.8 shows the prospects if we assumed a linear trend based on the linear trend plotted from two points (1959 and 1998). If this trend is correct and were to continue linearly, there would be very few paddock trees in forty years from now - less than one tree for every six hectares. Dieback and tree planting were noted in the 1998 count and could have a negative or positive impact respectively on tree numbers in the future. Of course, the trend may not be linear and may be exponential, resulting in a decline of greater intensity.

Figure 3.8 Tree numbers over time for flat country (Kerb 1998)



The trend of tree decline is also extending into the less fertile ridge country, although in areas of reduced grazing intensity, eucalypt regeneration has occurred.

European settlement and associated agricultural practices have arguably had the greatest impact to date on the shrub layer, forbs and native grasslands within the catchment. The only areas where these species are reasonably preserved are primarily roadsides, reserves, State Forests and National Parks associated with the less fertile ridges. The Holbrook Landcare Group is currently seeking funds to establish seed orchards of local provenance shrub species to provide seed for future revegetation work, because of the limited shrubs currently available from which to collect seed.

There has been increasing interest in revegetation over the last 10 to 20 years and more recently an interest in better native vegetation management. To date, this interest has only had a minor impact on increasing overall catchment vegetation cover. For example, as indicated previously an estimated 60% of landholders have planted 976,000 trees, over 1,895 hectares in the last 10 years - this still only represents 1% of the catchment. It has also been estimated that 16% of landholders, have fenced out 476 hectares of remnant native vegetation - this represents 0.3% of the catchment.

It should also be noted that the habitat value of trees, particularly eucalypt species is associated with age. Hence, one big mature tree is not equal to one small tree. For example, one large box tree with a 100cm diameter at breast height (dbh) has approximately ten times the bark surface area of 40cm dbh tree, therefore far greater habitat value (pers. comm. Davidson 1998).

Extrapolating from experiences found in the New England tablelands there is a strong likelihood that insect induced dieback will progress from the Red Gums into other Eucalypt species.

Whilst there is native flora decline, habitat decline, pests and weeds, there will be biodiversity decline. There are continuing localised and regional losses of flora and fauna, while at the same time there are continuing increases in other flora and fauna (eg: cockatoos, kangaroos, foxes, sheep, cattle, phalaris). The overall implication of this will be a reduced natural resilience within the landscape of the Upper Billabong as the natural checks and balances will be reduced (Landsberg, 1998). Vegetation decline will also result in the reduced absorption potential of rainfall, resulting in more water being added to the groundwater system, thus increasing salinity, soil acidity and erosion

One large box tree has 10 times the bark surface area of a smaller tree, therefore far greater habitat value.

1. USEFUL BACKGROUND MATERIAL

(a) Elevation, Geology and Soils

Elevation

Elevation within the Upper Billabong Catchment varies from 220 metres on the Billabong Creek at Morven in the west of the catchment, to 889 metres at Mount Jergyle in the east. The township of Holbrook has an elevation of 270 metres.

Geology

The geology of the catchment is a variable pattern of sedimentary and granitic rocks interspersed with expansive Quaternary deposits of variable thickness and composition. In several sites mining of metals and minerals has taken place.

The geological structure and composition of the landscape is more accurately termed surface geology. Recorded by landform and regolith, the surface geology of the Upper Billabong is characterised by extensively weathered granite and sedimentary rocks interspersed with depositional basins and floodplains.

During the last million years (Quaternary Period) the catchment basins accumulated vast deposits of weathered materials, organic accumulations and wind-borne dusts. This process is characterised by interactive cycles of alluvial and colluvial deposition, interacting with fluvial and aeolian redistribution. Consequently the regoliths and terrain patterns reflect dynamic polygenesis (Degeling 1977).

The geologic parent materials, mixed sedimentary and granites are far older, dating back to the paleozoic era, 250 to 500 million years ago, when the environment was warmer and drier, and extensive flooding from rising sea levels coincided with massive sedimentation. The sedimentaries are incredibly diverse, ranging from soft sandstone to hard slate with all manner of layered variations.

Soils

Soils are developed by physical, chemical and biological processes, including the weathering of rock and the decay of vegetation. Soil materials include organic matter, clay, silt, sand and gravel, mixed together to form a natural medium in which most plants will grow (SCS 1991).

Subcatchment studies undertaken by the DLWC provide an overview of the Upper Billabong's soils (Woodward-Clyde 1998b). Soils work within the Upper Billabong Catchment is currently being undertaken more intensively by the Department of Land and Water Conservation, but at the time of writing, the soils maps were in a draft stage only. The soils map will be inserted in the Annual Supplements to this Plan when they become available.

The main soils found within the Upper Billabong Catchment include:

Lithosols: found on steep slopes and ridges where there is plentiful outcrop. These soils consist of rocky fragments and are shallow skeletal soils.

Red Podzolics: typical of steep slopes and ridges where they have formed from underlying Ordovician sediments. These soils become more acid with depth, are well drained and are highly prone to erosion. A lighter coloured red clay loam separates an upper loam layer from a red clay subsoil. These soils may form a hard crust following cultivation.

Yellow Podzolic: found on footslopes in drainage depressions. These soils are poorly drained and are highly prone to erosion. They exhibit characteristic yellow, sticky subsoil. Infiltration is quite low as a hard crust often forms across the soil surface.

Brown Podzolic: less prone to erosion and are more organic rich than other podzolic soils.

Solodic: occur on lower footslopes and in drainage depressions. The subsoil is often mottled and in dry conditions separated from the topsoil by a bleached layer. Solodic soils have a hard-setting surface, are alkaline and highly prone to erosion. Yellow solodics have a yellow B horizon.

Yellow Solonetzic: poorly drained, are generally not at high risk of erosion but are at high risk of acidity. Occur in areas of low relief, occasional swamp and patches of gulags. Terminates abruptly to the east and south. Merges to the west with grey and brown clay soils. A hard silty clay loam topsoil is separated from a yellow clay subsoil by a bleached softer silty clay loam. All layers set to a hard crust with exposure, becoming virtually impermeable and leading to excessive runoff. Moderate to low fertility. Dispersible.

Siliceous Sands: formed *in situ* from underlying granite or elsewhere from colluvial granitic material. This soil has a uniform clayey sand texture throughout; softer rock minerals having been broken down into clay, while harder, more resistant minerals have remained as coarse grains. These soils are usually deep, slightly acid, moderately well drained, at high risk of erosion and at extreme risk of acidity. The A2 horizon is bleached.

Grey and Brown Clays: products of depositional processes involving a high proportion of fine materials of both mineral and organic origin. Characteristics can include self mulching deep A horizon soil systems, with cracking clay subsoils, usually over confining clay layers, unless severely degraded. They flood periodically and being prone to ponding can accumulate deep layers of organic materials and sediments. These soils are prone to wind and water erosion when drained and or bared. If the sub soil clays become the surface soil, they are hard-setting, cracking clays, with strong impeded drainage when wet.

Alluvial soils: highly variable, lack developed profiles and may be multi-layered silts, sands, gravels and clays. Alluvial fans and terraces have been amongst the first casualties of land degradation through active soil erosion and periodic gullying.

(b) Current Landuse

A breakdown of the major landuse and ownership categories within the catchment is shown in Tables 4.1 and 4.2 and Appendix 9, Map 1.

Table 4.1 Landuse within the catchment, May 1998
(Woodward Clyde 1998c)

Landuse	Area (to the nearest 500ha)	Percentage
Annual Based Pasture (eg: introduced grasses and weeds)	71,000	41%
Perennial Annual Mix (eg: phalaris based)	29,500	17%
Forested (>50% canopy cover) (eg: State Forests)	22,500	13%
Annual with subdominant perennials (eg: native grasses)	19,000	11%
Cropping/Bare Area	12,500	7%
Woodland (10-50% canopy cover) (eg: hill tops with a scattering of trees)	11,500	7%
Commercial Plantations (eg: pines)	2,500	1.5%
Pasture Establishment/Bare Area	2,500	1.5%
Urban Land	500	0.5%
Perennial Pasture dominant (eg. lucerne)	500	0.5%a

Table 4.2 Landuse/ownership within the catchment:

Ownership/Landuse	Hectares	Percentage
Rural Land	160,000	93.0 %
State Forest	8,000	4.5 %
Public Roads and Reserves	2,000	1.0 %
Urban Land	500	<0.5 %

(c) Agricultural Statistics

Agriculture is the main landuse within the catchment.

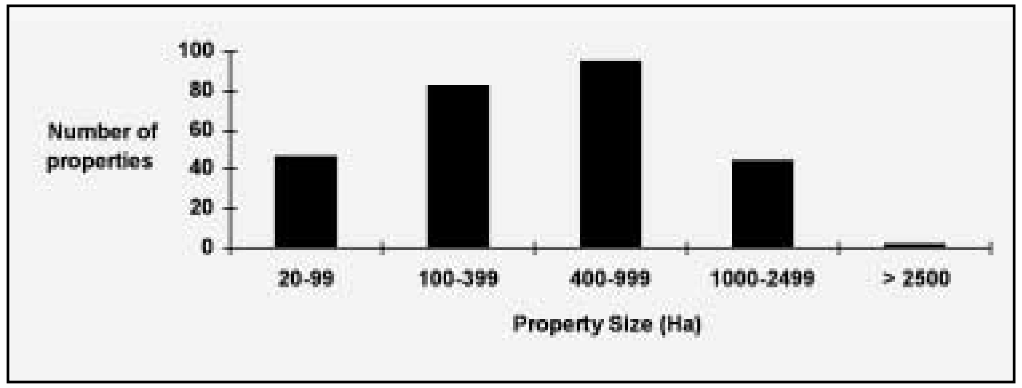
How some of the Agricultural Estimates were derived:

Unless otherwise stated, Upper Billabong catchment estimates for the number of farm businesses, gross value of agricultural production, beef and sheep production, crop production, pasture seed production, hay production, pasture establishment, tree planting, remedial works, fertiliser and soil conditioner usage, have been derived from Australian Bureau of Statistics data (ABS 1996a). The estimates have been derived through determining that 14% of Culcairn Shire's and 80% of Holbrook Shire's agricultural production lies within the Upper Billabong Catchment. These percentages have been taken from ABS agricultural figures for each of the shires and combined to derive estimates for the catchment. Through this approach, agricultural influences to the east and west of the catchment will slightly affect the accuracy of the overall results.

Number of Farms and Size

As stated previously in Appendix 2, within the Upper Billabong Catchment there are 270 independent property owners with properties greater than 20 hectares in size (Figure 4.1 based on Culcairn and Holbrook Shire records). It is estimated there are 188 farms within the catchment that earn greater than $5,000 per annum from agriculture (ABS 1996a).

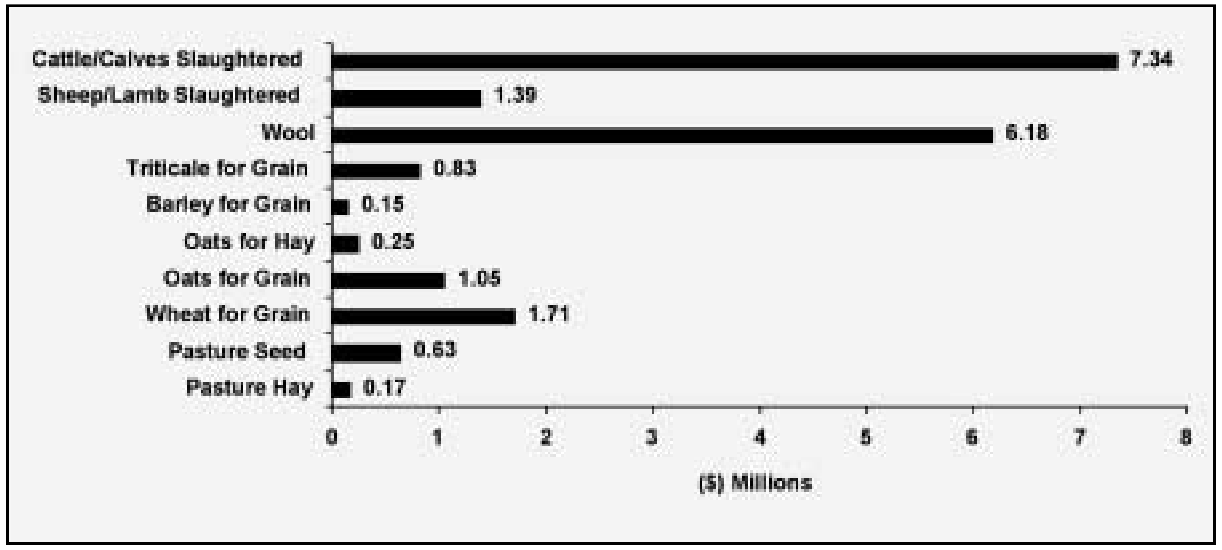
Figure 4.1 Comparison of farm size in the Upper Billabong catchment (Culcairn and Holbrook Shire property records 1997)



Gross Value of Production

The total gross value of production (GVP) generated from agriculture within the Upper Billabong catchment was estimated at $22.6 million in the period April 1995 to March 1996. Table 4.3 shows the main GVP comes from sheep and cattle. Figures for wheat are probably higher than reality, whilst figures for barley are possibly lower due to cropping influences to the west of the catchment impacting on the figures. Canola in recent times has become a more prominent crop.

Table 4.3 Gross Value of Production figures for the catchment from major agricultural enterprises (ABS 1996a)



Within the Upper Billabong, there are 270 independent property owners with properties greater than 20ha.

Beef and Sheep

Beef and sheep production are the main agricultural enterprises within the catchment. Catchment estimates for beef and sheep numbers as at 31 March 1996 (Table 4.4) show:

- 72% of farms have sheep and 84% have beef cattle
- the total numbers of cattle and sheep are 57,756 and 228,005 respectively.

Table 4.4 Beef and Sheep figures for the catchment (ABS 1996a)

Item	% of Farms	Number
Breeding ewes, one year and over	66	139,444
All other sheep (excluding breeding ewes)	72	88,561
Sub Total		228,005
Beef cattle	84	57,756
Total		285,761

Crop, Pasture Seed and Hay

Catchment estimates for crop, pasture seed and hay production for the period April 1995 to March 1996 (Table 4.5) show in that year:

- 4% of the catchment area was utilised for cropping
- and 2% for hay production.

Table 4.5 Crop, Pasture Seed and Hay Production 1995/96 (ABS 1996a)

Item	% of Farms	Amount (Tonnes) April 1995 - March 1996	Area Sown (ha) April 1995 - March 1996
Wheat	17	6,861	2,291
Oats	36	6,130	3,263
Barley	4	708	316
Triticale	17	4,048	1,611
Pasture Seed	7	180	679
Pasture Cut for Hay	49	13,694	3,557
Total		31,629	11,717

Cropping area has also been obtained from the “Habitat Mapping” undertaken by Woodward Clyde in May 1998 (Appendix 9, Map 1). It was found that 12,575 ha or 7% of the catchment is dedicated to cropping.

Pasture Establishment and Perennial Pastures

Catchment estimates for pasture establishment during the period April 1995 to March 1996, and in total up until March 1996 (Table 4.6) show:

- 43% of farms have undertaken (at varying levels) perennial grass based pasture establishment
- 17% of the catchment has been sown to a perennial grass based pasture
- 1% to a Lucerne based pasture and
- 3% was sown to pasture between April 1995 and March 1996.

Table 4.6 Pasture Establishment (ABS 1996a)

Item	% of Farms	Area Sown (ha) April 1995 - March 1996	Area (ha) Total at March 1996
Mix of Perennial Grasses and Legumes	43	2,150	28,714
Mix of Annual Grasses and Legumes	23	1,715	15,666
Sown Grasses	7	395	1,405
Pasture Legumes (excl Lucerne)	5	124	1,818
Lucerne (Pure)	16	171	1,234
Lucerne and other Species	7	129	382
Total		4,683	69,505

The figures on perennial pastures in the above table are confirmed by the "Habitat Mapping" undertaken by Woodward Clyde in May 1998 (Appendix 9, Map 1), the results of which are summarised in Table 4.7 below.

Table 4.7 Perennial Pasture Types (Woodward Clyde 1998c)

Perennial Pasture type	Area (ha)	% of total catchment
Perennial species dominant (primarily Lucerne)	612	0.5%
Mix of Perennials and Annuals (primarily phalaris based)	29,629	17%
Annual species dominant with some perennials (primarily native based)	18,943	11%

Fertiliser and Soil Conditioner Usage

Catchment estimates for fertiliser and soil conditioner usage for the period April 1995 to March 1996 (Table 4.8) show in that year:

- 49% of farms added phosphatic fertiliser
- 22% of the catchment area had fertiliser and
- 1% had soil conditioner applied.

Table 4.8 Fertiliser and Soil Conditioner Usage (ABS 1996a)

Item	% of Farms	Amount (Tonnes)	Area (ha) April 1995 - March 1996
Mainly nitrogenous fertiliser	13	312	3,952
Phosphatic fertiliser	49	3,219	26,989
Compound and blended fertiliser	27	651	6,574
Sub Total		4,182	37,515
Lime used to correct or stabilise soil acidity	17	2,917	1,441
Dolomite used to correct or stabilise soil acidity	0.5	60	41
Gypsum used to correct soil physical problems	2	131	92
Sub Total		3,108	1,574

(d) Other significant industries

Of particular significance to rural landuse in the Upper Billabong is the establishment of a softwoods processing mill in Holbrook by the Austral Softwoods Holbrook Pty Ltd. The mill employs 104 people and processes about 158,000m3 of logs. Little more can be said about the business and its affect on natural resources in this early phase of its development in Holbrook. However, its influence should not be underrated. Businesses of this sort have the potential to engender confidence in alternative landuses on farms in the district.

(e) Climatic data

Table 4.9 and Figure 4.2 give a summary of climatic data for the Upper Billabong Catchment.

Table 4.9 Climatic data for the Upper Billabong Catchment
(Bureau of Meteorology 1997)

Climatic data type	Source	Period	Reading
Average annual rainfall	Holbrook Post Office	1948 - 1994	695 mm
Highest rainfall year (1973)	Holbrook Post Office	1948 - 1994	1,075 mm
Lowest rainfall year (1967)	Holbrook Post Office	1948 - 1994	247 mm
Lowest average rainfall month	Holbrook Post Office	1948 - 1994	43 mm (Feb)
Highest average rainfall month	Holbrook Post Office	1948 - 1994	76 mm (Jun)
Highest number of mean raindays	Albury Pumping Station	1970 - 1985	15days (Aug)
Lowest number of mean raindays	Albury Pumping Station	1970 - 1985	6 days (Feb)
Mean daily maximum temperature	Albury Pumping Station	1970 - 1985	22°C
Mean daily minimum temperature	Albury Pumping Station	1970 - 1985	8.2°C
Lowest mean monthly temperature	Albury Pumping Station	1970 - 1985	2°C (Jul)
Highest mean monthly temperature	Albury Pumping Station	1970 - 1985	31°C (Feb)
Mean number of days with frost	Wagga AMO/AWS	1941 - 1996	52.6 days
Mean number of days with hail	Wagga AMO/AWS	1941 - 1996	1.9 days
Mean daily pan evaporation	Wagga AMO/AWS	1941 - 1996	5 mm
Months rainfall exceeds evaporation	Wagga (evap) Holbrook (rain)	1941 - 1996	Jun - Aug
Mean days of strong wind	Wagga AMO/AWS	1941 - 1996	16 days

Figure 4.2 Mean monthly rainfall (Holbrook P.O.), Temperatures (Albury Pump Station) and Pan Evaporation (Wagga Wagga)
(Bureau of Meteorology 1997)

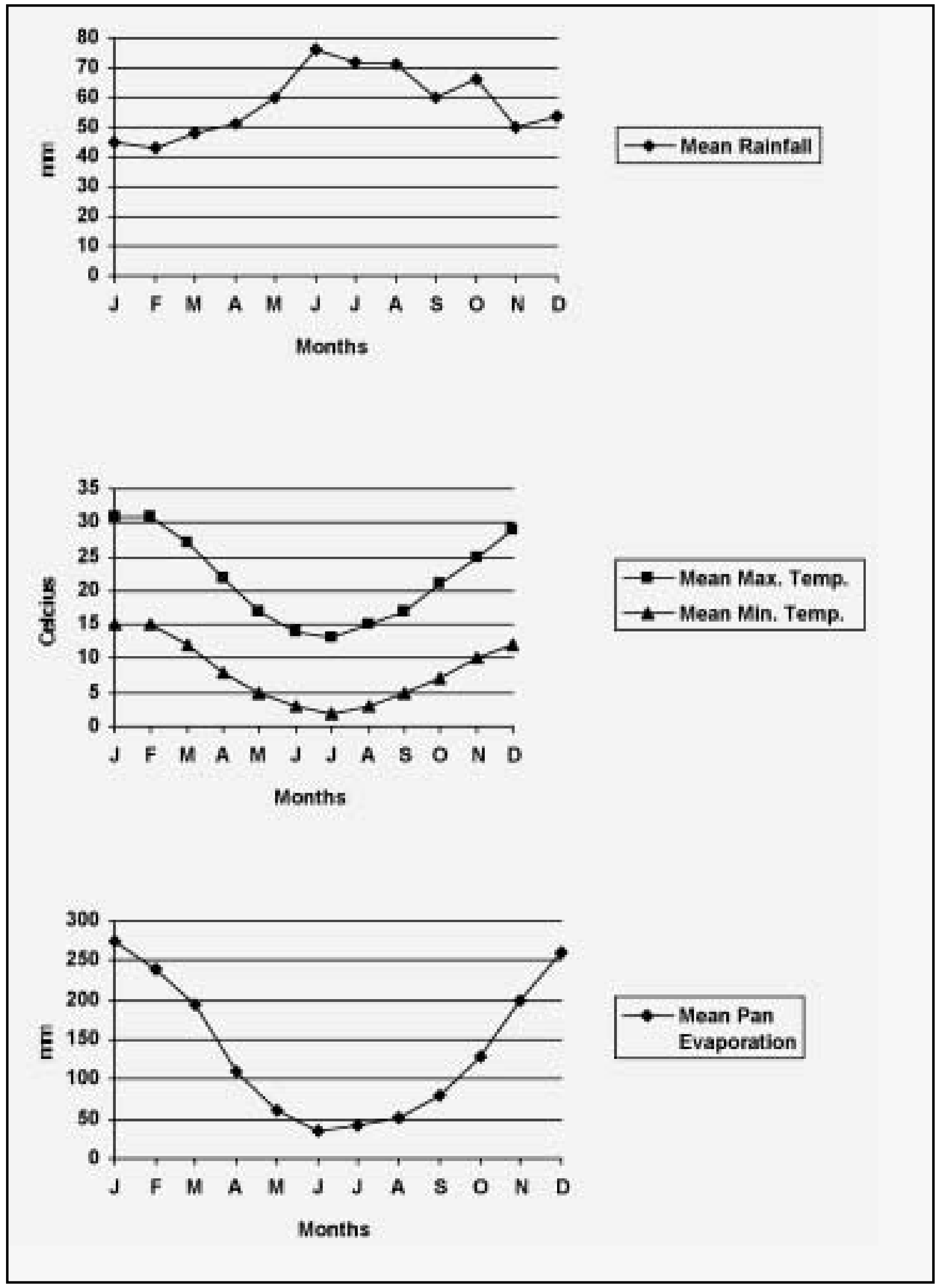
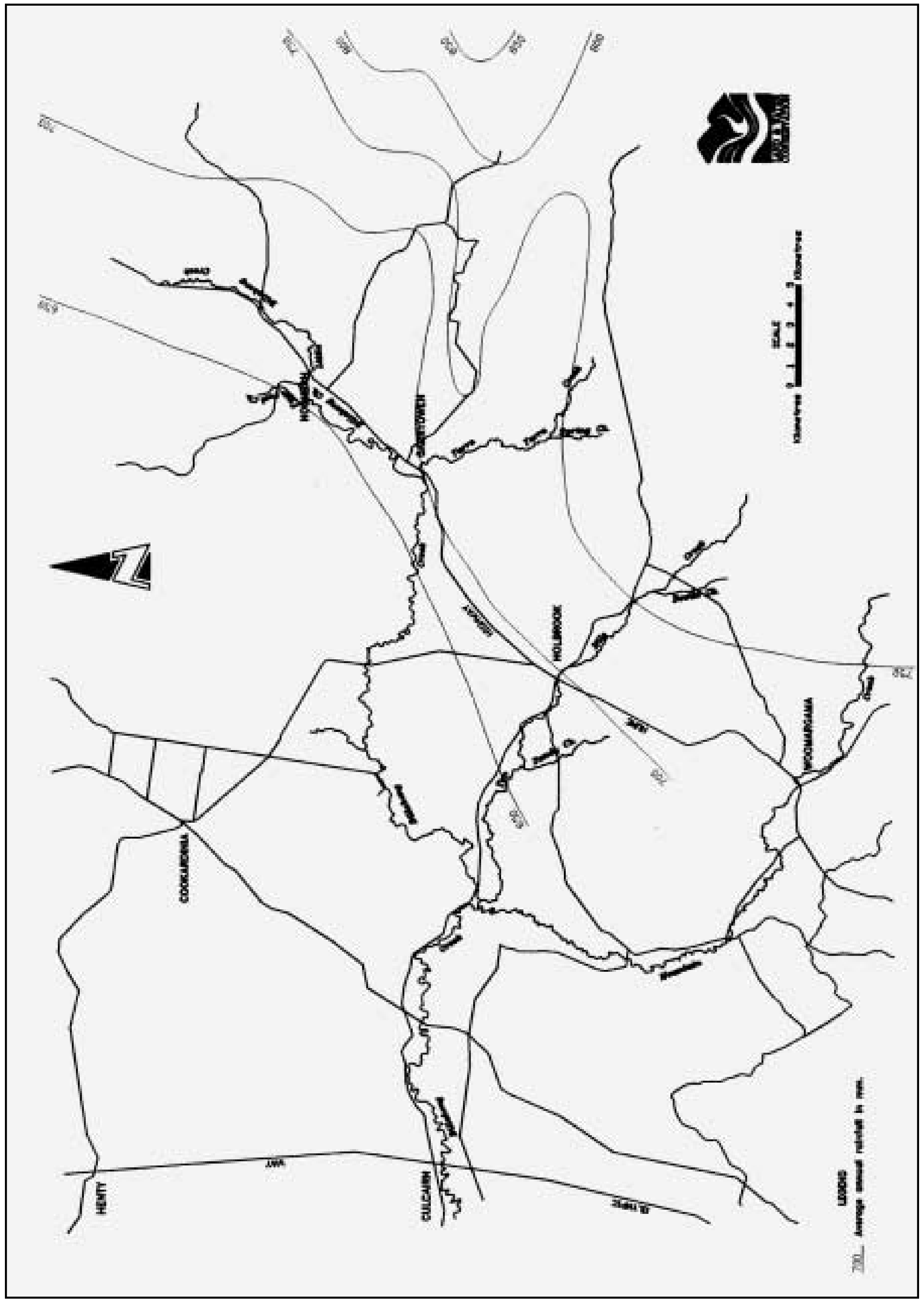


Figure 4.3 shows the rainfall contours for the district derived from 17 point sources (Bogoda 1992). Ten of these seventeen point sources are within the Upper Billabong Catchment and seven just outside, and were obtained from the Bureau of Meteorology.

Figure 4.3 Rainfall contours for the Holbrook district (Bogoda 1992)



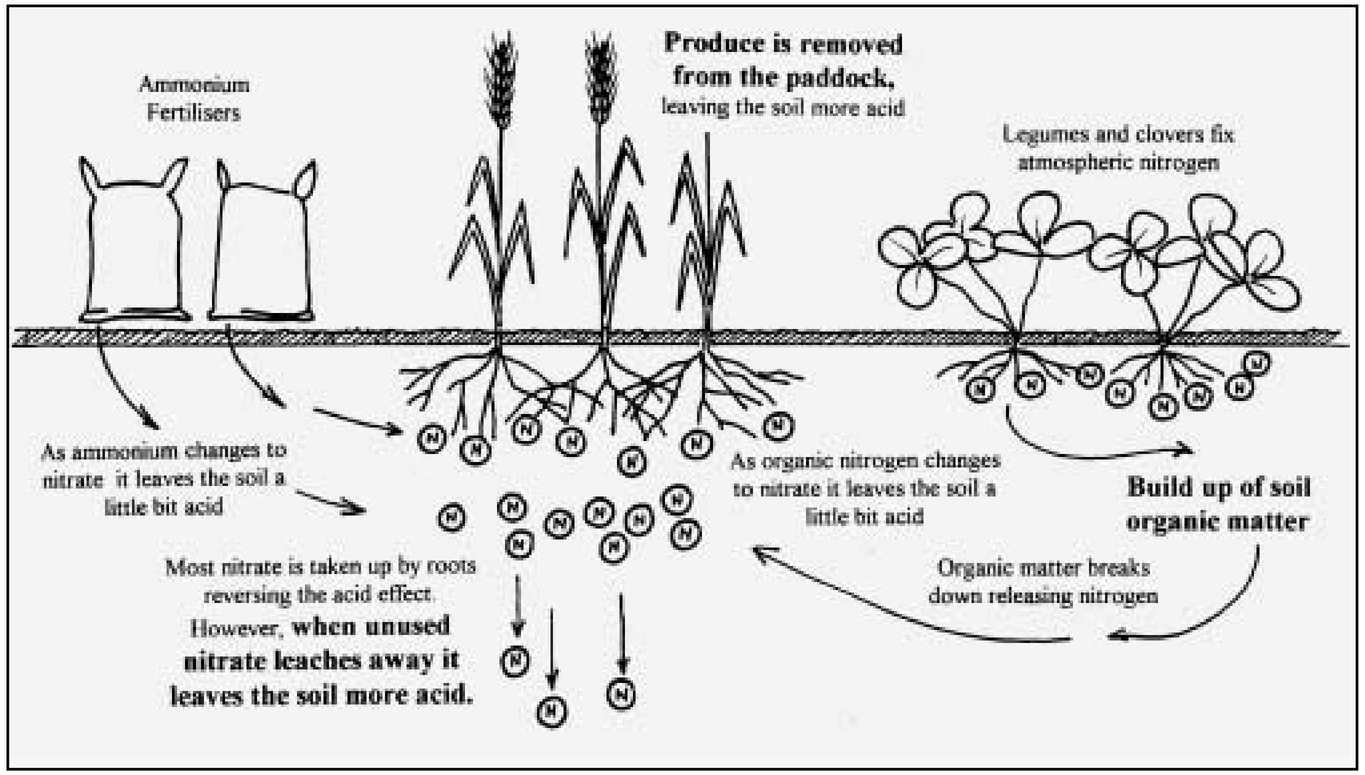
ISSUE D: SOIL ACIDITY

Causes of Soil Acidity

Soils acidify naturally as they weather over thousands and millions of years. The acidity of any soil varies according to the type of rock it comes from, the length of time it has weathered, and the local climate. As a result, some soils are very acid (low pH) while others are more alkaline (high pH). Soil acidity is particularly prevalent in the high rainfall cropping and pasture zones of eastern Australia, where rainfall exceeds 500 millimetres (Fenton 1994, Fenton *et al.* 1996). Agriculture contributes to acidification in three main ways (Figure 4.4).

The most acidifying fertilisers are ammonium sulphate and monoammonium phosphate (MAP)

Figure 4.4 The three main causes of soil acidity
(Fenton 1994; Fenton *et al.* 1996)



1. Leaching of Nitrate Nitrogen

Nitrate nitrogen is the form of nitrogen used by plants. It is either produced in the soil by the breakdown of organic matter, supplied as nitrate fertiliser, or produced chemically from ammonium type fertilisers. The breakdown of organic matter and the chemical changes of the ammonium type fertilisers leave the soil more acid. This effect, though, is usually temporary because the soil returns to its original pH after the nitrate nitrogen is taken up by plant roots. However if there is more nitrate nitrogen than the plant can use, it drains away (leaches) into the groundwater system, leaving the soil permanently more acid.

The amount of acid added to the soil by ammonium nitrogen fertilisers as they break down to the nitrate form varies according to the type of fertiliser. The most acidifying are ammonium sulphate and monoammonium phosphate (MAP). Less acidifying are urea, ammonium nitrate, diammonium phosphate (DAP) and anhydrous ammonia. Fertilisers that contain nitrate nitrogen (other than ammonium nitrate) are not acidifying, and in fact have an alkaline effect.

2. Build Up of Organic Matter

Over the last 50 years the regular use of fertiliser and improved pastures, particularly medics such as subterranean clover, have increased the amount of organic matter (high in nitrogen) in the soil by up to four times.
While organic matter improves the soil structure, it also makes the soil more acid. However, organic matter will not build up indefinitely, and when a new equilibrium is reached, where the build up balances the breakdown, the acidification process stops.

3. Removal of Produce

Grain, pasture and animal products are slightly alkaline and their removal from a paddock leaves the soil slightly more acid. If very little produce is removed such as in wool production, then the system remains almost balanced. If, however, a large quantity of produce is removed, particularly clover or lucerne hay, the soil is left significantly more acid. Removal of produce by burning - for example burning of stubble - leaves the soil slightly more alkaline.

Superphosphate has virtually no direct effect on soil pH, but it stimulates growth of clover and other legumes, resulting in a build up of organic matter which in turn increases soil acidity. Also there is an increase in nitrate nitrogen in the soil that comes with the higher levels of organic matter. This increases the likelihood of soil acidification from leaching of nitrate nitrogen.

Testing Soil pH (Hall 1997)

There are two laboratory techniques for measuring soil pH: one measures the pH of the soil mixed with water, and the other the pH of soil in Calcium Chloride (Ca Cl2) solution. Figures obtained through these two methods will differ.

pH in Water (pHw) The results of this method more closely reflect current soil conditions than the calcium chloride method and therefore the actual pH to which plants are exposed.

pH in Calcium Chloride (pHCa) The readings given by this method are usually lower than the water method by 0.5-1.0 pH units, but more readily predict response to lime.

The calcium chloride method shows less seasonal variability than the water method and is a useful diagnostic measurement as soils can be sampled at anytime during the year and more confidently compared with previous results.

Plant Responses

Most plants prefer a $pH_{(w)}$ range between 6.0 and 7.5 (pH $CaCl_2$ 5-6.5), but will grow outside this range although yield may be affected. Table 4.10 shows the preferred range of common species.

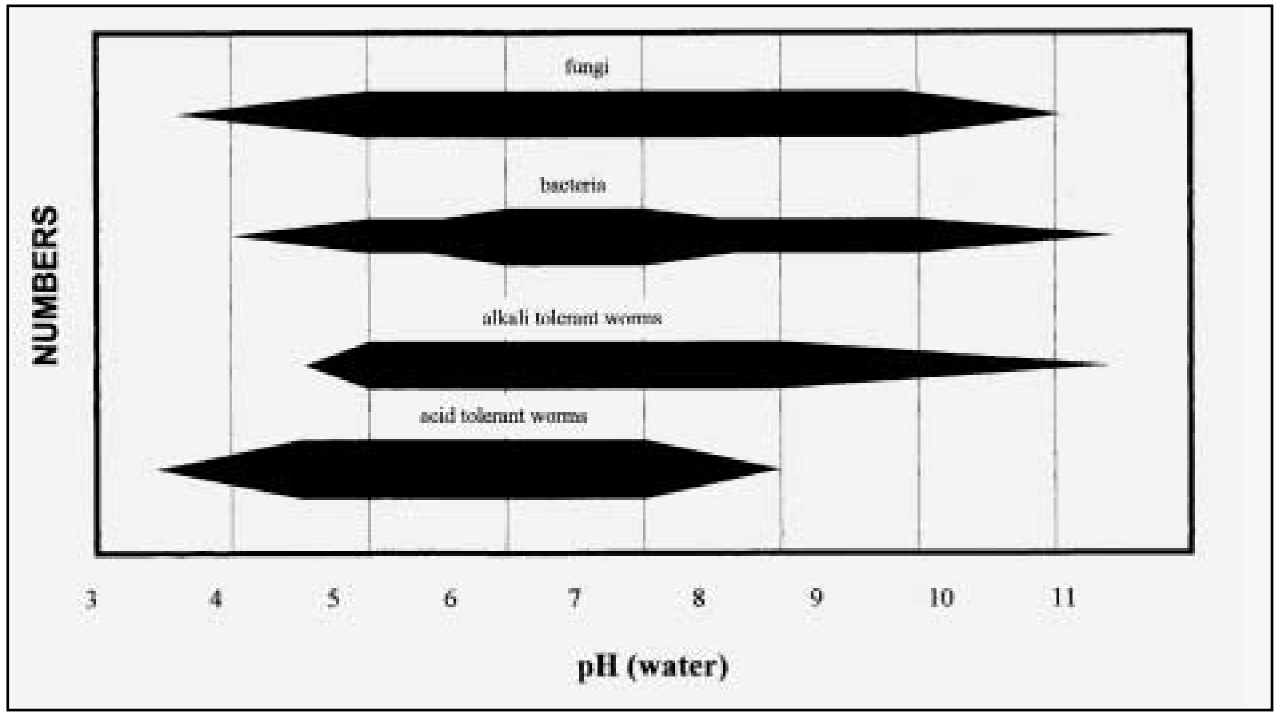
Table 4.10 Preferred $pH_{(w)}$ ranges for plants (Hall 1997)

Crops	$pH_{(w)}$	Pasture	$pH_{(w)}$
Soybeans	6.0-7.0	Medics	6.5-8.5
Barley	6.0-7.0	White Clover	6.0-7.0
Canola	6.0-7.4	Phalaris	6.0-8.1
Peas	6.0-7.5	Red Clover	6.0-8.3
Sunflowers	6.0-8.0	Cowpeas	5.5-7.0
Lupins	5.0-7.0	Ryegrass	5.3-7.0
Wheat	5.1-8.4	Sub Clover	5.2-7.0
Triticale	4.3-8.3	Serradella	5.2-7.0
Oats	4.2-8.0	Cocksfoot	5.0-7.6

Soil Biological Activity

Soil biological activity is also affected by soil pH. This becomes important when approaching the extremes of soil acidity and alkalinity, where for example various species of earthworm and nitrifying bacteria disappear. Rhizobia strains vary in their sensitivity to soil pH, and have preferred ranges within which they are effective (Figure 4.5).

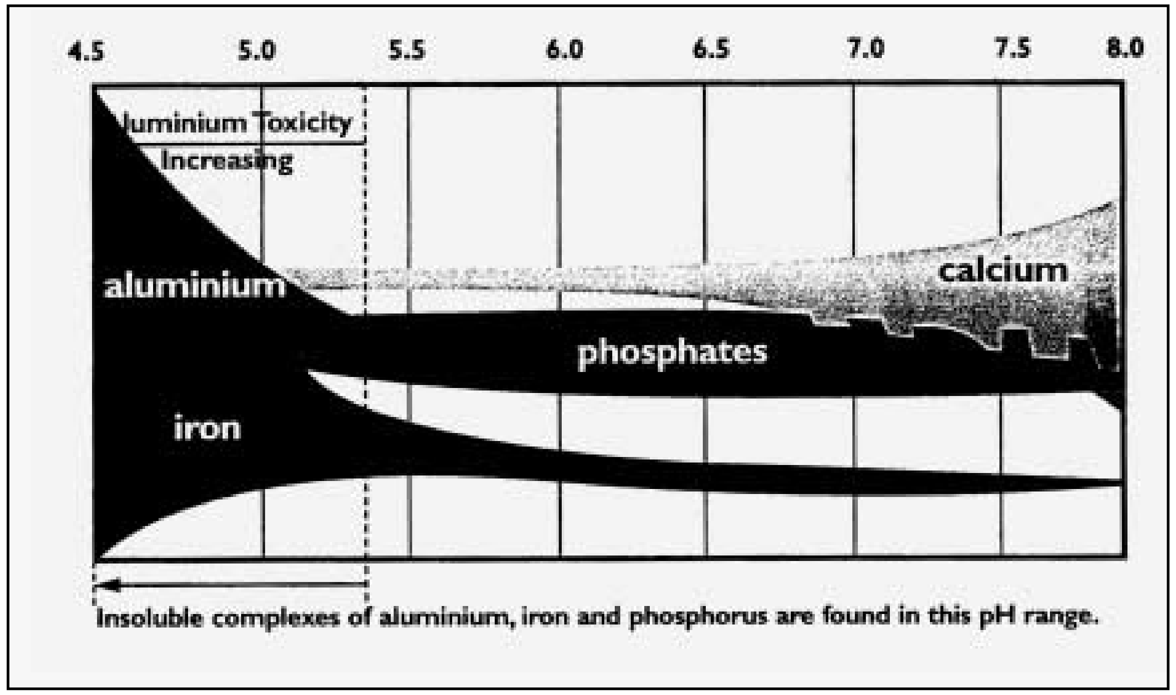
Figure 4.5 Soil biological activity and soil pH (Hall 1997a)



Nutrient Availability

Soil pH will influence both the availability of soil nutrients to plants and how the nutrients will react to each other. At low pH many nutrients become less available to plants, while others such as iron, aluminium and manganese become toxic to plants. In addition, aluminium , iron and phosphorus combine to form insoluble compounds (Hall 1997a). Figure 4.6 shows that at a pH below 5.5 in water, aluminium starts forming complexes with phosphorus - and its effect on phosphorus and its toxicity to plants rapidly increases as pH drops below 5.5. This may be compounded by increasing iron toxicity in acid soils.

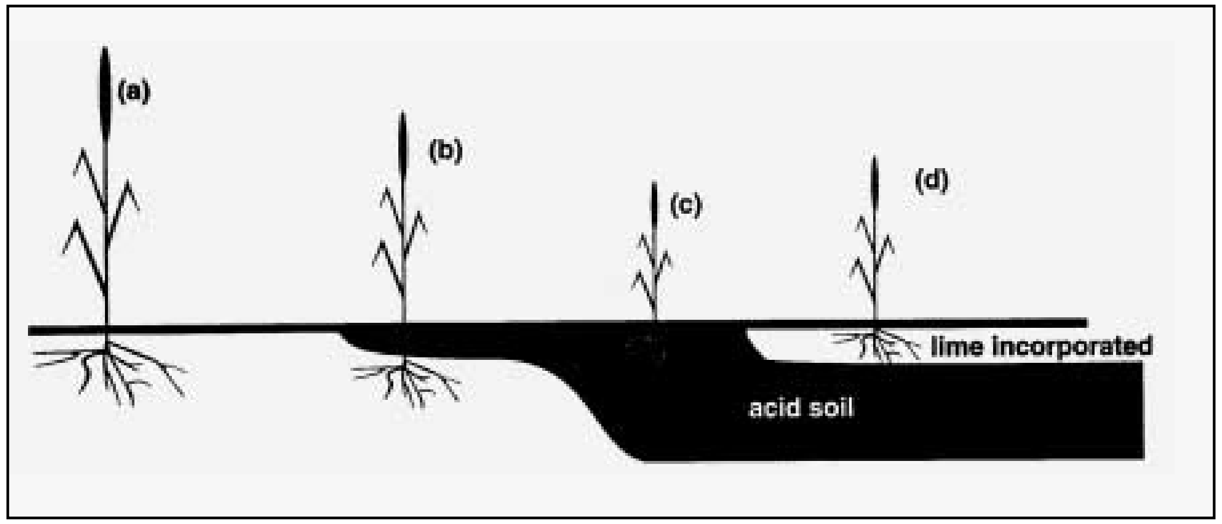
Figure 4.6 The effects of soil pH on Aluminium (Hall 1997c)



Subsoil Acidity

As shown in Figure 4.7, when pH in the surface soil drops to 4.9 (pH CaCl2) or below, acidity starts to move into the subsoil. Once the subsoil is acid only the more tolerant plants such as oats, triticale, subclover and cocksfoot can be economically grown. Even if lime is applied and incorporated into the topsoil, acidity will not be corrected. Less tolerant plants will germinate but will not develop root systems required for long term survival (Plant d in Fig.4.7). Subsoil acidity means permanent soil degradation and a massive problem for future landholders.

Figure 4.7 The effect of subsurface acidity on a sensitive species such as barley (Fenton 1996)



For further information:

"*Soil Acidity and Liming.*" Agfact. NSW Agriculture (1996).

"*Soil Acidity in Agriculture.*" Agnote. NSW Agriculture (1994)

"*Understanding Soil pH*",

"*Causes of Soil Acidity*" and

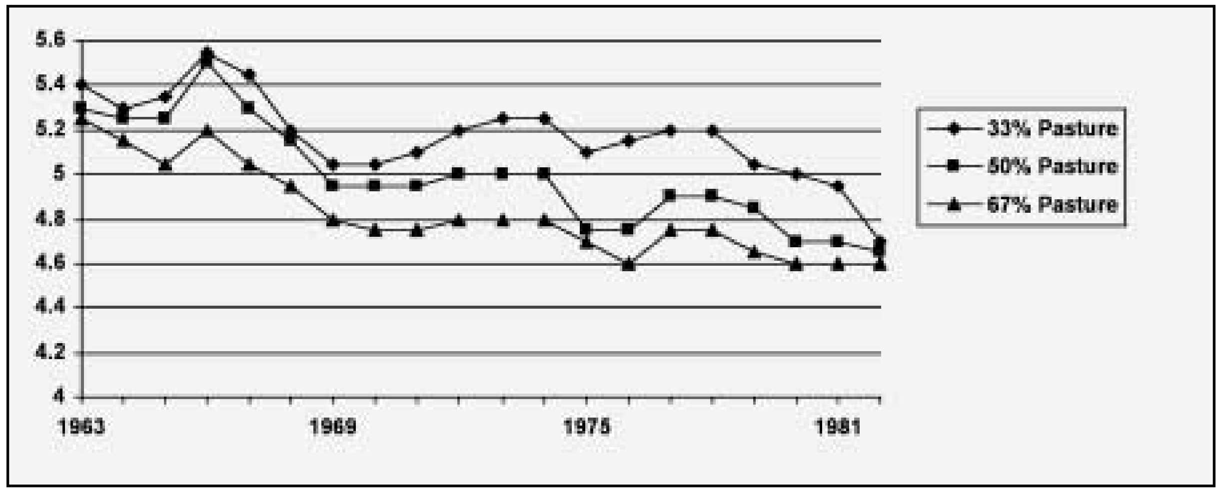
"*Understanding Aluminium in the Soil*" - Soil Sense Notes DNRE - Rutherglen (1997).

Current Status of Soil Acidity

Agricultural practices can greatly increase the rate of acidification. In NSW there are examples of neutral or slightly acid soils that have developed a serious acidity problem in less than 30 years. Research has shown that it takes 30 to 50 years for subterranean-clover-based pasture to induce a soil pH decline of one unit (Dann 1987) and that acidification rates are lower on strongly acid soils (Scott *et al.* 1997). Figure 4.8 shows the change in soil pH that has resulted from normal agricultural practices. The rotation with the most pasture (67%), a ratio of two years pasture to one year cropping, acidified fastest.

Appendix Map 4 shows the extent of soil acidity in the Upper Billabong by presenting the lime requirements to bring soil pH to 5.2 (CaCl).

Figure 4.8 Soil pH in three different pasture crop rotations at Wagga Wagga 1963-1982 (Fenton 1994)



Studies being undertaken at “Brooklyn” (Book Book), approximately 50 kilometres north of Holbrook, in a 650 mm rainfall zone, are indicating that soil acidification rates under perennial pasture are slower than under annual pastures and annual pasture/crop rotations (MASTER Experiment, Field Day Handout). The table below shows the acidifying effect of various farm enterprises.

Table 4.11 The acidifying effect of various farm enterprises (Hall 1997b)

Enterprise	kg of lime/ha/year to balance acidification
Grazed Perennial Pasture	100 to 200
Grazed Annual Pasture	150 to 200
Wheat/Lupin Rotation	200 to 300
Lucerne Hay	200 to 700

A survey of soil acidity undertaken within the Upper Billabong Catchment found the following results:

Table 4.12 Soil Acidity related soil analysis in the Upper Billabong (pers. comm. Fanning 1998)

Area representative of the sampling	13,840 ha
Number of paddocks surveyed	326
*Estimated Average Pre-European pH (0-20cm)	4.2 - 5.4
Average pH - CaCl (0-10cm)	4.6
Average pH - CaCl (10-20cm)	4.4
Minimum pH - CaCl (0-20cm)	3.8
Maximum pH - CaCl (0-20cm)	6.9
Average Al% (0-10cm)	11.3
Average Al% (10-20cm)	18.6
Minimum Al% (0-20cm)	0.3
Maximum Al% (0-20cm)	61.9

* Based on soil sampling in as close to “natural areas” within the Upper Billabong Catchment. “Natural” soil acidity tended to be greatest in more skeletal soils in the higher rainfall zone, (pH 4.2-4.9) whilst the alluvial flats tended to have reduced soil acidity (pH 4.9-5.4).

Future Trends and Implications Associated with Soil Acidity

The base or lowest soil acidity level that the soils of the catchment can obtain is pH 3.8 (CaCl) (pers. comm. Fanning 1999). It will take hundreds of years before the soils of the area will start dropping below this level (pers. comm. Sykes 1999).

Assuming current landuse practices are maintained and that we are working with the soil acidity averages for the catchment, the predicted average time within which this base level of pH below 4.0 will be obtained is an estimated 50 years. However, caution needs to be applied in using these averages as the rates will vary enormously depending particularly on the soils and land management. Under certain conditions the rate might be less than 20 years, with some soils having already reached these base levels (pers. comm. Fanning 1999). It should also be noted that as soil acidity increases, the rate of acidification decreases.

The implication of the current situation and predicted future trend is that the ability to produce various crops and pastures will become increasingly limited. There will also be the added problem of increasing subsoil acidity which will be far more difficult to ameliorate in the short term.

3. ISSUE E: SOIL EROSION

Soil erosion is the removal (eating away) of soil material by wind or water at rates in excess of formation.

Causes of Soil Erosion

The causes of soil erosion are often complex. Cultural, institutional, social, economic, environmental and political factors play varying, interrelating roles.

The causes of erosion primarily relate to clearing, burning, agricultural landuse (particularly landuse that results in reduced ground cover) and rabbits. The landuse history has had a major effect on the degree of degradation. Droughts and floods, although natural, have at varying times exacerbated erosion. Fire, both natural and human induced has also had an exacerbating impact.

Erosion Prior to Human Settlement

Before extensive erosion and accelerated land drainage, mobilised sediments, minerals and nutrients were intercepted as natural resources, converted into biomass and recycled through catchment ecosystems. Prior to human settlement, under similar climatic conditions, depositional soils and regoliths were continuously growing and expanding (aggrading), not depleting and shrinking (degrading) (Woodward-Clyde 1998a).

Erosion, the Current Status and Future Trends

Gully and Streambank Erosion

Detailed mapping of gully and streambank erosion (including the classification of erosion severity), was undertaken by the DLWC in the early 1990s based on 1980-87 aerial photography. This information has been updated and is presented in Appendix Map 2 and Table 4.13. Gully erosion is a more obvious form of soil erosion and consists of open, incised and unstable channels. By definition, streambank erosion is confined to incised drainage lines and results from lateral undercutting and abrasion (Lucas undated).

The causes of soil erosion are often complex. Cultural, institutional, social, economic, environmental and political factors play varying, interrelating roles.

Table 4.13 Stream and gully erosion within the Upper Billabong (Woodward-Clyde 1998a)

Type of Erosion	1998	Prediction 2030
Length of stream and gully erosion	470 km	Low 500 km High 750 km

Gully and streambank erosion have dissected regoliths, drained aquifers and destroyed riparian ecosystems throughout the catchment. The dissected regoliths are acting as a discharge channel for salts and nutrients. The extent of recent and active gullying is disturbing and on the increase in a few areas of the catchment. However, overall, the current situation is not as bad as it was prior to the late 1950s, when much more of the catchment was actively gullying. Based on surveys and investigations, it is estimated that three or four serious gully erosion cycles have occurred in the Upper Billabong since European settlement. Buried soils overlain by various alluvial strata along Lunt's Creek indicate erosion may have occurred periodically under aboriginal occupation (Woodward-Clyde 1998a).

Surprisingly, very little of the sediments are being deposited in the Upper Billabong; mostly they are transported further down stream (Woodward-Clyde 1998a). This of course means that downstream users suffer the consequences of erosion in the Upper Billabong.

Sheet and Rill Erosion

Detailed mapping of sheet and rill erosion was undertaken by the DLWC in the early 1990s based on 1980-87 aerial photography. This information has been updated and is presented in Map 2 and Table 4.14.

Sheet erosion involves the removal of a fairly uniform layer of soil from the land surface by raindrop splash or runoff. No perceptible channels are formed.

Rill erosion is the removal of soil by runoff, with numerous small channels, up to 30cm deep being formed. Rill erosion typically occurs on recently cultivated or disturbed soils (Lucas, undated). Rill erosion is locally significant in some areas, but not a major problem in the catchment at present. On the other hand sheet erosion is wide spread (Woodward-Clyde 1998a).

Table 4.14 Sheet and rill erosion within the Upper Billabong (Woodward-Clyde 1998a)

Type of Erosion	1998	Prediction 2030
Area of sheet/rill erosion	18715 ha	Low 20 000 ha High 25 000 ha

Large areas influenced by sheet erosion are now thick stands of eucalypt regeneration. The competitive nature of the eucalypts is limiting the establishment of ground cover (Woodward-Clyde 1998a).

Wind Erosion

Wind erosion is the detachment and transport of soil by wind. It is a significant form of degradation in drier cropping areas and on dry soils with inadequate vegetative cover. Like other forms of erosion, most damage occurs as a result of a small number of infrequent major events.

Wind erosion in a 1987-88 Land Degradation Survey of NSW was regarded as severe west of Holbrook. The traditional grazing areas in the upper parts of the catchment are, to a lesser extent, prone to wind erosion. However, during dry periods the risk increases, particularly on granite soils with low vegetative cover (Lucas, undated).

4. ISSUE F: WEEDS

A weed is a plant growing where it is not wanted. Any species in the plant kingdom can be a weed. Many plants previously used as ornamentals, medicinal and culinary herbs, and crops, are today's weeds.

The criteria for a species to be classified as a weed usually includes an ability of the species:

- to spread beyond its original distribution, becoming naturalised in new habitats;

and

- to have a relatively high population growth rate, as well as other undesirable characteristics (Parsons & Cuthbertson 1992).

Plants can be weeds in terms of both agriculture and remnant vegetation, but many are specific to either one or the other. Some plants are desirable in one situation but a weed in another: for example bracken fern belongs in native vegetation but when it moves onto farm land it is considered an agricultural weed. Conversely, phalaris is a desirable farm plant, but an environmental weed when it invades native vegetation. So it is often the situation or context that determines a plant's status, not the plant itself (Stelling 1998).

At least 10 per cent of Australia's flora now consists of introduced species (Campbell 1994). Flora surveys undertaken by Burrows (1996) within Pulletop and Benambra State Forests (as they then were) found introduced species to represent 22% and 29% respectively of the total plant species found in these sites.

The listing of weeds within the Upper Billabong catchment is potentially large and open to debate. Table 4.15 provides details of the noxious weeds under legislation within the Upper Billabong catchment (pers. comm. Hibberson 1998; McNaughton 1998).

The action for the different noxious weed categories are as follows:

W1 - Weed must be notified to local council then fully and continuously suppressed and destroyed.

W2 - Weed must be fully and continuously suppressed and destroyed.

W3 - Weed must be prevented from spreading and its numbers and distribution reduced.

W4a - Shall not be sold, propagated or knowingly distributed. No part of plant can grow within 3m of boundary.

W4b - Shall not be sold, propagated or knowingly distributed. Established plants must be prevented from flowering and fruiting.

W4c - Shall not be sold, propagated or knowingly distributed. Occupier must prevent spread to adjoining property.

W4d - Shall not be sold, propagated or knowingly distributed. Any tree 3m in height or less must be removed. Any tree within half a kilometre of remnant urban bushland as defined by SEPP 19, and not deemed by council as having historical or heritage significance, shall be removed.

W4f - Shall not be sold, propagated or knowingly distributed. Occupier must implement biological control or other control program directed by the local control authority.

For more Information: Culcairn or Holbrook Shire weeds inspector.

Noxious Weeds of Australia. (Parsons and Cuthbertson, 1992). Inkata Press.

Noxious Weed Control Handbook - Herbicide Control. (Milvain, 1995). NSW Agriculture.

Causes of Plants becoming Weeds

The factors causing a plant to become a weed are primarily:

- a plant, seed, or plant material being introduced or spread into an area
- disturbance or imbalance to the natural system. Examples could include clearing, road grading and grazing.

Examples of plants introduced into Australia that have now become noxious weeds within the catchment include:

- blackberry, which was imported to Tasmania in a pot from England in 1843, “three years later the vines were out of control”. As late as the 1890s a Victorian Government botanist was encouraging blackberry planting;
- St John’s Wort: in the 1880s a midwife in Bright introduced St John’s Wort as a traditional drug for inducing human abortion. She planted the seeds in the garden, “within a few years the wort was growing on properties throughout the north-eastern mountain valleys” (Barr & Cary 1992).

Current Status and Future Implications associated with Weeds

Noxious weeds currently having the greatest impact on the catchment are St John’s Wort, Noogoora Burr and Blackberry. It is difficult to determine and quantify what the future impact of weeds will be within the catchment (pers comm. Hibberson 1998). Landuse and/or land management are the determining factors on the impact of weeds.

Table 4.15 Noxious Weeds Within The Upper Billabong Catchment
(pers.comm. Hibberson 1998; McHaughton 1998)

Weed species							
Botanical Name	**Common Name Category**	**Action for Noxoius Weed**	**Control Measure Recommended**	**Biological Control Catchment (High, Med, Low)**	***Degree of Concern in Catchment**	**Where Most Prevelant in the Environment**	**Impact on Agricultue or**
Ailanthus altissima	Tree of Heaven	W3 (Holbrook) W2 (Culcairn)	Mechanical removal of large trees. Spray. Cut stump. Basal bark spray.	None	Low (Holbrook and Culcairn)	Morgan’s Ridge. Isolated patches throughout catchment	
Alternanthera phloxeroides	Alligator Weed	W1 (Holbrook and Culcairn)	Chemical Spray	for aquatic plant form only	High (Holbrook) Low (Culcairn)	Woomargama	Can impair flow in waterways
Cenchrus incertus	Spiny Burrgrass	W2 (Holbrook) Not Applicable (Culcairn)	Competitive summer pasture (eg Consol lovegrass). Chemical Spray. Heavy Grazing. Cultivation - Integrated or on own.	None	High (Holbrook) Low (Culcairn)	Catchment clean at the moment	
Centaurea solstitalis	St Barnaby’s Thistle	W3 (Holbrook) W2 (Culcairn)	Legume based competitive pasture. Slashing if timing right. Chemical.	None	Medium (Holbrook and Culcairn)	North West section of catchment	Affect stock and domestic animals
Echium spp	Patersons Curse	W3 (Holbrook and Culcairn)	Spray. Spray and Graze. Pasture Improvement. Biological agents.	7 in total including a moth, weevils and beetles.	Low (Holbrook) Medium (Culcairn)	Widespread	Can lead to liver damage in stock. Hayfever in humans.
Hypericum perforatum	St John’s Wort	W3 (Holbrook) W2 (Culcairn)	Pasture Improvement. Grazing Management. Chemicals. Biological Control.	Defoliating beetle, aphid and mite.	Medium to High (Holbrook) High (Culcairn)	Predominantly East of Highway. Scattered throughout.	Causes photosensitivity in stock.

Table 4.15 Noxious Weeds Within The Upper Billabong Catchment cont...

Weed species							
Botanical Name	**Common Name Category**	**Action for Noxoius Weed**	**Control Measure Recommended**	**Biological Control Catchment (High, Med, Low)**	***Degree of Concern in Catchment**	**Where Most Prevelant in the Environment**	**Impact on Agricultue or**
Ligustrum lucidum *Ligustrum sinense*	Broadleaf privet Narrowleaf privet	W4b (Holbrook) Not Applicable (Culcairn)	Mechanical removal. Chemical spraying. If in hedge form prevent flowering and seeding.	None	High	Townships of Woomargama and Holbrook.	Causes breathing problems in humans.
Marrubium vulgare	Horehound	W3 (Holbrook) W2 (Culcairn)	Cut and burn. Pasture improvement and good grazing management. Chemical.	Under investigation (moths)	Medium (Holbrook) Low (Culcairn)	Scattered patches throughout the catchment	Contaminant of wool. If forced to graze meat may be tainted. Invades good pasture.
Onopordum spp.	Scotch Illyriun Thistles	W2 (Holbrook) W2 (Culcairn)	Establish strong perennial grass based pasture. Grub single plants at least to depth of 50mm - to avoid reshooting. Chemical.	Seed head weevil, stem weevil and seed head fly.	High (Holbrook) Medium - High (Culcairn)	Isolated areas predominantly West of the Highway	Vegetable fault in wool. Dense spines prevent grazing. Competitive in pastures.
Raphanus raphanistrum	Wild Radish	W2 (Holbrook and Culcairn)	Well balanced pasture with good grazing management. Chemical.	??	Medium (Holbrook and Culcairn)	Scattered mainly where cropping occurs.	Reduces crop and pasture yield, contaminates grain and pasture seed. Taints meat.
Rosa rubignosa	Sweet Briar	W3 (Holbrook and Culcairn)	Mechanical removal grubbing. Grazing with goats. Chemical.	None	Medium (Holbrook and Culcairn)	Mainly east of Highway	Harbour for pests. Reduced grazing due to prickles.

Weed species							
Botanical Name	**Common Name Category**	**Action for Noxoius Weed**	**Control Measure Recommended**	**Biological Control Catchment (High, Med, Low)**	***Degree of Concern in Catchment**	**Where Most Prevelant in the Environment**	**Impact on Agricultue or**
Rubus fruiticosus (agg. spp.)	Blackberry	W3 (Holbrook) W2 (Culcairn)	Mechanical removal. Slashing. Grazing with goats. Chemical.	Leaf rust fungus	High (Holbrook) Low (Culcairn)	East of Highway - predominantly North East of catchment	Harbour for pests. Blackberry can dominate all other vegetation. Invades water areas.
Solanum elaeagnifolium	Silver Nightshade.	W2 (Holbrook) W3 (Culcairn)	Chemical. Quarantine infestation and prevent seeding.	None	High (Holbrook and Culcairn)	Western areas of catchment	Competes with summer crops and pastures. Fruit is toxic to animals.
Sorghum halpense	Johnson Grass	W2 (Holbrook and Culcairn)	Chemical	None	High (Holbrook) Low (Culcairn)	Hume Highway north of Holbrook.	Severe crop loss spreads rapidly. Produces nitrates at potentially toxic levels.
Toxico-dendron succedaneum	Rhus Tree	Not Applicable (Holbrook) W2 (Culcairn)	Mechanical removal of large trees. Spray. Cut stump. Basal bark spray.	None	Low (Holbrook and Culcairn)	None	Allergic reaction in some humans
Xanthium spp.	Bathurst and Noogoora burr	W2 (Holbrook and Culcairn)	Hoeing and chipping. Slashing. Chemical.	Bathurst Burr - Colletotrichum Noogoora Burr - stem gall moth	High (Holbrook) Medium (Culcairn)	Billabong Creek (Noog.) Scattered (Bathurst)	Contaminant of wool. Toxic to stock. Compete strongly with pastures.

* Refers to their current level of concern and potential to spread witin thecatchment.

Other Weeds of Concern but not classified as noxious within the catchment include (NB This list is not exhaustive and open to debate): Capeweed, Dandelion, Fleabane, Oxalis, Saffron Thistle, Silvergrass, Stink Wort, Wireweed.
Environmental Weeds: Apple Trees, Broom, Hawthorn, Kikuyu, Peppercorn Trees, Paspalum, Phalaris, Pines, Poplars, Privet, Tree Lucerne, Wild Oats, Willows.

1. GROUNDWATER

Investigations by the Holbrook Landcare Group and the Department of Land & Water Conservation (DLWC) of bores, piezometers and wells within the catchment show groundwater salinity to range from 200 to 6,500 mS/cm (Table 5.1).

Table 5.1 Groundwater salinity within subcatchments of the Upper Billabong catchment (pers. comm. Kulatunga 1998)

Sub-catchment	**Groundwater Salinity (µS/cm)** **<280 (Good) 280 - 800 (Fair) >800 (Poor)**
Forest Creek	1,000 – 2,400
Sawyers Creek	500 – 5,600
Little Billabong	300 – 6,500
10 Mile	200 – 4,900
Thugga Lane	1,600 – 3,300
Four Mile	1,000 – 5,500
Mountain Creek	300 – 2,600

Indicative results on other groundwater quality traits (Table 5.2) can be obtained by looking at water quality tests undertaken on treated water for the town of Holbrook and village of Woomargama. The water is obtained from deep bores at Ralvona Lane and Woomargama, respectively.

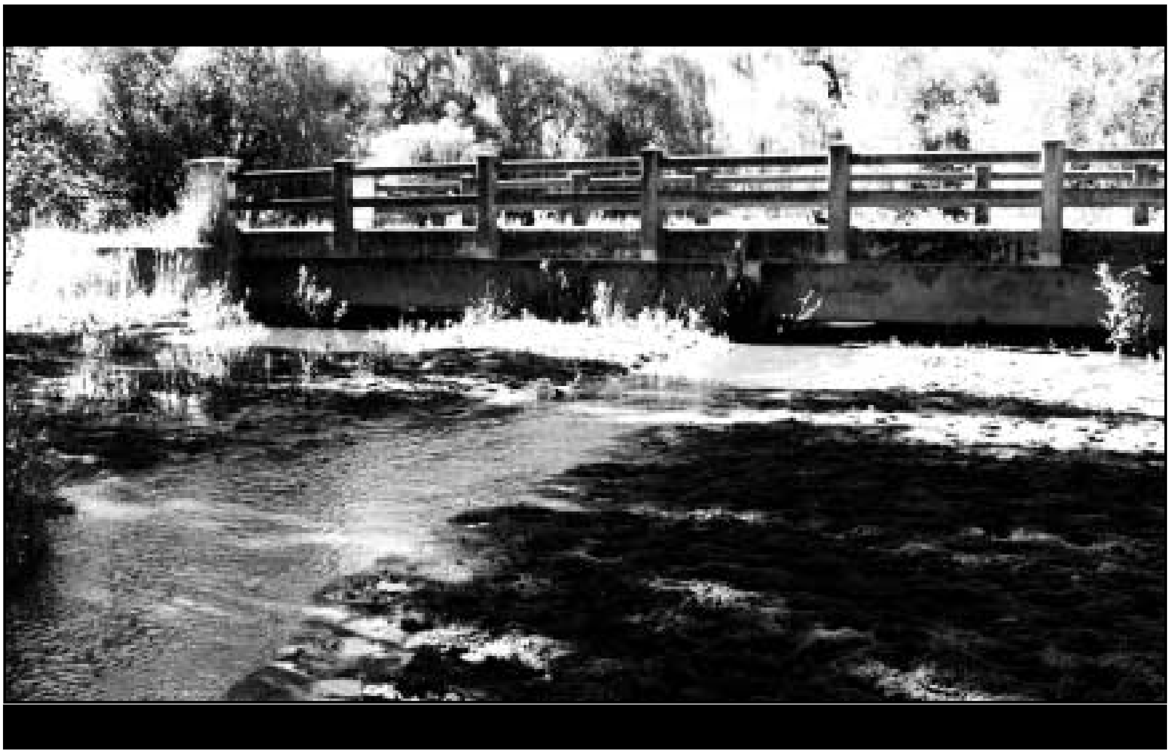


Table 5.2 Water quality tests for treated town water at Holbrook and Woomargama (Riverina Water April 1998)

Test	Units	Woomargama	Holbrook	Guidelines*
Turbidity	N.T.U.	0.8	0.3	site specific
Specific Conductance	µS/cm	355	529	N/A
pH		7.6	8.4	6.5-8.5
Fluoride	mg/L	0.4	1.3	N/A
Alkalinity as CaCO3	mg/L	73	153	N/A
Chloride	mg/L	60	63	N/A
Nitrite as N	mg/L	<0.1	<0.1	1.0
Nitrate as N	mg/L	<0.1	<0.1	10.0
Bromide	mg/L	<1	<1	0.2
Phosphorus reactive as P	mg/L	<0.01	0.05	N/A
Sulphate	mg/L	7	25	400
Sodium	mg/L	47	80	300
Ammonium as N	mg/L	<0.1	<0.1	0.01
Potassium	mg/L	1	<1	N/A
Magnesium	mg/L	10	10	N/A
Calcium	mg/L	7	14	N/A
Ca Hardness as Ca CO3	mg/L	16	35	200
Total Hardness as CaCO3	mg/L	57	74	500
Silica as SiO2	mg/L	25	42	N/A
Aluminium	mg/L	<0.05	<0.05	0.2
Copper	mg/L	0.07	<0.05	1.0
Zinc	mg/L	<0.05	<0.05	5.0
Iron	mg/L	0.29	<0.05	0.3
Manganese	mg/L	0.13	<0.01	0.1

*Australian Water Quality Guidelines (1992) N/A indicates no guidelines are available

2. ISSUE G: DRYLAND SOIL SALINITY

Causes of Soil Salinity

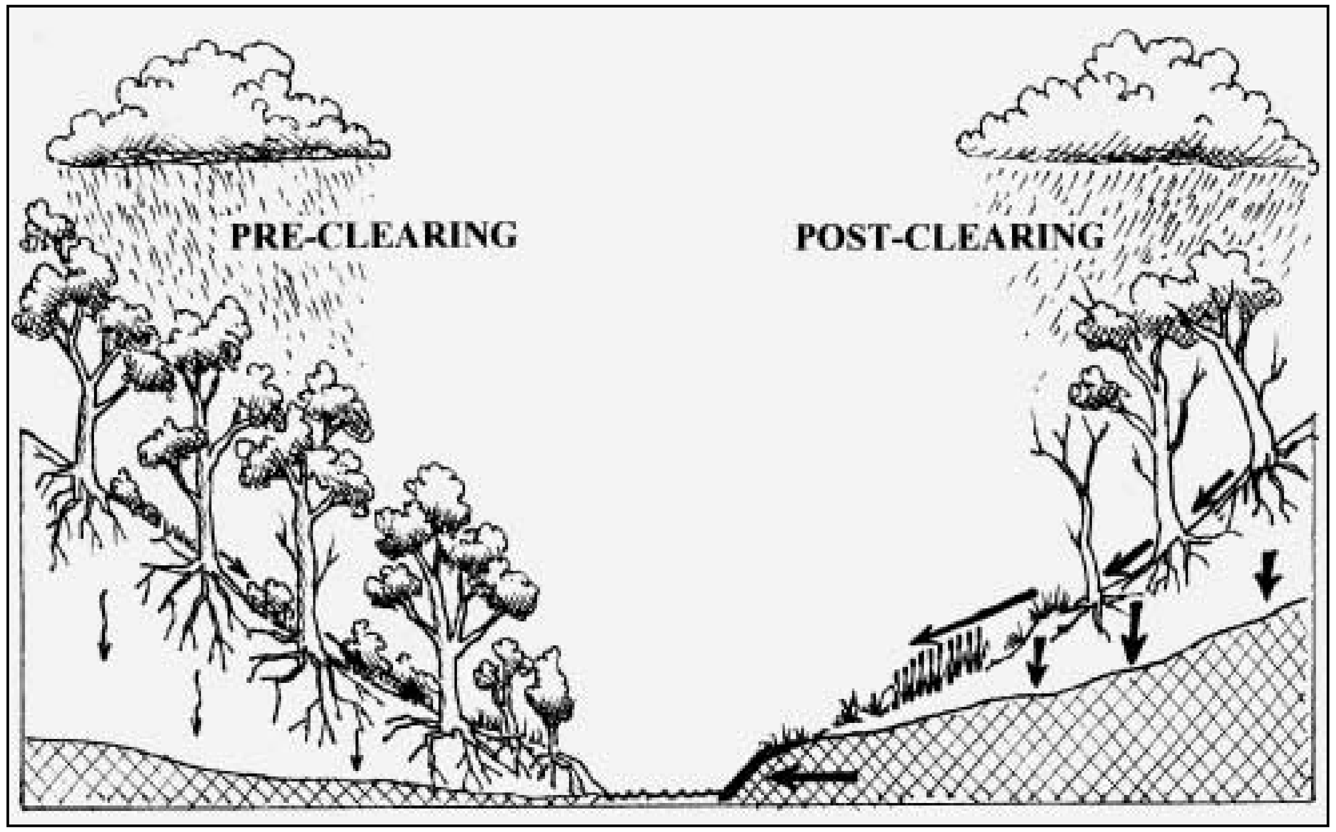
Salinity is a groundwater problem. Groundwater is all the water that fills the air spaces between the soil, gravel and rocks in the ground beneath us. The watertable is the surface groundwater, beneath which all the airspaces are filled with water. These air spaces are filling up as a result of the dramatic land use changes that have taken place since settlement. Thus, the watertable is rising (Anderson *et al.* 1992).

Clearing of native vegetation has caused increased rainfall to "leak" (recharge) through to the groundwater. The native vegetation had a far greater potential to "sponge" up the rainfall with its deep roots and surface organic material - the depth of the sponge was often several metres below the soil surface (Anderson *et al.* 1992). However, as Woodward-Clyde (1999c) points out, it should not be assumed that prior to European settlement there was a natural balance between rainfall and water use by native vegetation.

Salinity is a groundwater problem

Since clearing, European farming techniques have been used. Annual crops and pastures such as wheat and clover are grown. These plants have shallow root systems, which means the soil sponge is usually less than one metre deep. Much more water leaks through into the groundwater system, which causes watertable levels to rise until water eventually reaches the surface (discharge) (Figure 5.1).

Figure 5.1 Pre-Clearing and Post-Clearing and its influence on the watertable



The rise in the watertable can mobilise salts stored at depth in the soil profile. These salts are concentrated at the surface by evaporation. The watertable does not need to reach the surface to cause dryland salinity; when the watertable reaches a critical depth below the soil surface of between one and two metres, water can be drawn to the surface by capillary action. Plants then suffer the toxic effects of salt. If the watertable reaches the surface, plants suffer the effects of both waterlogging and salinity.

Where the salt comes from

The main sources of salts in the Upper Billabong catchment are:

- *Cyclic salts* - ocean salts carried inland and deposited by rainfall. For example, salt input from rainfall in the Murray Darling Basin (106 million hectares in area) has been measured at about one million tonnes per year. The dominant salt deposited in this way is sodium chloride (NaCl).
- *Weathering* - of the mineral constituents of the soil and rock. Weathering processes break down minerals and often release chemicals that form soluble salts. The nature of the salts released depends on the type of the rock being weathered.
- *Fossil or connate salts* - may also be present in the soil profile. These salts are derived mainly from entrapped salty solutions, or from fossil water present in marine sediments laid down in earlier geological times.

For further information:

Salt Action. 1994. "*Dryland Salinity*." Series of eight brochures. *The Causes* through to *Options for Control*.

Current Status of Soil Salinity and Future Implications and Trends

Table 5.3 and Appendix Map 2 provide a summary of salt affected areas within the Upper Billabong catchment.

Table 5.3 Soil Salinity within the Upper Billabong (Woodward-Clyde 1998a)

	1998	Prediction 2030
Soil Salinity	133 ha	Low 250 ha High 500 ha

The land degradation map (Appendix Map 2) indicates that the areas currently affected by soil salinity are largely associated with the "break of slope" and in the "wet phases of the plains and re-entrant valley floors," within the floodplain and slope regolith units (Appendix Map 3) (Woodward-Clyde 1998a). These will also be the areas influenced the most by salinity in the future.

Most salinity outbreaks tend to be localised and small (<1 hectare) in size. There is only one large salinity outbreak (~40ha in size) within the Upper Billabong catchment, found at the corner of the Hume Highway and Four Mile Lane. The soil surface salinity associated with the outbreaks is predominantly moderate (EC_e 2,000-6,000 µS/cm). Sea barley grass, moist ground, small areas of bare ground and occasional patches of salt crystals are the main indicators of salting. The relatively low incidence of extremely saline soil is in part due to the reduced natural level of salts found in the soils of the Upper Billabong catchment when compared with soils further west. Groundwater salinity can be used as an indication of the salts found within soils. As a comparison, groundwater salinities within the Upper Billabong range from 200 to 5,000 µS/cm whilst groundwater salinities in the Wakool area range from 20,000 to 50,000 µS/cm.

Salt concentration was also found to be higher in areas where there was construction of impeding structures (e.g. roads or dams) along natural drainage lines. These structures did not necessarily impede surface water flow but did tend to impede subsurface water flow resulting in increased concentrations of salt (Woodward-Clyde 1998a).

Possibly of greatest immediate concern with respect to salinity is the gully erosion within the Upper Billabong catchment. Gullies are now acting as a release point for groundwater flows carrying salts, causing increased salt loads within tributaries. This issue is covered further in the section on water quality.

Periodic attempts have been made to describe the groundwater status of the Upper Billabong catchment. Bogoda (1992) and Woolley and Bogada (1992) carried out a reconnaissance survey in 1991 that covered 60 bores that had been constructed from the 1940s through to the late 1980s. In general, it was noted that there had been a marked rise in groundwater pressures over that period with an average annual rise of 28cm/year. However, Woodward-Clyde (1999d) cautions on using these figures "since the 'average' was calculated over two time periods varying from 4 to 5 years to 40 to 50 years."

The following figures provide an indication of the groundwater pressure surface within the Upper Billabong catchment. This information will be monitored over time to determine which sections of the catchment exhibit the greatest change in groundwater pressure - those parts of the landscape most important to recharge and discharge processes (Woodward-Clyde 1998d).

Figure 5.2 Upper Billabong Groundwater Pressure Surface, September 1998 (Woodward-Clyde 1999d)

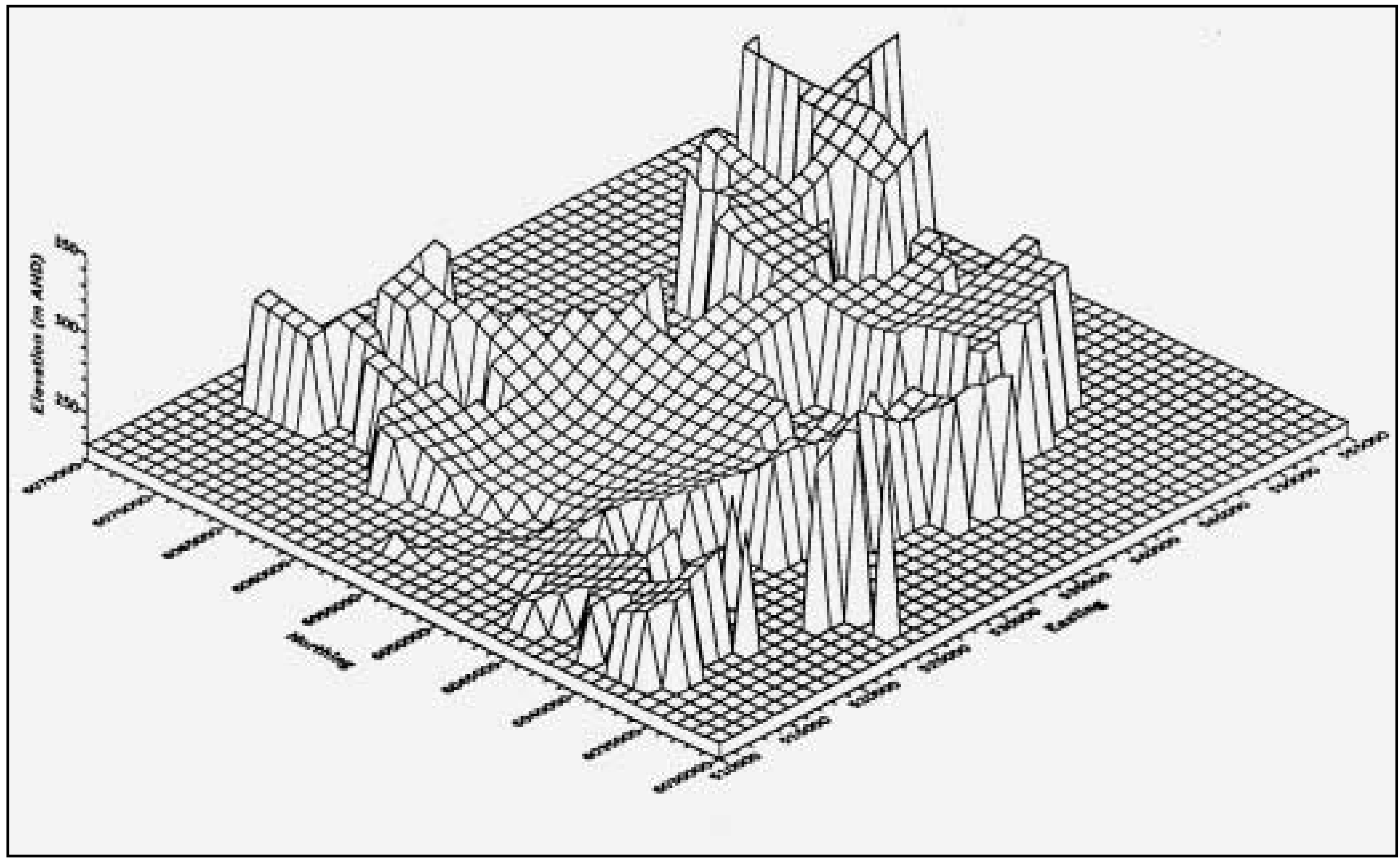


Figure 5.3 Groundwater Pressure Surface West to East, September 1998 (Woodward-Clyde 1999d)

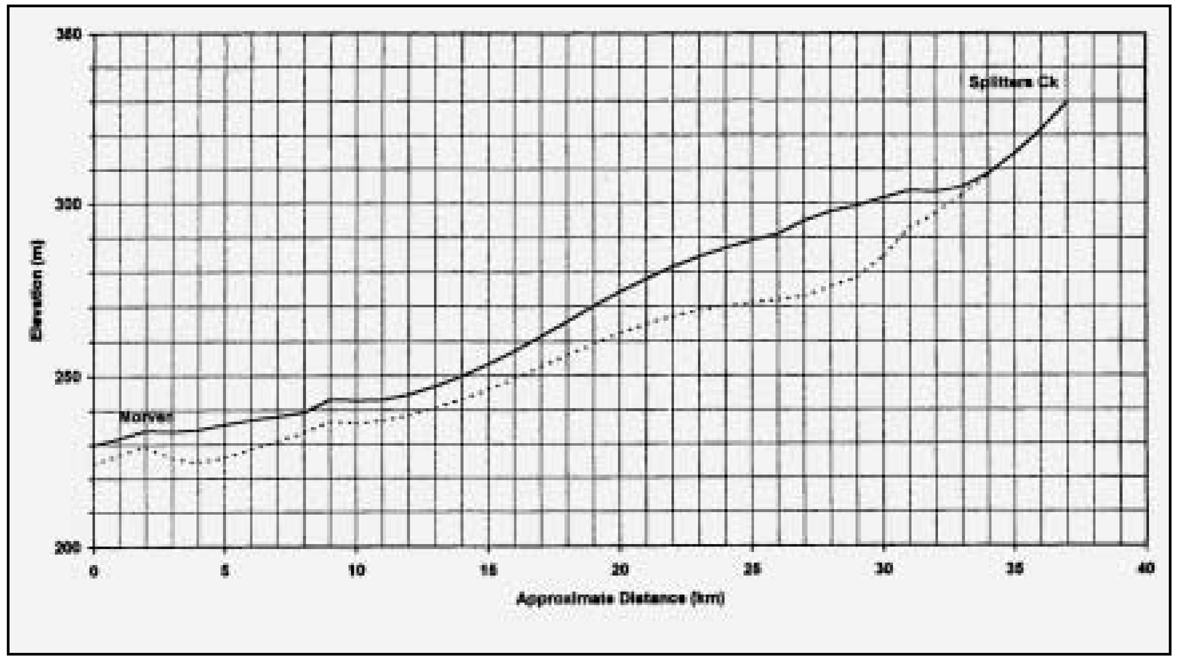
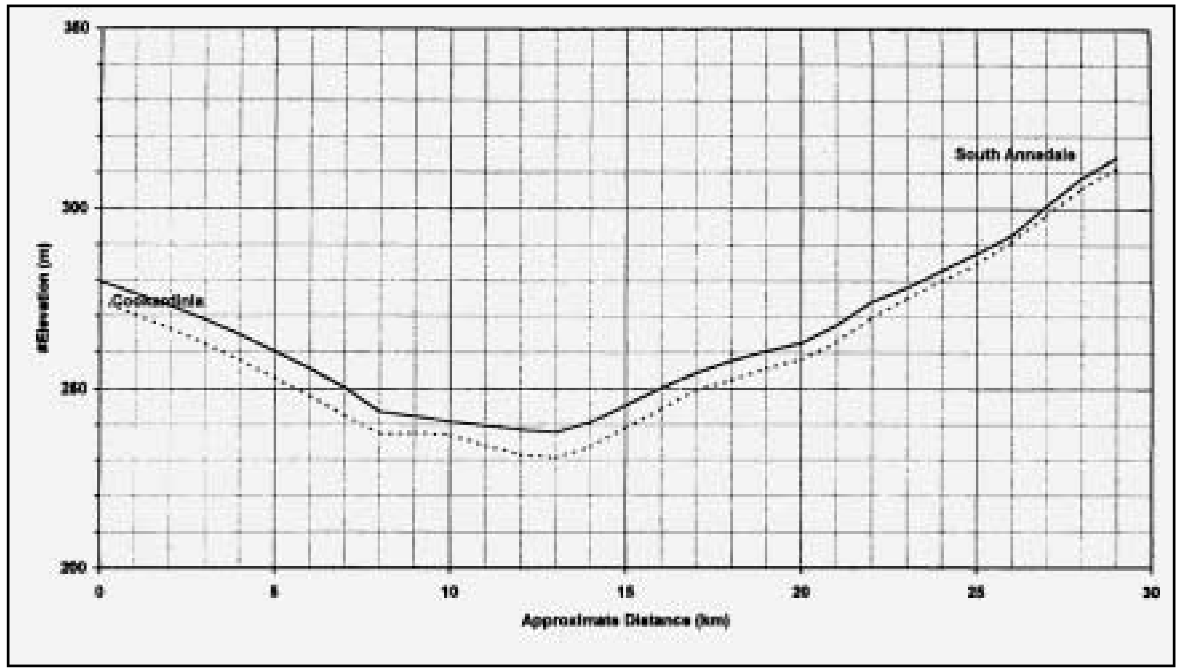


Figure 5.4 Groundwater Pressure Surface North to South, September 1998 (Woodward-Clyde 1999d)



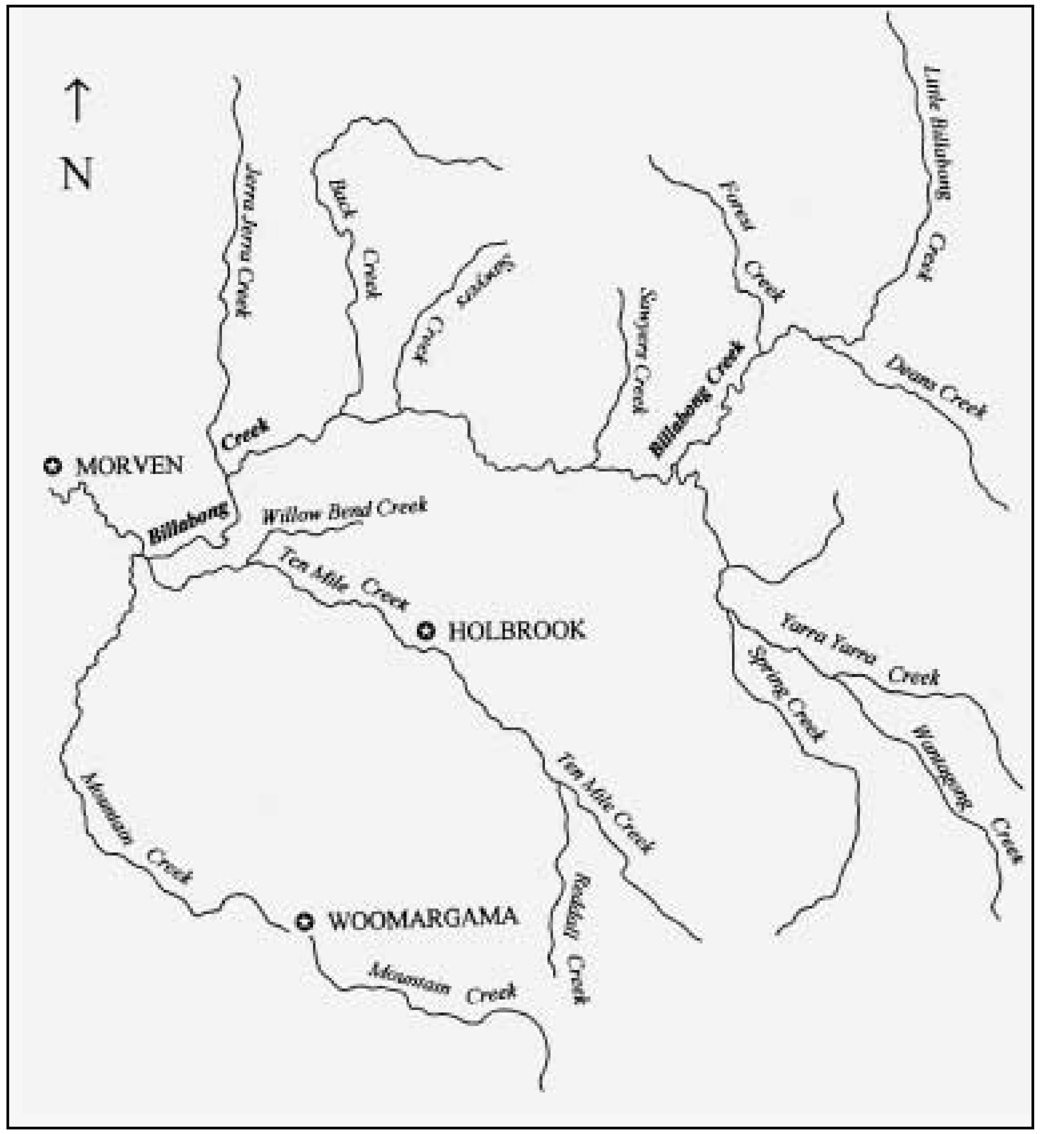
To effectively mitigate salinity effects into the future, Woodward-Clyde (1999d) recommends future recharge control be applied to whole catchments rather than individual components of the landscape.

3. SURFACE WATER

Major Watercourses

The major watercourses found within the Upper Billabong Catchment are shown in Figure 5.5. The total length of the major watercourses within the catchment is 294 kilometres. The main tributaries within the catchment are Billabong Creek (48km), Yarra Yarra Creek (22km), Ten Mile Creek (34km) and Mountain Creek (40km).

Figure 5.5 Major watercourses within the Upper Billabong Catchment



Water Quality

The data available to evaluate water quality in the catchment is limited to field instrument work carried out by local landholders and Holbrook Landcare. There has been no planned agency program for the catchment in this regard. Results should therefore be viewed as indicative only.

Based on limited data for the Billabong Creek, most water samples usually pass the criteria for secondary contact recreation and livestock supplies (EPA 1997).

Salinity

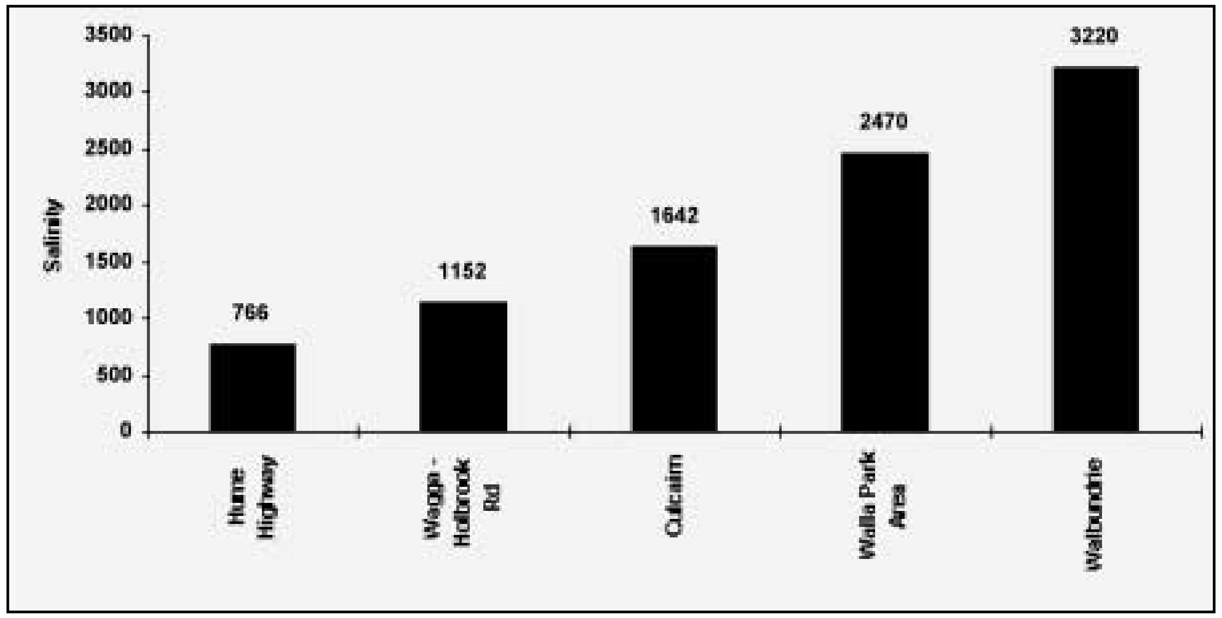
(1,000 µS/cm = 1,000 EC = 1 dS/m: approximately equal to 640 ppm, depending on the ionic constituents present)

Streamwatch results from the Landcare Group over a 12-month period in 1996/97 showed salinity varied across the catchment from 1680 µS/cm (high) at Forest Creek to 24 µS/cm (pristine) within Ten Mile Creek (pers. comm. Hulm 1998). Water quality tests undertaken in 1994 “at the end of a storm” on the Billabong Creek at Morven (bottom end of the Upper Billabong catchment) showed salinity readings of 750 µS/cm (medium to high) (EPA 1994).

In 1997, Murray Darling Basin Commission research stated that the water salinity “within Billabong Creek at Walbundrie shows the highest significant rising trend measured in the Murray Darling Drainage Division”, showing an annual increase of 40 µS/cm over a 21 year period to 1991. At this same site the saltload annual trend was said to be + 4.8 tonnes/day which is +9% per year. (MDBC, 1997). Recent CSIRO research (Jolly *et al.* 2001) shows that the Billabong Creek east of Walbundrie has the highest mean EC and rising EC trend in the whole NSW Murray-Darling system and the third highest in the Murray Darling Basin (the Avoca River and Barr Creek in Victoria showing the highest readings). These figures are estimates of salt concentration. Thus, to have a high concentration of salt is not the same as contributing a high salt load to the Murray if the volume of water the Billabong contributes is relatively low. Nevertheless, high salt concentrations have serious consequences for local riparian and aquatic biota.

The large increase in median salinity between Culcairn (531 µS/cm) and Walbundrie (980 µS/cm), a creek distance of only 47 km, indicates a significant discharge between these centres (O’Connell 1997). “Low flows and dryland salinity in the Upper Billabong Creek catchment results in high to extremely high salinity readings at times” (EPA 1997). Water salinity increase within the Billabong Creek is shown in Figure 5.6. The salinity was found to increase from 766 µS/cm at the Hume Highway to 3,220 mS/cm at Walbundrie (MDBC 1997).

Figure 5.6 Water Salinity readings (mS/cm) along Billabong Creek, February 1998 (MDBC, 1997)



Turbidity

Streamwatch results from the Holbrook Landcare Group during 1996/97 showed turbidity ranged from 273 NTU (High) at Yarra Yarra Creek in March after a 66mm rainfall event in 24 hours (O’Connell 1997) to a low of 5 NTU (pristine) within Thugga Creek (pers comm. Hulm 1998). Results from EPA monitoring undertaken in 1994 showed turbidity below 50 NTU (mild) in most upper catchment tributaries, with a rise to over 200 NTU (high) at several sites after a rainfall event in June 1994. These sites were Four Mile Creek (Dean’s Creek), Wantagong Creek, Yarra Yarra Creek, Mountain Creek (highest reading of 545 NTU) and Billabong Creek itself (O’Connell 1997).

pH

Streamwatch results from the Holbrook Landcare Group during 1996/97, where pH was measured using pH “strips”, indicated slightly acidic conditions in many tributaries, with median values close to 6 (Good = 6.5-9.0). This may be associated with soil acidity; however these readings are likely to be accurate to only 1 pH unit because of the sampling method used. Monitoring done by the Environmental Protection Authority (EPA) in the upper catchment in 1994, showed neutral pH at over 40 sites (O’Connell 1997).

Dissolved Oxygen

Dissolved oxygen should not normally fall below 6 mg/L for the protection of aquatic life. Monitoring by the EPA in the Upper Billabong catchment tributaries in 1994 showed dissolved oxygen generally within the range 6 to 10 mg/L. Warmer weather and low flow conditions in December 1994 resulted in many tributaries having dissolved oxygen below 5 mg/L (O’Connell 1997).

Pesticides

Pesticides include agricultural chemicals such as herbicides, insecticides, nematicides, rodenticides and miticides. Sampling for pesticides has been limited to the irrigation areas (O’Connell 1997). There have been no known water quality tests for pesticides undertaken in the Upper Billabong catchment.

Nutrients

Nutrients are elements such as nitrogen and phosphorus that are essential for biological growth, but may lead to water quality problems when in excess. Combined with stagnant water and high light penetration, elevated nutrient levels are considered the most critical factors in the development of algal blooms (GH & D 1992). Little is known of algal blooms in the Billabong Creek except that they are rarely reported (EPA 1994).

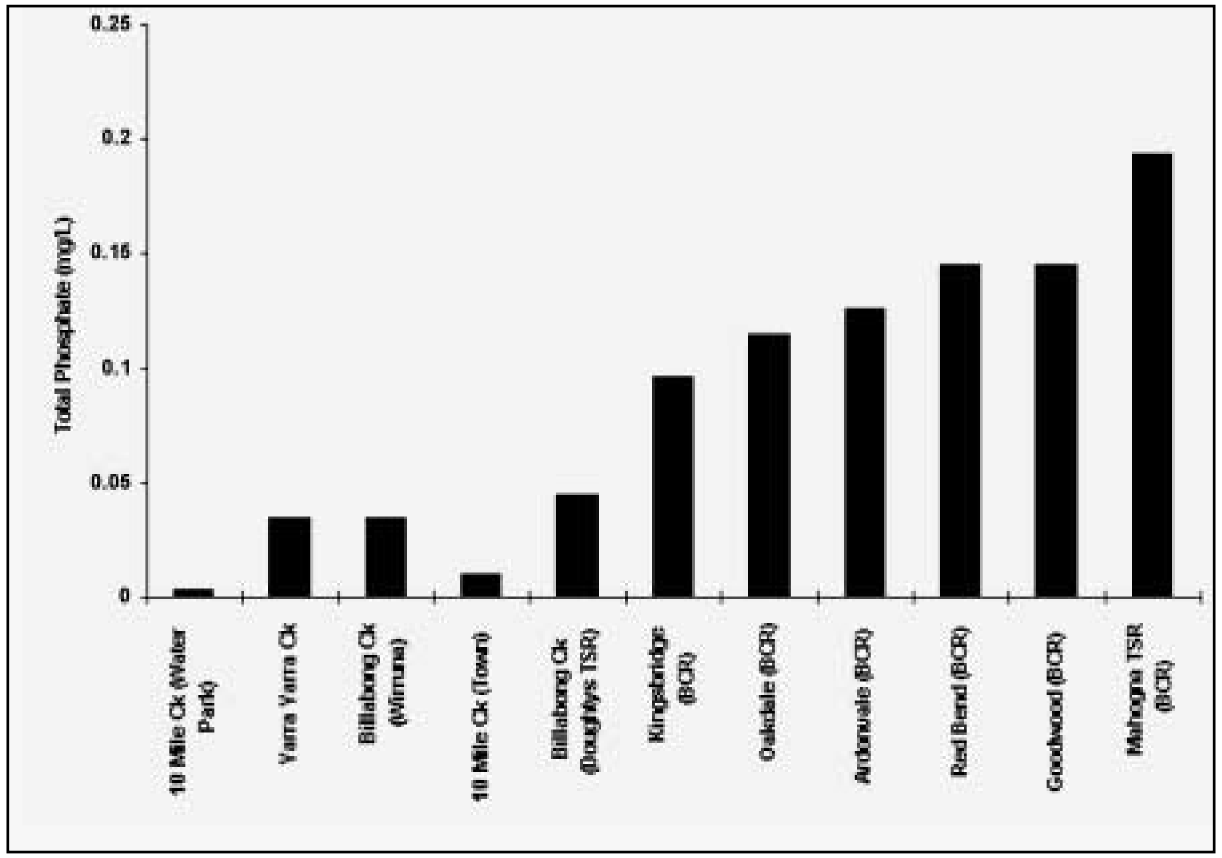
Total Phosphorus (TP): EPA’s monitoring program in 1994 shows that tributaries in the Upper Billabong catchment generally have low concentrations of TP. During April and December 1994, baseline TP was between 0.01 and 0.05 mg/L at most sites (fair). In June 1994, TP increased in most sites to be between 0.03 to 0.30 mg/L (fair to high) indicating a significant nutrient contribution from land runoff. A site at Mountain Creek provided an exception to this general pattern. Sampling of this site in April and December 1994 found very high TP concentrations (0.74 and 0.84 respectively). In June 1994 the concentration was lower, at 0.34 mg/L, indicating possible dilution of a point source of phosphorus (O’Connell 1997).

Sampling along the Billabong Creek in April 1998 prior to rain and at the end of a significantly dry period produced the readings in Figure 5.7. The graph shows an increase in phosphate levels as you move downstream.

Figure 5.7 Total Phosphate (mg/L) levels in the Billabong Creek to Rand
(pers comm. Hulm 1998)

good = < 0.02 mg/L fair = 0.02 - 0.05 mg/L poor = > 0.05 mg/L (NB. The standard guidelines for total phosphate levels were developed for larger river systems and are probably too stringent for intermittent streams such as the Billabong Creek).

BCR = Billabong Creek within Culcairn and Rand Landcare Group Area



Total Nitrogen (TN): EPA's monitoring program from 1995-97 shows TN in the Upper Billabong catchment to vary from 0.732 to 1.995 mg/L (good to fair), with no clear relationship between rainfall and increased runoff in June 1994 (O'Connell 1997).

Metals

Heavy metals are a group of metals with high atomic weights and are usually present at low concentrations in natural waters (especially iron). Some are essential to aquatic life, but at higher levels many are toxic, especially zinc, copper, cadmium, lead and mercury. Michell Leather at Culcairn have analysed Billabong Creek samples for iron on a quarterly basis since 1993. These results show iron levels ranging from 200 to 5,000 µg/L, which is generally above the threshold for causing taste, odour and staining problems if used for domestic supply. The guideline for drinking (aesthetic) is less than 300 µg/L and the upper guideline for protection of aquatic life is less than 1,000 µg/L (ANZECC 1992). It is unlikely that toxic effects will occur at total iron concentrations below 1,000 µg/L (pers. comm. Christy 2000). There have been no other known water quality tests reported for metals in the Upper Billabong catchment.

Temperature

The temperature of water in the Billabong Creek shows both diurnal and seasonal fluctuations. Temperatures at Walbundrie average 10oC in the winter and 20oC in the summer. The median recorded temperature from 1995 to 1997 at Walbundrie was 16.7oC. Overall the temperatures of the Billabong Creek and its tributaries are within the range of natural ecosystems (O'Connell 1997).

Macroinvertebrates

Freshwater macroinvertebrates are a group of animals without backbones, sufficiently large to be seen with the unaided eye (ie: larger than 0.5 mm) and that live at least part of their life in freshwater (Bennison *et al.* 1989). In October 1994, EPA hosted a macroinvertebrate field day with Holbrook Landcare Group. Sampling was taken at three sites (10 Mile Creek, Wantagong Creek and Yarra Creek). About 37 taxa were identified down to the family/genera level. Although water quality data was collected at these sites, the macroinvertebrate composition appeared to be more influenced by stream flows and the availability of substrate (O'Connell 1997).

Algae

Monitoring for algae has been undertaken by the DLWC at Walbundrie. The dominant blue-green algae found were *Oscillatoria and Raphidiopsis* with the "alert level" being low (ie: more than 2,000 blue-green algae cells/ml) (O'Connell 1997). Vinall (pers. Comm. 2000) observes that despite the high salinities at Walbundrie, the blue-green algae recorded are more typical of fresher waters, with the salt tolerant genus *Nodularia* not featuring high on the list.

Bacteria

Determining bacterial levels poses particular difficulties because the samples need to be analysed quickly, their concentrations in streams may change rapidly, and relatively frequent sampling is required for the study to be effective (O'Connell 1997). There are no known water quality tests that have been undertaken for bacteria in the Upper Billabong catchment.

Fish

From 1994 to 1996, NSW Fisheries at Walbundrie has undertaken winter and summer sampling of fish populations in the Billabong Creek. The dominant species, by far, was European carp (85%), followed by small numbers of goldfish (7%), golden perch (7%) and redfin (1%). Work undertaken by NSW Fisheries and the Holbrook Landcare Group shows the presence of carp in many upper catchment tributaries. Carp were first observed in Little Billabong Creek in February 1983, and have more recently moved into other subcatchments such as Mountain Creek and Forest Creek. The largest concentrations appear to occur at junctions close to the Billabong (O'Connell 1997).

4. ISSUE J: WATER QUALITY DECLINE

Causes of Water Quality Decline

Water quality decline within the Upper Billabong catchment is mainly influenced by clearing, stock, carp, fertilisers and cultivation. These factors can all interplay and lead to erosion, sedimentation, riparian habitat decline, salt, and nutrient loading, which in turn lead to decreased water quality.

Current Status and Future Trends associated with Water Quality

The above sections summarise the water quality tests that have been undertaken within the Upper Billabong catchment to date.

Water quality tests for turbidity, phosphorus and nitrogen have generally provided results within the good to fair range. However, results for turbidity and phosphorus were found to be poor when testing after high rainfall events, due to the increased mobilisation of soil particles (erosion) associated with the increased surface water flow.

With increasing economic pressure within agriculture, there is also the increasing pressure toward high input agriculture, which includes increasing applications of fertiliser and increasing production of clover-based pastures. Potentially, this carries an increased risk of higher levels of phosphorus and nitrogen in our waterways (pers. comm. Ridley 1999).

Grazing of the riparian zone, as well as the erosion and sedimentation of tributaries within the catchment have had major impacts on the nature and therefore habitat value of the creeks. Grazing has resulted in reduced vegetative cover, particularly in the form of shrubs, grasses and reeds along the creeks. This vegetation would have filtered water and reduced erosion.

It is estimated that the 285,761 sheep and cattle within the Upper Billabong (ABS 1996a) are able to produce the equivalent waste of 804,000 humans (Water Quality Working Group 1999). As livestock have direct access to most tributaries within the catchment, this has a major impact on the health of those tributaries.

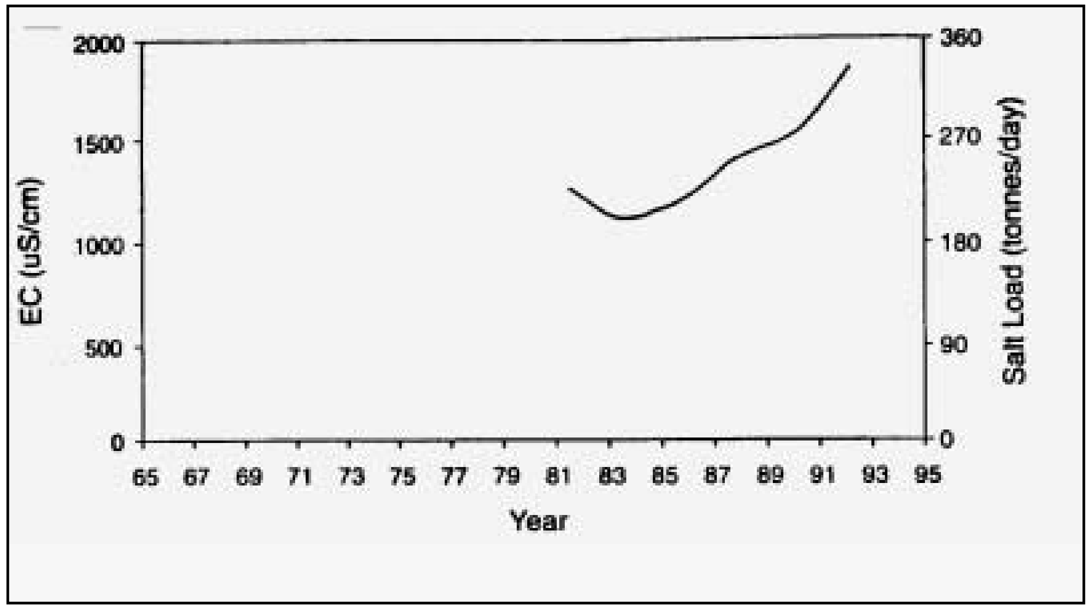
Creeks that are tree-lined are very attractive to livestock. Livestock suffer less impact from the elements in tree-lined creeks than in the rest of the paddock, because they use the stream for shade, shelter and water (Stelling 1998). Older persons within the catchment can recall deep holes and “swimming pools” along the Ten Mile and Billabong Creeks (pers. comms. Geddes 1997; Scobie 1998; Shearer, 1997). The sedimentation of these holes has had a major impact on fauna within the creeks, including species such as Platypus, Murray Cod and Yellow Belly. Species such as these would be the natural predators on the increasing populations of introduced European Carp.

Based on nutrient trends analysis, streambank erosion mapping, density of streams, and water quality information, the Murray Catchment Management Committee’s *Water Quality Working Group* ranked subcatchments within the Murray based on their nutrient generation potential (ability to release nutrients into waterways). The Upper Billabong was one of the two subcatchments ranked as a high priority out of a total 18 (Water Quality Working Group 1999).

Water salinity is another water quality issue of great concern. As discussed above, the water salinity “within Billabong Creek at Walbundrie showed the highest significant rising trend measured in the Murray Darling Drainage Division”, showing an annual increase of 40 µS/cm over a 21 year period to 1991. At this same site, the saltload annual trend is + 4.8 tonnes/day which is +9% per year (Figure 5.8) (MDBC 1997). Recent CSIRO research (Jolly *et al.* 2001) shows that the Billabong Creek east of Walbundrie has the highest mean EC and rising EC trend in the whole NSW Murray-Darling system. The large increase in median salinity between Culcairn (531 µS/cm) and Walbundrie (980 µS/cm), a creek distance of only 47 km, indicates a significant discharge between these centres (O’Connell 1997). “Low flows and dryland salinity in the Upper Billabong Creek catchment results in high to extremely high salinity readings at times” (EPA 1997).

The state-wide “water reform” program currently underway will bring with it more comprehensive and stringent testing of water quality and riparian zone attributes.

Figure 5.8 Water Salinity in the Billabong Creek at Walbundrie (MDBC 1997)



1. OVERVIEW OF ACTIONS

The actions listed in the tables below meet the community's values, vision and objectives with regard to the catchment. The actions and targets will be one of the most dynamic components of the Upper Billabong LWMP, and they will be in a continuous state of assessment and change. Figure 5.1 summarises some of the actions and targets to the year 2030.

Appendix 9, Map 5 shows the priority target landuse areas for protection and management of existing remnant native vegetation, farm forestry and for change from annual cropping and pasture regimes to perennial regimes.

All of the actions are important and all need to be undertaken. However, the actions have been formulated and prioritised by members of the Holbrook Landcare Group and Upper Billabong LWMP Working Group. Members prioritised and ranked the actions by answering the question:

> "Rank the 'On-Ground Actions' and 'Education And Marketing Actions' according to those you feel will best meet the community vision, best meet your personal values, best address the community's issues of concern, and minimise energy/resource expenditure".

The results represent the "cumulative" thinking of the Working Group and Landcare Group. This has been done to provide some guidance to the groups and their employees as to the actions of greatest interest at this point in time.

All of the actions are important and all need to be undertaken

Table 6.1 “On-Ground” Actions

(NB. All actions are important and need to be undertaken).

Rank	On Ground Actions	Priority	Relates To Catchment Issue
1	Revegetation of predominantly cleared country with emphasis on the use of local natives	High	B, C, D, E, G, J, K
2	Improved management of areas of remnant native vegetation	High	B, C, F, K
3	Enhancement of remnant native vegetation areas that have been degraded	Medium	B, C, D, E, F, G, J, K
4	Soil Acidity Mitigation	Medium	A, B, D, E, G
5	Establishment of Perennial Pastures (eg: phalaris, cocksfoot and lucerne)	Medium	A, B, D, E, F, G
6	Farm forestry with emphasis on proven pine and eucalypt species	Medium	A, B, D, E, G, I, J
7	Improved management of existing areas of native perennial pasture	Medium	A, B, D, E, F, G, J, K
8	Erosion Control Works (reshaping and structural works)	Medium	E, J
9	Establishment of Alternate Industries (eg: aquaculture, olives, bush foods persimmons, loquats, specialist farm forestry, etc.)	Medium	A, B, D, E, G, I,
10	Establishment of Local Seed Production Areas (to particularly provide seed from species difficult to obtain (eg: most shrubs)	Medium	B, C
11	Instigation of Conservation Cropping practices	Low	A, B, E, F, J
12	Establishment of Wildlife Sanctuaries	Low	A, B, K
13	Establish Adopt-a-Roadside program by service groups	Low	B, F, L

Table 6.2 “Education and Marketing” Actions

(NB. All actions are important and need to be undertaken).

Rank	Education And Marketing Actions	Priority	Relates To Catchment Issue
1	Newsletter	High	B
2	Business Planning Workshops (preferably through subcatchment groups)	High	A, B
3	Brochures on local “best bet” case studies	Medium	B
4	Physical Planning Workshops (preferably through subcatchment groups)	Medium	A, B
5	Investigate New and Alternate Marketing Practices for *current* enterprises	Medium	A, B, I
6	Farm Walks	Medium	B, L
7	Investigate New Enterprises and Industries	Medium	A, B, I
8	Field Days	Medium	B
9	Workshops	Medium	B
10	Community Meetings: To keep the community up to date, seek support and guidance.	Medium	B, H, L
12	Landcare Education in Schools	Medium	B, I
13	Resource Library in the Landcare Shopfront	Medium	B
14	Seminars	Medium	A, B
15	Marketing of Holbrook Landcare and the LWMP to the wider community outside the catchment	Medium	A, B, H, I, L
16	Establishment of a Herbarium (with a focus on local plant species)	Medium	B, C, F, K
17	Bus Trips	Low	B, L
18	Displays/Posters	Low	B
19	Painting red of a high profile (eg: Hume Hwy) dead tree plus signage and plantings	Low	B, L

“Seeking of public funds” and the “Development of a yearly planner of activities” were not included in the above rankings, but have been included in the Table 6.5 below (Ancillary Actions) as they were felt to be actions that would be undertaken automatically.

2A. ON GROUND ACTIONS

Estimated costs of action are shown in Appendix 7. Table 6.3 provides more detailed information on the main on-ground works.

The Base Estimate column (1998) represents the 'starting point' determined from base data. The Base Estimate is mostly given as an area, with the percentage of the whole catchment shown in brackets.

The Performance Indicator columns estimate the cumulative total amount of the specific action that ought to have been achieved by the date indicated. For example, by 2015, three percent of the catchment (or 5,130ha in total) should have been dedicated to revegetation with local species. Most of the performance indicators are shown as an area, with the percentage of the whole catchment shown in brackets.

The last row of the table collates the total area of land where landuse could be improved. Over time, as improvements are implemented, the overall area that needs further improvement will decrease.

2B. EDUCATION AND MARKETING ACTIONS

Table 6.4 details the Education and Marketing initiatives. Table 6.5 lists two important actions (seeking funds and annual planning) that are consequential to implementing the Plan.

Table 6.3 On-Ground Actions

On Ground Actions	Description of the Works and desired criteria	Priority Locations	Persons Responsible for assisting Community to achieve actions	Base Estimate	Performance Indicator (cumulative total for the Upper Billabong)		
1 Revegetation using mostly local natives	• Inspect, assess and develop establishment and management objectives and options. • Revegetate (direct seeding or planting) utilising mostly locally native plant stock. • Works may include weed and pest control, ripping, fencing and guarding. • Where Landcare funding is obtained: a minimum of 40% shrubs will be required in the planting to maximise biodiversity and dieback mitigation benefits; preference will be given to larger blocks with reduced edges and fencing requirements; shelterbelt plantings should be at least 20m wide; management agreements required. • There will be sub catchment planning exercises to maximise vegetative linkages.	(1) Enhance areas with good vegetative cover already. (2) Revegetation of creeklines and gullies (including eroded gullies). (3) Threatened vegetation communities associated with the flats.	Rebirding Project Officer, Landholders, Greening Australia	1,895ha (1%)	3,420ha (2%)	5,130ha (3%)	8,550ha (5%)

Table 6.3 On-Ground Actions cont...

	On Ground Actions	Description of the Works and desired criteria	Priority Locations	Persons Responsible for assisting Community to achieve actions	Base Estimate	Performance Indicator (cumulative total for the Upper Billabong)		
2 & 3	Management and Enhancing of remnant native vegetation.	• Inspect, assess and develop management objectives and options. Management options may include: reducing or eliminating grazing, weed and pest control, revegetation, fire, fencing and thinning of thick eucalypt regrowth. • Emphasis will be placed on: Protecting larger areas of native vegetation with increased biodiversity and habitat values where minimal value adding of these features is required; Protecting areas that provide for other public benefits such as improved water quality, reduced erosion and reduced salinity, • Entering into of management agreements will be a requirement where Landcare incentives are sought. • Entering into trusts and covenants will be encouraged.	(1) Hill and mountain tops - where most good remnant or existing vegetation remains; Creek line and gully vegetation. (2) Threatened vegetation communities associated with the flats.	Rebirding Project Officer, Landholders, Greening Australia	8,550ha (5%)*	13,680ha (8%)	20,520ha (12%)	29,070ha (17%)
4	Soil Acidity Mitigation	• Promote the uptake of landuse practices that reduce the reliance on ameliorates to mitigate soil acidity (eg: establishment of deeper rooted species; farm forestry; revegetation with local natives and perennial grasses).	Cropping and Grazing lands	South West Slopes Community Acid Soils Project Officer, Implementation Officer.	Av. pH ($CaCl_2$) 4.6 (0-10cm); 4.4 (10-20cm)	Undefined: awaiting Murray Catchment Management Board targets		
4	cont...	• Ongoing encouragement of soil testing and periodic application of ameliorants (eg: lime) to mitigate soil acidity in pastures and crops. • Encourage the use of acid tolerant crops and pastures and less acidifying farm procedures (eg: rock phosphate, maintenance of soil carbon).						
5	Perennial Pastures (eg: phalaris, cocksfoot and lucerne)	• Provide for the improved establishment and management of perennial pastures. • Establishment options might include pest and weed control, liming, cultivation, fertiliser application and sowing. • Where Landcare funding is sought: management agreements will be required; no funding for conversion of native grasslands; controls on the spread of seedlings (eg: through buffer strips and spraying) into areas of native vegetation.	(1) Establishment: Areas that currently have a predominance of exotic annual species; (2) Management: Areas that currently have a good base of "improved" perennial pastures. (3) Flats within the catchment that provide a good carrying capacity	Implementation Officer, Landholders, NSW Agriculture and Private Agronomists	29,070ha (17%)	35,910ha (21%)	42,50ha (25%)	42,750ha (25%)
6	Farm forestry with emphasis on proven pine and eucalypt species	• Inspect, assess and develop establishment and management objectives and options. • Utilise species with desired growth and timber qualities with access to markets. •Works may include obtaining of a development permit, weed and pest control, deep ripping, planting, fertiliser application, fencing and guarding.	(1) Cleared agricultural land with a predominance of exotic species (2) Easy access to roadage.	Implementation Officer, landholders, Farm Forestry Extension Officers.	2,540ha (1%)	5,822ha (3%)	10,260ha (6%)	17,100ha (10%)

Table 6.3 On-Ground Actions cont...

On Ground Actions	Description of the Works and desired criteria	Priority Locations	Persons Responsible for assisting Community to achieve actions	Base Estimate	Performance Indicator (cumulative total for the Upper Billabong)			
6 cont...	• Wide spaced plantings may be desirable in lower rainfall zones (< 700mm).							
	• Where Landcare incentives are sought: management agreements will be required; permanent buffer plantings using local natives should be incorporated into sensitive areas (eg: gullies); control on the spread of pine seedlings into areas of native vegetation; biodiversity qualities will be maintained and enhanced.							
7 Native Perennial Pastures	• Investigate objectives and options and develop guidelines for the improved management and establishment of native perennial pastures; • Techniques may include manipulated grazing, fencing, fire and allowing for seed-set	Areas currently with a good base or predominance of native grasses.	Implementation Officer, Landholders, Greening Australia, NSW Agriculture and Private Agronomists	3,420ha (2%)*	8,550ha (5%)	17,100ha (10%)	17,100ha (10%)	
8 Erosion Control Works	• Emphasis will be placed on reduction of erosion through the maintenance of adequate ground cover. • Subcatchment farm walks and planning exercises will assess, determine the level of activities and maximise the integration of erosion works.	(1) Encourage the protection and improved management of currently un-eroded land and gullies. (2) Work from the gully heads down with erosion control	Landcare Subcatchment leaders, DLWC and Catchment Extension Staff, Landcare Support Officer.	N/A	Instigate new planning and works in 1-2 subcatchments per year			

On Ground Actions	Description of the Works and desired criteria	Priority Locations	Persons Responsible for assisting Community to achieve actions	Base Estimate	Performance Indicator			
8 cont...	• Funding requirements for structural works (eg: earth works, rock weirs and walls) will be determined on a sub catchment basis to maximise the cost effectiveness (ie: refer to approach taken by Mountain Creek and Little Billabong subcatchments). • Use of permanent concrete structures will be discouraged. • Fencing and revegetation of gullies will be encouraged and assisted in the short term through the Rebirding program.	works throughout the subcatchments.						
9 Alternate Industries	• Refer to the Actions #5 and #7 in Table 6.4 below (Education and Marketing Actions). • Practices that are consistent with the catchment vision will be favoured.	Cleared agricultural land	As per Actions #5 and #7 in Table 6.4 below (Education and Marketing Actions).	<100ha (0.05%)	500ha (0.3%)	3,420ha (2%)	15,390ha (9%)	
10 Seed Production Areas	• Assess and develop sites for the establishment of locally native seed production areas, to supply primarily seed of locally threatened shrub species for future revegetation works. • The parent-stock will be local provenance. Parent-stock for each species will be sourced from a number of plants and populations to ensure genetic vigour. Accurate propagation and planting records will need to be maintained.	Throughout the catchment	Greening Australia, Landholders, Landcare Support Officer	Small number of sites in early stages of development	20 sites established over 3 years			
11 Conservation Cropping practices	• Provide for the increased uptake of conservation cropping practices. • Provide up to date information	Cropping areas within the catchment	NSW Agriculture, Catchment	5,130ha	8,550ha	13,680ha	15,390ha	

Table 6.3 On-Ground Actions cont...

On Ground Actions	Description of the Works and desired criteria	Priority Locations	Persons Responsible for assisting Community to achieve actions	Base Estimate	Performance Indicator (cumulative total for the Upper Billabong)		
11 cont...	on residue (stubble) retention, liming, zero tillage, minimum tillage, raised bed farming, weed control, controlled traffic and reducing compaction.		Extension Staff, Landholders, Private Agronomists, Implementation Officer.	(3%)*	(5%)	(8%)	(9%)
12 Sanctuaries	• Establish feral proof sanctuaries. The sites need to be assessed for their sanctuary value and objectives, works and management guidelines determined. • Where distinct and desirable native fauna benefits can be gained through the establishment of a feral proof sanctuary, an appropriate feral proof perimeter fence will be designed and erected. Possible fauna benefits: protection of threatened species currently on the site; the reintroduction of locally extinct species.	(1) Areas with minimal disturbance to natural resources that are able to maintain viable fauna populations. (2) Sites with dedicated land managers	Landholders, Fauna and Flora Specialists, Landcare Support Officer, Greening Australia, National Parks, DLWC	Some reserves on private land but none with feral proof fencing	1	4	No specific longer term targets
13 Adopt a Roadside	• Challenge, encourage and involve local community groups in adopting a roadside. • Works associated with the roadside might include weed control, revegetation works and litter removal campaigns. • Could be combined with 'The Red Tree' (see Eduction and Marketing Actions below).	High profile or significant roads close to towns	Landcare Support Officer, Urban Landcare Group, Community Organisations.	none	4	No specific longer term targets	
Total area of catchment where landuse could be improved	• Overall estimate of the area of land where landuse practices could be improved (eg: conservation cropping instead of cultivation cropping; farm forestry, revegetation or perennial pasture instead of annual pasture; regenerated native pastures instead of degraded native pastures; native remnant vegetation enhanced and well-managed instead of degraded)	As above	As above	120,295ha (71%)	95,760ha (56%)	58,140ha (34%)	25,650ha (15%)

Table 6.4 Education and Marketing Actions

Education and Marketing Actions	Description of Initiatives	Audience and Location	Persons Responsible for Assisting Community to achieve actions	Performance Indicator (cumulative total for the Upper Billabong)
1 Newsletter	Quarterly - up to date landcare information.	Community throughout catchment and beyond landholders and other specialists.	Implementation Officer, Landcare Support Officer in conjunction with	Every 3-4 months.
2 Business Planning Workshops:	Involve subcatchment groups in programs that involve a balance of physical, personal and financial planning (eg: Farming for the Future).	Subcatchment Groups throughout the catchment.	Landcare Support Officer and Subcatchment Leaders, Farm Planning Extension Staff	2-3 subcatchment groups per year.
3 Brochures:	Local best practice case studies, eg: revegetation techniques, perennial pasture, farm forestry, olive establishment, conservation cropping.	Community throughout catchment and beyond	Implementation Officer and Landcare Support Officer, in conjunction with landholders and other specialists.	2 brochures/year.
4 Physical Planning Workshops:	As per Action # 2 • Subcatchment tours would be a core part of this planning.		Landcare Support Officer and Subcatchment Leaders, Farm Planning Extension Staff	2-3 subcatchment groups per year.

Table 6.4 Education and Marketing Actions cont...

	Education and Marketing Actions	Description of Initiatives	Audience and Location	Persons Responsible for Assisting Community to achieve actions	Performance Indicator (cumulative total for the Upper Billabong)
5	Investigate New and Alternate Marketing Practices for *current enterprises:*	• Engage consultants or other specialists to investigate the potential of alternate management and marketing practices, value adding practices and return maximisation; • Conduct seminars, workshops, farm walks, field days when appropriate.	Community throughout catchment and beyond.	Implementation Officer, Landcare Support Officer, Landcare Executive and LWMP Working Group members. Link with established research bodies and regional development groups.	Undefined. (Interim target: Investigate 2 alternate management and marketing practices/year).
6	Farm Walks	• On farm forestry, perennial pastures, conservation cropping practices, revegetation techniques, improved native vegetation management (including native grasses), alternative best-bet •On improved understanding of natural resources (eg: flora and fauna walks and surveys).	Landholders. Strategic locations throughout the catchment	Implementation Officer, Rebirding Project Officer in conjunction with other landholders and technical specialists.	Farm walks, workshops and field days: total of 4-6 per year
7	Investigate New Enterprises and Industries:	• See also Action #5 above; • Engage consultants or other specialists to investigate new enterprises and industries. • Possibilities: holistic grazing, carobs, olives, persimmons, loquats, nuts, cut flowers, herbs, specialist farm forestry, etc. • Engage consultants or other specialists to investigate the potential of legal trade in native flora and fauna.	Community throughout catchment and beyond	As per Action #5	Undefined. (Interim target: Investigate 3 new enterprises and industries/ year).

Table 6.4 Education and Marketing Actions cont...

7	cont...	• Look at the potential of sustainably managing and utilising local native species (eg: local meat industry for kangaroos; bush foods). • Conduct seminars, workshops, farm walks, field days when appropriate.			
8	Field Days	As per Action #6 above	As per Action #6 above	As per Action #6 above	As per Action #6 above
9	Workshops	As per Action #6 above	As per Action #6 above	As per Action #6 above	As per Action #6 above
10	Community Meetings:	• Keep the community up to date and obtain feedback; • Seek input, support and guidance; • Provide an overview of plan and latest developments.	• Community throughout the catchment and key organisations. • Strategic locations through out the catchment	Implementation Officer and LWMP Working Group members.	A series of 5 meetings per year
11	Landcare Education in Schools:	Involve schools in landcare activities and education programs; eg: fauna surveys, streamwatch, tree plantings, murder under the microscope, seed collecting and propagation etc.		Implementation Officer, Landcare Support Officer, Rebirding Project Officer in conjunction with other landholders and schools	Ongoing
12	Resource Library in the Landcare Shopfront	Resource Library of best practices	Community throughout catchment and beyond	Implementation Officer in conjunction with landholders and other specialists.	On-going
13	Seminars	As per Action #6 above	As per Action #6 above	As per Action #6 above	Seminar or bus trip: one per year

Table 6.4 Education and Marketing Actions cont...

Education and Marketing Actions	Description of Initiatives	Audience and Location	Persons Responsible for Assisting Community to achieve actions	Performance Indicator (cumulative total for the Upper Billabong)
14 Marketing of Holbrook Landcare and the LWMP to the wider community outside the catchment:	• Maintain Landcare Shopfront; • Market the vision, objectives, issues, targets, actions, cost sharing desires etc. to other bodies. Presentations would be tailored to the specific audience. • Focus will be on this catchment being a model catchment, landscape change, community instigated change and a positive outlook - making our dreams happen. • Develop and supply promotional materials eg: clothing, hats, pens etc with Holbrook Landcare logo.		Landcare Support Officer, Implementation Officer, Landcare Executive and LWMP Working Group members	On-going as needed
15 Establishment of Herbarium	Focus on local plant species	Community throughout catchment and beyond	Implementation Officer in conjunction with landholders and other specialists. Develop links with Charles Sturt Uni in their herbarium development	Ongoing
16 Bus Trips	As per Action #6 above	As per Action #6 above	As per Action #6 above	As per Action #13 above
17 Displays/ Posters	• Displays for field days, seminars, conferences, meetings etc. • Displays of vision, values, objectives, issues and actions	Community throughout catchment and beyond	Implementation Officer and Landcare Support Officer.	Ongoing as required
18 Painting red of a high profile dead tree	• Combine with On-ground Action #13; • High profile location, eg: Hume Highway; • Simple signage, eg: "*Holbrook Landcare Improving the Environment*".	Community throughout catchment and beyond	Landcare Support Officer, Urban Landcare Group, Community Organisations.	1 tree

Table 6.5 Consequential Actions

Consequential Actions	Description	Audience and Location	Persons responsible for assisting Community to achieve action	Performance Indicator
Seeking of Public Funds.	Use LWMP as a vehicle for seeking public cost sharing, donations, carbon credits, biodiversity credits, salinity credits annuities, rate rebates and sponsorship.	Local, State and Federal Government, businesses, philanthropic trusts and corporate bodies. Catchment and beyond	Landcare Support Officer, Landcare Executive and LWMP Working Group members.	As per yearly funding requirements to implement the plan (on-going)
Develop a yearly planner of activities	Prepare annually a plan of activities to be instigated and undertaken for the year.	Promote and involve the community throughout catchment and beyond.	Landcare Support Officer, Implementation Officer, Landcare Committee, LWMP Working Group members.	Once per year. (on-going)

3. HOW DO THE ACTIONS RELATE TO THE ISSUES?

The goal of this plan is to reverse the negative effects of the issues, by implementing the actions. Each action is multi-functional. Most positively affect several of the issues. This is logical enough when one considers that each issue is not discrete and separate from the others. There are myriad inter-relationships between issues.

Loss of ground cover caused by soil acidity can contribute to erosion and salinity. Similarly, loss of biodiversity can cause dieback. Loss of trees is linked to rising groundwater and salinity. Salinity causes loss of trees, resulting in further loss of biodiversity. So too, the solutions are not discrete and separate. Table 6.6 summarises some of the main actions and the issues to which they relate. It also shows the contribution of the Holbrook Landcare Shopfront in dealing with the issues.

Table 6.6 A summary of the plan actions for within the Upper Billabong Catchment and the issues they will positively influence.

Issues / **Actions**	A. Reduced Economic Viability	B. Lack of Education	C. Tree Decline/ Dieback	D. Soil Acidity	E. Erosion	F. Weeds	G. Salinity	H. Government Under-standing	I. Decline of Rural Services and Population	J. Water Quality Decline	K. Biodiversity Decline
Revegetation with local natives											
Better management and enhancement of remnants											
Soil Acidity Mitigation											
Perennial Pastures											
Farm forestry											
Native Perennial Pastures											
Erosion Control											
Alternate Industries and Practices											
Seed Orchards											
Conservation Cropping											
Sanctuaries											
Education, Awareness and Marketing Programs											
Landcare Shop Front											

1. COSTS OF THE "DO-NOTHING" SCENARIO

Costs associated with some of the physical degradation issues of concern can be allocated primarily based on productivity losses and management costs (Table 7.1). These sorts of figures need to be viewed with caution as they do not reflect the true environmental and social costs associated with the issues both within and beyond the catchment (eg: downstream costs to mitigate salinity, nitrification and sedimentation; lost employment due to reduced productivity; biodiversity losses). To attempt to obtain these environmental and social costs would be very difficult and costly. The other point to be mindful of is the fact that gross margins and interest rates can be highly variable (eg: sheep and cattle prices have fluctuated between $10 to $25 per DSE over the last ten years).

Table 7.1 Some estimated costs associated with some of the degradation issues within the catchment.

Degradation Issue	Assumptions used	Justification	Approx. Cost per year
Tree Decline and Dieback	• Gross value of agricultural production within the catchment: $22.6 million. • Optimum proportion of tree cover: 25%. • Average productivity loss associated with cropping and grazing enterprises: 20%. These productivity losses relate to lost shelter and shade and increased land degradation (Miles *et al*. 1998). • Conservatively half of the catchment has inadequate tree cover, particularly the flats of the catchment. Therefore, inadequate tree cover affects half the gross value of production, resulting in 10% lost production. However, the potential productivity gains associated with native vegetation on farm (shade, shelter and land degradation mitigation) are usually lost due to the costs of retention or establishment; eg: fencing, weed and pest control.	An average 10% productivity loss can be applied to the gross value of production within the catchment. These productivity losses relate to lost shelter and shade and increased land degradation losses.	$2,825,000
Soil Acidity	Gross value of agricultural production within the catchment: $22.6 million.	A conservative average 20% productivity loss can be assumed (pers. comm. Sykes 1999; pers. comm. Fanning 1999).	$5,650,000

Soil Acidity cont...		This is associated with soil acidity which, on average in the main farming areas within the catchment, has fallen from approximately 5.0 to 4.5 (pH 0-20cm Ca Cl).	
Rill and Sheet Erosion	• Research in the Wagga and Cowra districts have indicated crop losses due to sheet and rill erosion to be on average 35% (Chisholm *et al.*1987). • DSE of 5 on unimproved pasture or marginal country. DSE of 10 on improved pasture or fertile country.	• An average productivity loss of 35% can be applied to soils exposed to rill and sheet erosion. • 18,715 ha of the catchment have been affected by rill and sheet erosion (primarily marginal hill country). • The productivity loss associated with these areas = (18,715hax $92.50/ha x 0.35)	$605,898
Gully and Stream Bank Erosion	• DSE of 10 in non-eroded gullies. The average width of productivity loss due to gullies is estimated to be 3 metres (Hassall & Assoc. 1998). • A gross margin of $18.50/DSE which is typical of merino breeding enterprises of the region	There are 466 km of gully and stream bank erosion within the catchment. The productivity loss associated with these areas = (140ha x $185/ha).	$25,900
Weeds	• The average cost associated with weed control in the establishment of improved pastures and cropping was $65 per hectare (pers. comm. Anderson and Cary-Castleman 1999). • A gross margin of $18.50/ DSE which is typical of merino breeding enterprises of the region • DSE of 5 on unimproved pasture or marginal country. DSE of 10 on improved pasture or fertile country. • The average cost of weed control in remnant native vegetation in the Murray catchment on private property was determined	• Employment of Shire weed inspectors, materials and on-costs. • Weed control associated with establishment of improved pastures and crops = (~9,500ha/ annum x $65/ha). • General on-farm weed control costs on established improved pastures and unimproved pastures =	$55,000 $617,500 $1,974,000

Weeds cont...	to be $7/ha (Miles *et al.* 1998). It has been assumed that weed control of unimproved agricultural land could be double this figure.	(~141,000ha x $14/ha). • Weed control required in areas of existing remnant native vegetation or revegetation sites = (~20,500ha x $7/ha)	$143,500
Salinity		There are currently 133 ha of the catchment, on average, moderately influenced by salinity. A 50% reduction in agricultural production can be assumed for these areas = (133ha x $185 x 0.5).	$12,302
Total			$11,909,100

2. GENERAL DISCUSSION OF THE COSTS AND BENEFITS OF THE PROPOSED ACTIONS

(a) Primarily Public Benefits

Atmosphere

The emission of greenhouse gases is the most pressing issue relating to the atmosphere. Greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and perfluorocarbons (PFCs). The main sectors to contribute these gases are: energy, transport, industrial processes, agriculture, land use change, forestry and waste. Since the onset of industrialisation (about 1750), the concentration of CO_2 has increased by more than 30% and methane by more than 145%. Climate models suggest greenhouse gases may lead to global warming. The models suggest an increase in global surface temperature, relative to 1990, of about 2^oC by 2100 (CSIRO 1996a).

The greenhouse gas issue is relevant in the Upper Billabong catchment. For example, remnant vegetation, revegetation and farm forestry all have the capacity to store CO_2. Of these three, farm forestry for timber production probably has the greatest capacity to sequester carbon due to the economic incentive to maximise growth rates. However, the capacity of the vegetation to store CO_2 will be dependent on the end use of the vegetation. For example, timber being utilised in the construction of buildings has greater potential to store carbon for a longer period than timber utilised for paper products.

Perennial pastures will probably allow for increased grazing animals and therefore increased CH_4 emissions (a greenhouse gas, one tonne of which has the same warming effect as 21 tonnes of CO_2).

Increased Employment / Population

There is potential for the on-ground actions to provide for increased employment within the Upper Billabong catchment.

In "Holbrook Afforestation Development Study" (1990), Margules & Partners suggested that plantations employ a greater number of people per hectare than wool or beef enterprises, based on Victorian studies. However, in the study by Margules it was noted that districts with plantations but no major processing facilities might suffer a net local employment loss if plantation replaces farmland.

In case studies of the Oberon and Central Tablelands districts undertaken by State Forests of NSW, it was found that farm forestry had an "employment multiplier" effect of 2.11. There was also an increase in the number of persons resident per person employed, the average figure being 3 persons resident per person employed. It should however be noted the area has an average annual rainfall close to 900mm, compared to this catchment's average of less than 700mm.

There is potential for the on-ground actions to provide for increased employment

Increased perennial pasture establishment will increase stock carrying capacities. In the best cases, for every 8,000 to 10,000 DSE there should be an increase of one labour unit on the farm (Holmes & Sackett 1997). There would also be flow-on benefits.

Increased Habitat and Biodiversity

Enhancement of remnants of native vegetation and revegetation of areas with local native species will produce the greatest gains for habitat and biodiversity. In general, the larger the patch and the less the disturbance (eg: clearing, grazing, pasture improvement and cropping), the greater a site's natural biodiversity.

A *Birds on Farms* survey (Barrett 2000) involving 330 farms throughout Australia found:

- There is a strong correlation between bird diversity and the presence of tree cover near farm dams and creek lines.
- Pasture improvement practices of clearing native vegetation, replacement with exotic species, higher stocking rates and fertiliser regimes have resulted in the disappearance of natural ecosystems and reduction in bird diversity. This poses a dilemma given that, at the same time, farmers are under pressure to improve pastures in order to remain economically viable.
- Larger patches of trees are preferred for successful breeding (nesting) compared to fragmented patches.
- The number of honeyeater species is significantly greater if a patch of woodland is square or circular shaped rather than a narrow strip.
- Fewer migratory or nomadic bird species, such as grey fantails, leaden flycatchers and sacred kingfishers, are found in patches of woodland isolated by wide stretches of cleared land compared with less isolated patches. As a guide, birds should not have to travel more than 200 metres across open grassland.
- Nest-predators such as magpies, butcherbirds and crows are more common in sites that are continuously grazed and least common in sites that were seldom grazed. Understorey-dependant species showed the opposite trend, being least common in sites that were always grazed and most common in sites that were never grazed.

Farm Forestry will bring some biodiversity gains (State Forests 1998). For example, in a study undertaken by Charles Sturt University, it was found that pines supported 50% more wildlife than cleared farmland. Studies in the Ettamogah State Forest (a predominantly young pine plantation with belts of natives and associated wetlands) found 144 birds, 17 species of mammals, 11 reptiles and 10 frog species. An independent study in North-East Victoria compared fauna levels in a mature eucalypt forest with an adjoining pine plantation. Of the 14 native animal species in the eucalyptus forest, 11 occurred in pine plantations. In addition, 71 bird species were recorded in the mature eucalypt forest and 35 of these occurred regularly in the pine plantations. Of the 35 species, 27 were found to be breeding in the plantation (Margules & Partners 1990).

Widely spaced farm forestry planting (<850 trees/ha at establishment) would particularly suit the Upper Billabong's lower rainfall areas (<700mm). Wide-spaced plantings will allow for more understorey establishment and therefore increased biodiversity due to reduced canopy closure.

Many people believe that eucalypt plantations would be better for the environment, but plantations in general support less wildlife than native forests for the following reasons:

- Plantations are structurally simple, as only one species is planted over a large area, and hence only a single layer of vegetation is available for use by many birds and animals.
- Plantations lack old trees with holes and hollows that are required by many mammals and birds for nesting.
- Plantations do not produce the same diversity of foods as native forests (State Forests 1998).

Reduced Nutrient Flows

The nutrients of interest are phosphorous and to a lesser extent nitrogen. CSIRO's Division of Water Resources undertook a literature review (1996b) that suggests that landuse is a convenient predictor of nutrient loads. It is generally accepted that, in freshwater, phosphorous limits rate processes and total biomass, while nitrogen availability controls the species composition of algal blooms. Table 7.2 provides a summary:

Table 7.2 South-east Australian average annual nutrient export data (CSIRO 1996b)

Broad Landuse Types	Total Phosphorous		Total Nitrogen	
	Range	**Typical**	**Range**	**Typical**
Urban	0.4-3.6	1.0	3.2-22.4	6.6
Improved Pasture	0.1-0.7	0.3	0.6-4.6	3.3
Unimproved Pasture	0.07	0.07	2.2	2.2
Cropping	-	-	-	-
Market Gardens	2.7-14.3	7.1	20-34.5	26
Forests	0.03-0.1	0.06	0.9-1.5	1.1

Based on a literature review of 12 sources. It is assumed that the higher nutrient losses associated with improved pastures are due to the addition of fertilisers.

Also of interest is a study that was undertaken by the Co-operative Research Centre for Catchment Hydrology in 1997 looking at controlling sediment and nutrient movement within catchments. Table 7.3 below provides a summary of their results.

Table 7.3 Buffer zone performance of six metre wide vegetation strips (Bren *et al*. 1997).

Buffer Strip Type	Total Phosphorous		Total Sediment	
	Lost	Trapped	Lost	Trapped
Medium Density Improved Pasture (6m)	41%	59%	2%	98%
Near Natural Riparian Forest (6m)	47%	53%	4.5%	95.5%
Low Density Improved Pasture (3m) plus Near Natural Riparian Forest (3m)	30%	70%	2%	98%

Freshly Cultivated Soil above the Buffer Strips.

Soil Type: Granite Derived Loam.

Overland Flow Rate: Low.

Surface Slope: 16%.

Reduced Salinity

Salinity is affected by the relationship between plants and water uptake. The greater the root system and vegetative surface area, the greater the potential of the plant to evapotranspire water back into the atmosphere.

Trees and shrubs will have the greatest ability to do this. Work undertaken by Clifton (1992) has found large remnant trees in the Bendigo area use on average 142 litres per day. Work also undertaken by Clifton has shown trees within an established plantation of pine or eucalypt have the capacity to on average utilise 100 litres per tree per day. Based on this figure, Passalaqua (1996) proposes that a planting density of around 280 stems per hectare would utilise all available rainfall within the plantation area, in the 750 mm rainfall zone of the Upper Billabong Catchment.

Perennial pastures also have great potential to utilise water. Using Gypsum blocks at “Woorinyan” near Morven, Michael Keys from NSW Agriculture (1998) is showing the benefits of perennial pastures, particularly where the summer growing perennial, lucerne, is included in such pastures. His measurements suggest pastures containing lucerne are more efficient than a young windbreak of trees (average 3m tall) in drying out the profile to depth. He noted that in winter “neither perennial pastures nor trees are able to prevent soil saturation and hence deep drainage”. In conclusion he felt perennial pastures had the potential to make effective use of moisture to depth of 500 to 600mm.

Work by Ridley *et al.* (1997) at the Rutherglen Research Centre found soil water use was greater under perennials over the summer-autumn period and the soil profile was approximately 50mm drier at the beginning of each drainage season. Over 4 years, soil under phalaris became 33mm drier and cocksfoot 24mm drier ($P<0.001$) than under annual or bare fallow. Those authors conclude that “although perennial pastures are unlikely to stop all recharge to groundwater in high rainfall areas (>600mm/year) of south-eastern Australia, they offer a practical way to combine profitable agriculture with reduced land degradation.” In the greater than 600mm rainfall zone they add “tree cover is needed, and agroforestry offers considerable potential ... [A]lley farming offers less potential because of the limited potential of trees to capture water from beyond the root zone.”

Further work also undertaken by Ridley *et al.* (1998) found lucerne increased the water storage capacity of soil to at least 250 mm compared with approximately 100mm under annual crops. They add that in the cropping zone, phase farming based on lucerne offers substantial potential to restore the hydrologic balance.

On-site management will affect greatly the ‘sponging’ ability of plants. For example, there will be less water used during the establishment phases of farm forestry and pastures, compared with the growth phase. As well, overgrazing of perennial pastures will reduce the plant’s leaf surface area, which reduces water use.

To effectively mitigate salinity, Woodward-Clyde (1999d) recommends future recharge control be applied to whole catchments rather than individual components of the landscape.

The direct costs of salinity are borne by the affected landholders and in turn by the local and regional community, due to lower production from affected areas, which results in a reduction of expendable dollars. Production loses will be dependent on the severity of the salting and the production potential of the site. Salinity is a compounding problem predominantly affecting the lower, more productive soils within the catchment.

“The direct costs of salinity are borne by the affected landholders and in turn by the local and regional community, due to lower production from affected areas, which results in a reduction of expendable dollars.”

Reduced Soil Acidification and nutrient requirements

Tree root systems have the ability to penetrate the soil to depth far in excess of pasture species and take up phosphorous (P) and nitrogen (N), two of the main elements associated with the lowering of soil pH levels (Bush 1996). Calcium and other bases can be returned to the soil via leaf litter (Young 1991). This ability to recycle nutrients at depth is often assumed to increase pH over time (Bush 1996). However, Young (1991) indicated that the process, whilst it is in a favourable direction, was unlikely to be of sufficient magnitude in naturally acid soils to increase pH levels, but could check pH levels.

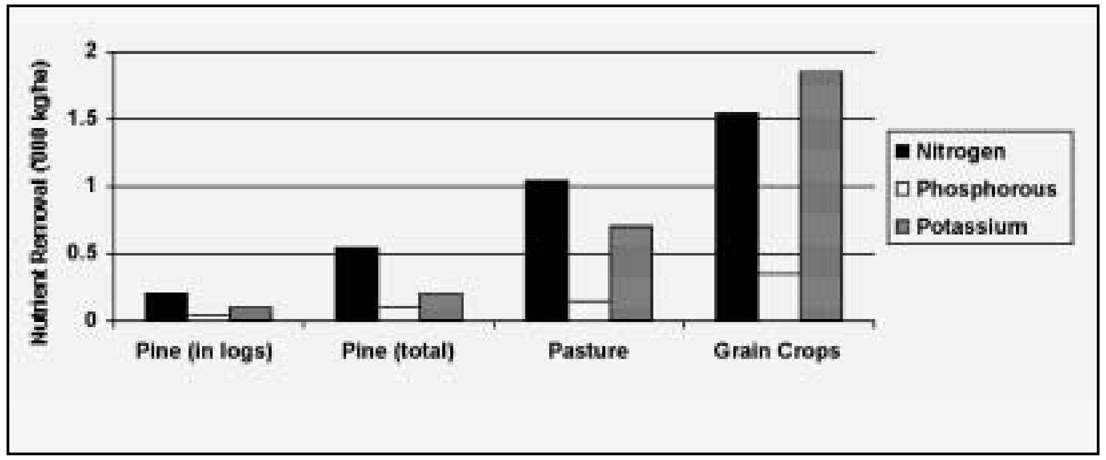
The leaching of N and P is also lower under trees than pastures, reducing acidification of deeper soils and allowing nutrients to be recycled through the upper horizon of the soil (Bush 1996).

Research undertaken by State Forests over a 20 year period has demonstrated that pine trees have less of an acidifying effect on soils than eucalypts or improved pastures (State Forests 1998). Pine plantations do not significantly deplete soil nutrient reserves, even after several rotations (see Figure 7.1 below). However, changes in the nature of surface soil organic matter is still likely with pines because of the high carbon to nitrogen ratio found in pine needle litter.

By comparison agricultural practices, such as pasture improvement, greatly modify soil properties. Soil organic matter and nutrient levels increase through the application of fertilisers. In particular, the level of available P increases as a result of regular applications of superphosphate.

In some circumstances, long-term pasture improvement with legumes produces a substantial increase in N levels and an increase in the acidity of the soil, through the accumulation and rapid turnover of organic matter and high rates of nitrogen mineralisation and nitrate production. These processes also promote the leaching of exchangeable cations.

Figure 7.1 Quantities of nutrients accumulated in a radiata pine plantation and in agricultural crops over a 30-year period (State Forests 1998).



The location of nutrients within a pine tree is important. The component that is harvested (the trunk) typically constitutes 70% of the above ground biomass, yet it contains only a small proportion of the nutrients. The crown and needle litter components of the pine tree, which are not usually removed from the site, contain between 50-70% of the nutrients in the biomass.

N uptake and nitrate leaching below 1.1m was estimated under phalaris, cocksfoot, annual ryegrass pastures and bare fallow in a four year experiment conducted by Ridley *et al.* (1997) at the Rutherglen Research Centre (693mm rainfall). The research found perennial grasses, particularly phalaris, took up more N in herbage than annual ryegrass. High concentrations of nitrate were measured at 1 metre depth below all treatments, suggesting nitrate losses from pastures have the potential to contaminate streams and groundwater. Perennial pastures were able only to reduce nitrate leaching compared with annuals in drier than average years. However, studies being undertaken at “Brooklyn” (Book Book), approximately 50 kilometres north of Holbrook, in a 650 mm rainfall zone, are indicating that soil acidification rates under perennial pasture are slower than under annual pastures and annual pasture/crop rotations (MASTER Experiment, Field Day Handout).

Values calculated for acid addition due to nitrate leaching resulted in a net requirement of 100kg lime/year under perennial pastures versus 150kg lime/year under annual pastures to stop further acidification under these pasture types. A one unit pH decline to 30cm depth was estimated to take 42 years under annual pasture or 67 years under perennial pastures (Ridley *et al.* 1999).

Reduced Soil Erosion

Soil erosion relates to the physical and chemical nature of the soil, slope, rainfall and the organic material (eg: vegetation) found within and on top of the soil. Areas fenced out and not exposed to grazing have the highest potential to reduce erosion. Farm forestry will periodically be exposed to potential erosion particularly at the time of timber harvesting. Perennial pastures should have reduced erosion potential when compared to annual pastures, however, this will depend on establishment and management techniques. Gully shaping, bed control structures, banks and pipes, dams, concrete and rock chutes or flumes can be applied as erosion control management options to enhance improved vegetative management and cover. Methods of treatment vary enormously in both cost and complexity. Permanent concrete structures should be regarded as a last resort. Sound technical advice should be sought before embarking on major structural and shaping works.

Based on works to date it is estimated it might cost on average $25,000 to $40,000 per subcatchment for structural and shaping works to contain the spread of erosion. This does not include fencing and revegetation costs.

(b) Both Public and Private Benefits

Aesthetic

A survey undertaken by Charles Sturt University (Miles et al. 1998) in the North East catchment area of Victoria and Murray catchment area of NSW looked at the costs and benefits associated with remnant native vegetation. It was found that aesthetics (or pleasant scenery) received the highest number of positive responses (Table 7.4).

Table 7.4 Benefits of Remnant Native Vegetation (Miles *et al.* 1998)

Benefit	Victoria (% of participants)	NSW (% of participants)
Aesthetics (pleasant scenery)	89	95
Timber for Firewood and Fencing	86	68
Increased Agricultural Production	77	73
Recreation	73	54
Habitat for animals which help to control pests	69	61
Increased stock production	62	84
Cleaner water	60	49
Nutrient cycling / Soil formation	45	42
Other	37	38
Increased crop production	0	25
No benefits	0	0

NB. More than one alternative could be selected by each participant

The above study highlights the importance of aesthetics. An aesthetically pleasant looking catchment has a significant impact that extends beyond native vegetation cover and health. Other factors that could be put into the category of aesthetics include healthy crops, pastures and livestock and clean vibrant, healthy towns with good infrastructure and services available.

Natural Pest Control

The greater the biodiversity of a site, the greater the potential for natural pest control. For example, it is estimated insectivorous birds such as honeyeaters consume about 24 to 38 kg of invertebrates (mainly insects) per hectare per year in a eucalypt woodland.

> “Over the whole year, on average, 81 per cent of invertebrate production is consumed by vertebrate predators and in summer and autumn this consumption causes a decline in the standing crop (of invertebrates). Clearly vertebrates are important predators on insects and other invertebrates on eucalypt branches, and encouragement of wildlife in eucalypt woodland would aid in controlling insect defoliation” (DCNR 1992).

Improved pastures and crops expose themselves to greater potential impacts from pests and for this reason require greater inputs to control the pests. The impact of pests can extend beyond the crops and pastures. For example, scarab and Christmas beetle larvae feed on the root system of improved perennial pastures and then in the adult phase move on to feed on the leaves of Eucalypts.

The greater the bidiversity of the site, the greater the potential for natural pest control.

Recreational

There are recreational benefits associated with (or within) areas of remnant native vegetation (Table 7.5). Some of the recreational benefits might include: solitude, bushwalking, interaction with nature, observation of how your plants are growing.

Reduced Dieback

As indicated in earlier discussion on dieback and tree decline (Appendix 3: The Natural Environment), the issue of dieback is one of ecological imbalance. Practices that reduce vegetative structure and increase the incidence of herbivorous insects (such as scarabs in improved pastures) have been shown to increase the impact of dieback. Plantings that bring back natural structure and diversity of both flora and fauna have the greatest potential to mitigate dieback. Therefore, better management and enhancement of existing native vegetation would have the greatest effect in mitigating dieback.

> "There is a strong correlation between bird diversity and the presence of tree cover near farm dams and creeklines."

Water Quality

Water quality is influenced by turbidity, salinity and nutrients. The greater the vegetative cover within the catchment, the more these influences can be mitigated.

(c) Primarily Private Benefits

Increased Agricultural Production

The proposed works have direct and indirect effects on production. Relatively quick gains result from the establishment of perennial pastures. The productivity gains associated with revegetation works and farm forestry would be longer term.

Work on improved pastures by Sykes (1997) and Keys (1996) (Table 7.5 and Figure 7.2 respectively) highlights the varying returns when different variables are used, for example, varying livestock costs and returns, lime application etc. It also highlights the need for a cash flow budget specific to each site.

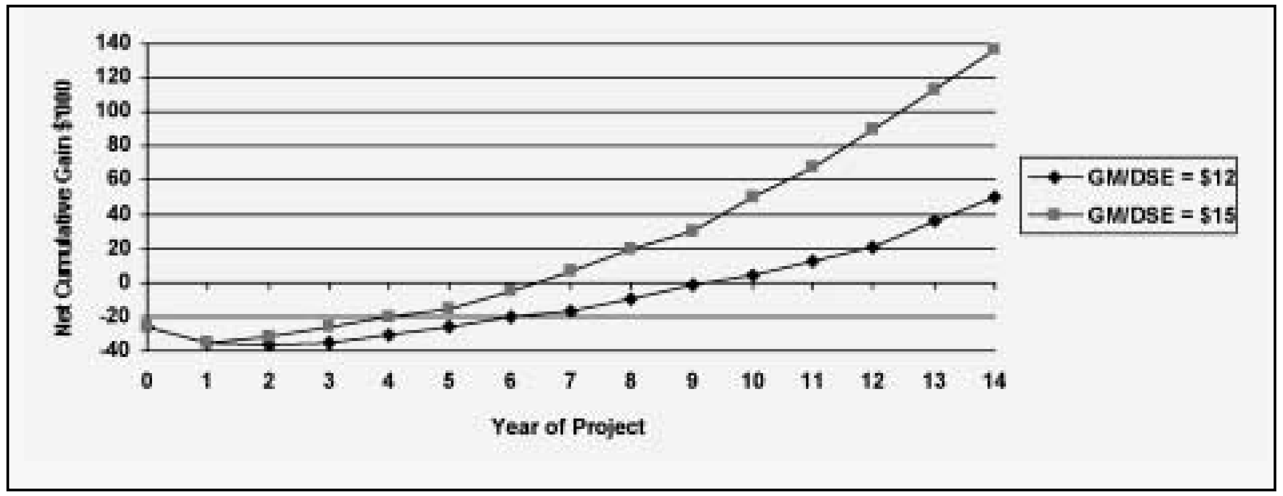
Table 7.5 Estimated return from after a number of years from differing extra stocking rates resulting from improvement to perennial pasture (Sykes 1997).

Years	2DSE /ha Lime*	2DSE /ha no Lime	4DSE /ha Lime	4DSE /ha no Lime	8DSE /ha Lime	8DSE /ha no Lime	10DSE /ha Lime	10DSE /ha no Lime
2	>-33%	-33%	-27%	-18%	-10%	-5%	-19%	-15%
4	-19%	-11%	-5%	3%	11%	16%	17%	21%
6	-8%	0%	5%	12%	19%	23%	31%	34%
8	-2%	5%	10%	16%	11%	18%	31%	37%
10	0%	7%	23%	27%	24%	28%	31%	38%
Cost ($/ha)	396	226	462	292	594	424	660	490

*Assuming an average increase in production of 20% from liming

Figure 7.2 Pasture improvement benefits over time (Keys 1996)

100 ha; est cost = $165/ha.; Maintenance cost/ha/yr = $20;
GM/DSE = $15; Stock Purchase Price/ DSE = $18;
Interest on debt = 14%; Interest on Credit = 4%

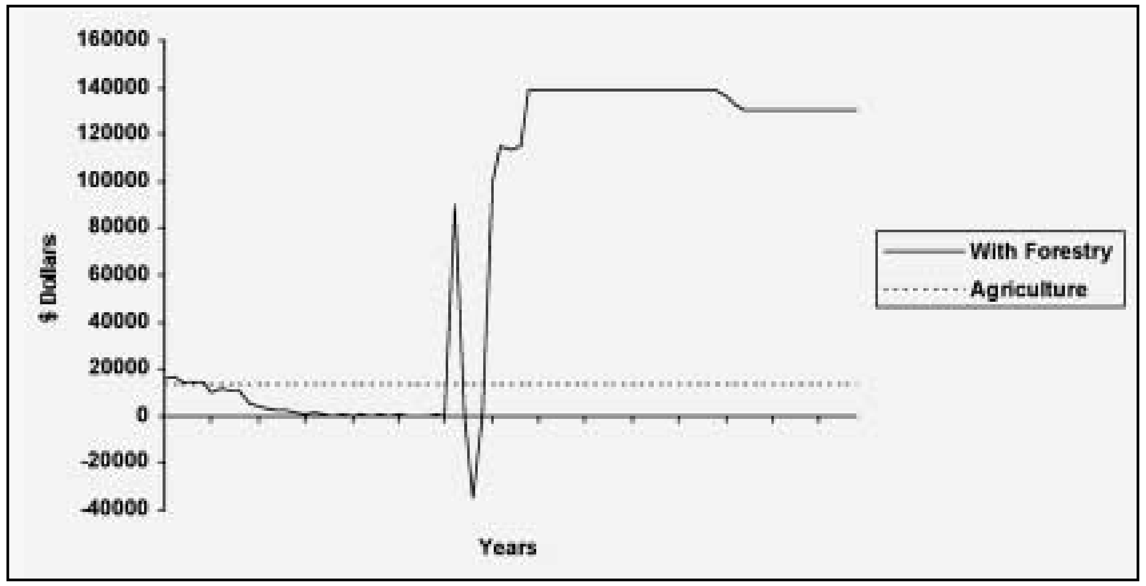


The key determinant of whether livestock producers pay for pasture improvement is their gross margin as it relates to carrying capacity, ie: gross margin/DSE. Unless this is around $15/DSE, or the stocking rate can be raised by more than 2DSE/ha, it will not pay (Keys 1996). The above graph shows it can take a long time to recoup costs associated with perennial pasture establishment. Current commodity prices further exacerbate the problem.

Work undertaken by Passalaqua and Stephens (1997) used an Agroforestry Estate Model to assess the potential of forestry versus agriculture (grazing). Included within the analysis was an assessment of cash flow. They compared forestry to agriculture over 130 hectares of "back country" where the average stock carrying capacity was 3.73 DSE over a hundred year time period (see Figure 7.3). They assumed the land and stock (animal or tree) were sold at the end of that hundred-year period.
The results found:

- Forestry (no value on labour) returns 8.5 % on the money invested.
- Forestry ($15/hour for labour) returns 7.57 % on the money invested.
- Agriculture (no forestry) returns 1.86 % on the money invested.

Figure 7.3 Farm Cash Flow: Agriculture vs Forestry (Passalaqua & Stephens 1998)



There is a decline in cash flow before the first harvest. The analysis has also allowed for a $30,000 road to be established to allow for the harvesting of the timber. "Once harvesting occurs the expected increase in cash flow should offset any monies that may be borrowed to finance the farm forestry project." (The graph has labour priced at $15/hour).

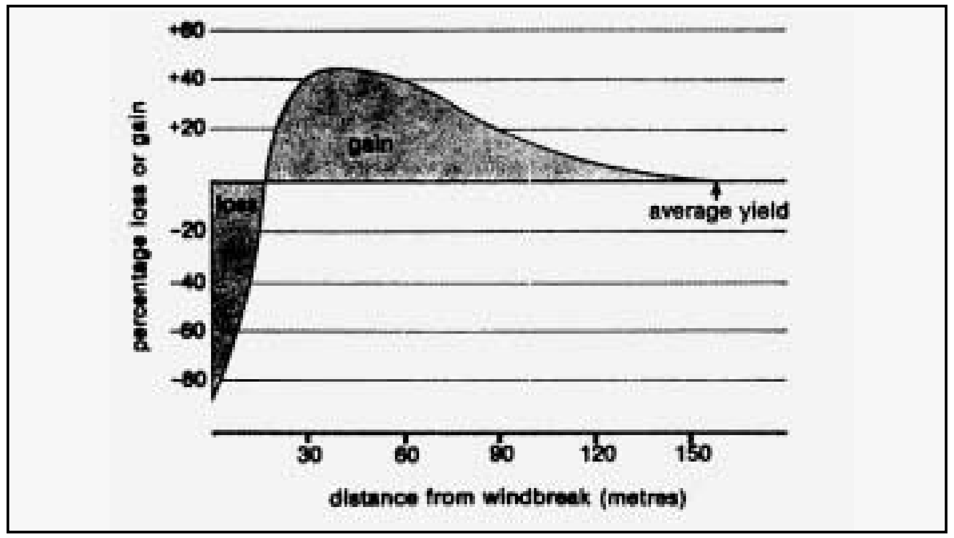
The Internal Rate of Return associated with farm forestry can be anything from 0 to 12%, using a discount rate of 7.5%. The main factors influencing the huge variation are roadage costs, distance to market and rainfall (pers. comm. Brown, 1999).

These figures show farm forestry comparative to a grazing enterprise to be very good. However the factors that dramatically limit the uptake of farm forestry by landholders in the Upper Billabong catchment are primarily risk, the long term commitment, the large establishment costs and the fact that most of the catchment has a rainfall of less than 700mm per year.

Shade and Shelter

Figure 7.4 illustrates the benefits that can be obtained from a windbreak of trees and shrubs.

Figure 7.4 The effect of a windbreak on crop yield
(VegNotes 4.2 1998b)



From research works, Miles et al. (1998) summarised the effects of shelterbelts and windbreaks on plant and animal production as follows:

- Benefits on crops:

  15-47% increase on the yield of various crops.

- Benefits on pasture growth:

  20-30% higher yields. Annual benefit of $38-$66/ha.

- Research at Gunnedah found pasture growth at its highest output level when the proportion of tree cover is 34%. Note that this figure relates to natural areas of bushland rather than shelterbelts or windbreaks.

- Benefits on Livestock Production:

  5-16% increase in lambing percentages. 29-31% wool production increases. 21% increase in liveweight gain. 17% increase in milk production.

(d) Both Private and Public Costs

NB: See Part 5 of this Appendix (Cost-Sharing - Current and Proposed) for further discussion.

Education, Technical Support and Training

A Landcare study undertaken by Charles Sturt University in Victoria in 1998 found community education fundamental to effecting change and that Landcare groups are one of the best ways of doing this work (Curtis *et al.* 2000). The study identified "significant influences on organisational effectiveness, including: the importance of having clear goals, objectives and plans; resource availability; facilitation by an outside agency; and access to a funded group coordinator."

The techniques for undertaking landcare works are constantly being updated. There is ongoing need for education, technical support and training on 'best bet' options and practices. These could be provided in various ways including:

- property and business planning workshops
- field days, seminars, farm walks
- case studies
- brochures, newsletters
- resource centre and reference books.

Technical experts will provide some of this information but there will also be tremendous opportunities for landholders to learn from their peers.

Environmental Weeds

If pines and phalaris grow in areas where they are unwanted (eg: in areas of remnant vegetation and creeklines), then they are environmental weeds. This problem is particularly associated near areas of disturbance (eg: graded road reserves). Selection criteria for incentives and education programs will assist in reducing this problem.

Fire Hazard

With revegetation works and perennial pasture establishment there are indirect and direct fire risks. Through site specific management regimes, these can be minimised. Generally it is not viable to insure against fire in plantations due to the insurance premiums being so high. Consequently, there is a financial incentive to avert the risk through wise management.

Improved Roadage

Farm production relies on roadage to the market place. Commercial farm forestry will increase pressure on road requirements both on and off the farm. This is highlighted in the table below.

Table 7.6 Heavy transport demands of rural land uses (tonnes/ha/year)* (Fortech undated)

Business	Input	Output	Total
Dairy: 180 cows, 100ha irrigated, 6,000 litres/cow/year	0.2	10.8	11.0
Beef: 350 cows, 1,000ha, sell 300/year	0.10	0.12	0.22
Sheep: 3500 ewes, 1,000ha, sell ,000 and 50,000 kg wool/yr	0.10	0.18	0.28
Grain: 1,000ha, crop 800ha, 1,200 tonnes/ha	0.2	1.2	1.4
Vineyards: 10 tonnes/ha yield plus 1 tonne/ha/yr fertiliser	1	10	11
Blue gum plantation: productivity 25 tonnes/ha/yr	0.5	25	25.5
Pine plantation: 20 tonnes/ha/year	0.2	20	20.2

* Estimates of average annual transport loads, excluding management vehicles.

Revegetation works

There are two main ways to revegetate, namely: (1) planting seedlings raised in nurseries (tube-stock); and (2) directly sowing seed into the ground (direct-seeding). At present, there are no clear indications that one method is more efficacious than another and choice of method depends on the physical characteristics of the site, personal preferences and philosophies on revegetation, relative costs and availability of seed.

As for relative costs, there are some differences of opinion between proponents of the two methods as to which is most cost effective. Stelling (1998) provides some estimates of costs of tubestock planting, which are reproduced below. A column has been added to the table below to show cost of tubestock planting as estimated by a local nurseryman (pers. comm. Passalaqua 2000).

On the basis of Stelling's estimates, she concludes that direct seeding would cost about 10-20% of tubestock planting. However, there is greater risk associated with direct seeding. The results are very dependent on rainfall and effective weed control. Failure of propagation requires the direct seeding exercise to be repeated. As well, the availability of sufficient seed supplies is a major limitation of direct seeding. Where seed supplies are scarce, nursery propagation is perceived to be a more efficient user of seed than direct seeding. Using Passalaqua's estimates, there is much less disparity between the costs of tube-stock planting and direct seeding.

Proponents of each method can point to successful examples in the local district. In either case, the priority from a nature conservation point of view is to provide, in so far as is possible, the widest variety of genotypes of locally indigenous plants sourced from locally growing parent stock.

Table 7.7 Variable estimates of costs of tubestock planting

Item	Cost Range (Stelling, 1998)	Approx. Cost (Stelling, 1998)	Approx. Cost (Passalaqua, 2000)
Seedling Purchase			
Tubes	$0.50-$1.00 each	$0.70	-
Cells		$0.35	-
• 95cc's eg hike	$0.30-$0.55 each	$0.40	$0.40 (only cost in this section)
• 45cc's eg lannen	$0.25-$0.40 each	$0.35	
Herbicide	$0.01-$0.05 per seedling	$0.05	$0.05
Deep Ripping	$0.05-$0.15 per seedling	$0.10	$0.10
Treeguards	$0.15-$2.00 per seedling	$0.15 (milk carton guard)	unnecessary
Labour			
*planting	$0.15-$1.00 per seedling	$0.20	$0.13
guarding	$0.25-$1.00 per seedling	$0.40	unnecessary
Total Costs per seedling (to rip, spray, plant and guard)	$1.11-$5.20	$1.95	$0.68

* if machine planting cost is usually less than 10 cents per seedling

Ongoing Acidification

Acidification of the soil is particularly a problem associated with medic-based pastures and crops. Acidification is also the net result of produce leaving the farm. See Appendix 4, Part 2 (Soil Acidity) for more information.

Structural Adjustment

Structural adjustment occurs in an organised or *ad hoc* manner and is a consequence of changes to input prices, commodity prices, resource availability and quality, government regulations, government assistance and industry infrastructure.
The level at which desired options are adopted is dependent on the above factors and as well as the level of education and incentives that might be provided.
Farm forestry is the main area where structural adjustment becomes an issue and, in this regard, structural adjustment could be seen as either positive or negative.

Water Quantity

On one hand, there is a desire to increase the number of perennial species within the catchment to mitigate rising watertables and soil acidity. On the other hand, there is a potentially negative effect associated with these species in reduced surface water flow. This has on-farm implications due to dams taking longer to fill and also off-farm implications down-stream due to reduced flows for stock, domestic and irrigation purposes. It may have nature conservation implications if flow is reduced below that which native plants and animals evolved to cope with. Whether large-scale revegetation with perennial species will result in flow greater or lesser than pre-European times is as yet inconclusive.

Work undertaken in the Murrumbidgee catchment looked at the implication of plantation expansion. It found that after afforestation:

> "the runoff frequency distribution will change markedly. Some streams in the basin that are currently perennial will become intermittent. In planning afforestation programs, catchment managers need to give careful consideration to the needs of downstream water users. Sound hydrologic forecasting is necessary, but so too is a policy and legislative framework to manage the potentially competing needs of timber production and water security." (Vertessy & Bessard 1999)

It is hoped that through the water reform process a clearer picture on this issue will evolve.

(e) Primarily Private Costs

Development application cost

Farm forestry is generally treated differently to agricultural developments. Both the shires of Culcairn and Holbrook require planning permits and associated fees to be lodged before farm forestry activities can be implemented. In Holbrook Shire, the development application fee is determined through a formula as a proportion of the of the average establishment cost, amounting to about $500 for a 20 hectare plantation. This is regarded as high in some quarters but is regarded as low by the shire, particularly when you take into account road maintenance (pers. comm. Parr 1999). The Shire planning process is due to be overtaken by the *Plantations and Reafforestation Act* 1999.

Extra livestock

With the establishment of a perennial pasture, there will initially be a destocking of the paddock over the first year followed by increased stocking in the second and subsequent years. This may result in the landholder needing to purchase stock. The increased stocking will be dependent on the increased carrying capacity - it is not uncommon for stocking rates to be doubled, particularly if soil ameliorants and fertilisers are added. The range of average cost of stock could be $18/DSE (Keys 1996) to $33/DSE (Sykes 1997). The average rate of increased stocking might be from 5 DSE (base pasture) to 7 DSE (end of year one - establishment) to 9 DSE (at the end of year three) (Keys 1996). The average rate of increased stocking in the Upper Billabong catchment is likely to be higher.

Increased Risk

With some proposed works there will also be increased risk. The risks could include:

- new and more critical management skills
- fire - particularly associated with plantation developments
- pests, disease and weeds
- markets (availability and prices)
- social acceptance.

Risk would be one of the greatest inhibiting factors to plantation establishment within the Upper Billabong catchment.

Loss of grazing or lost production

Through fencing of native vegetation, revegetation and farm forestry, production will be permanently lost or changed. Through perennial pasture establishment, there will be lost production primarily in the first year. However, in most circumstances the production losses will be compensated and enhanced due to gains or benefits in other respects.

Paddock establishment costs

Site specifics will dictate establishment and maintenance costs. Some of the issues associated with establishment and maintenance of perennial pastures are covered in the previous section on "Increased agricultural production" (Section (c): Primarily Public Benefits). Table 7.8 gives a breakdown on some of the potential establishment costs associated with pines and eucalypts.

Table 7.8 Potential establishment costs associated with pines and eucalypts (pers. comm. Brown 1999)

Operation	Pines ($/ha)	Eucalypts ($/ha)
Ripping (on contract >D6 to 60cm)	158	158
Weed control (Velpar DF, Atrazine, 2m strip)	58	
Weed control (Round Up, Simazine, Stomp, 2m strip)		37
Weed control application	45	45
Plants (1,000)	300	300
Planting	140	60
Clearing (scattered trees)	67	67
Vermin Control (carrot baiting for rabbits)	17	17
Fertiliser (starter phos)	95	95
Fertiliser application	30	30
Boron (ullexite)	72	
Totals	982	809

Other costs associated with farm forestry establishment include: *Native Vegetation Conservation Act* application ($500); development application (Culcairn and Holbrook Shire ~$500 for a 20ha plantation); dozer float (~$1,000); roadage (potentially $000's); fire fighting unit (~$5,000); fencing (~$2,000/km). Generally, the average establishment cost associated with farm forestry is $1,100 - $1,800 /ha. High establishment costs and long term returns are major factors inhibiting the uptake of farm forestry by many landholders.

Maintenance Costs

It normally requires 50 to 150 kg of lime/ha/year to maintain soil pH in a perennial pasture (Keys 1996). In 1997, Sykes costed 2.5 tonnes/ha of lime at ~$170/ha. The recommended fertiliser application rate for perennial pastures is 125kg/ha every year. This represents a maintenance cost of $20/ha (Keys 1996). In perennial pastures there will also be site specific maintenance costs associated with pests and weeds with costs being potentially highly variable (eg: $10-75/ha/year).

Table 7.9 gives a breakdown of the potential maintenance costs associated with pines and eucalypts over the lifetime of the plantation.

Table 7.9 Potential maintenance costs associated with pines and eucalypts (pers. comm. Brown 1999)

Operation	Pines ($/ha)	Eucalypts ($/ha)
Road Maintenance (Grading - NOT construction)	1,000	1,000
Weed control (2nd year as per first year)	103	
Weed control (Eucmix, if required in 2nd year)		155
Fire breaks, vermin control ($10/ha/year)	300	300
Form Prune	75	75
First Lift	495	375
Second Lift	495	375
Third Lift	375	375
Total over the lifetime of the plantation	2,843	2,655

Property Planning costs

There will be property planning costs associated with the undertaking of medium to longer term strategies on the farm. The costs incurred here could include:

- aerial photography of the farm ($150 - $500)
- undertaking of a "Farming For the Future" course (farm planning course) ($320)
- consultation with accountants, financial advisors, solicitors and private consultants ($100s - $1,000s)
- time developing the plans.

Transport

The greatest issue with respect to transport is the cost of haulage associated with timber. To illustrate the magnitude of this influence, suppose the price of pine pulp logs at the mill door is $33/t. Suppose further that the cost of log harvesting and loading on trucks is $15/t and it costs $6.50/t to haul logs to a mill 50km away. In this situation stumpage will be $11.50/t ($33-$15-$6.50 = $11.50). But if the distance to the mill were 150km with freight cost of $15.80 then stumpage would only be $2.20/t. For a freight distance of 175km, freight cost would be even higher. The result: stumpage could well be zero.

The characteristics of the road can also influence the cost of freight - more wear and tear on trucks, and increased travel time. As an example freight costs on a sealed road can be 12 cents/km/m_3 whilst on a farm track they can be 40 cents/km/m_3.

Transport costs will particularly be a factor for any hardwoods grown in the catchment because most markets are greater than 100km from Holbrook, with the closest being a small mill in Yackandandah. For softwoods there are established markets (with varying timber requirements) in Holbrook, Wagga Wagga, Tumut and Ettamogah.

Increased transport costs are also associated with perennial pastures as there will be more livestock to deliver to market.

3. BENEFIT COST STUDIES IN OTHER REGIONS

If all parties (stakeholders) are accepting of proposed works, then a cost-benefit analysis is unnecessary. The main reason for undertaking a benefit cost study is to weigh up the pros and cons associated with proposed works. The weighting placed on the pros and cons will vary, depending on individual interpretation and attributes of a specific site.

Numerous other districts have undertaken studies to derive the benefit cost ratios (BCRs) of various on-ground works similar to those being proposed for the Upper Billabong. Table 7.10 provides a summary of their results. Where the BCR is *less than one*, then the analyst regards the costs associated with the works as outweighing the benefits. Conversely, a BCR *greater than one* means that the analyst regards the benefits as outweighing the costs.

These benefit/cost ratios provide a guide as to the options and their "economic" implications. However, they are limited because they are based on economic appraisal where dollar values can be ascertained (eg: productivity gains and losses). Often, they do not take into account the benefits and costs that are difficult to value in dollar terms (eg: aesthetics, biodiversity, water quality, employment); in other words, they do not take into account the full value of environmental and social aspects generally.

Often, benefit/cost ratios do not take into account the benefits and costs that are difficult to value.

Table 7.10 Summary of Benefit Cost Ratio/Analysis results found for other regions

Remediation Actions Desired	Cost Benefit Analyses undertaken and their results	BCR
Fencing of Remnant Native Vegetation	Coorong and Districts Local Action Plan, 1997 "Maintain Remnant Native Vegetation"	2.36
	Hypothetical Example (MDBC, 1996) "Remnant Native Vegetation" Murray Catchment, (Miles *et al.* 1998)	1.00
	Given a five year time horizon and a discount rate of 7% governments could spend up to $40.5 million in the Murray catchment and still achieve a net economic benefit, provided conservation outcomes were achieved.	…
Planting with Native Species	Coorong and Districts Local Action Plan, 1997 "Corridor Plantings"	2.05
	Boorowa River Catchment Area "Tree Planting (non commercial) and Perennial Pastures"	1.38 - 1.41
	Campaspe, Catchment Salinity Action Plan "Trees"	0.31
	Hypothetical Example (MDBC 1996) "Widely Spaced Trees" and "Densely Spaced Trees".	1.07
Farm Forestry Planting	Cadell Land and Water Management Plan, 1995 "Irrigated Woodlot Establishment (Flooded Gum and Sydney Blue Gum)"	1.13
	Grazing and Forestry were compared over 100 years on 130 hectares on "Jayfields" a property in the northern end of the Upper Billabong catchment. Forestry returned 7.57% on money invested whilst grazing returned 1.86%.	…

BCR greater than 1 means the benefits outweigh the costs (in the analysts' view).

BCR less than 1 means the costs outweigh the benefits (in the analysts' view).

Farm Forestry Planting cont...	South West Slopes - Timber Industry Haulage Study (1993). Primarily looking at the benefit costs associated with improved roadage requirements if increased softwood plantations were to be developed.	1.2-3.3
Perennial Pasture Est. (Phalaris)	Coorong and Districts Local Action Plan, 1997 "Permanent Pasture"	1.05
	Denimein Land and Water Management Plan, 1995 "Perennial Species (Phalaris) into Irrigated Annual Pasture"	16.27
	Boorowa River Catchment Area "Tree Planting (non commercial) and Perennial Pastures"	1.38 - 1.41
	Campaspe, Catchment Salinity Action Plan "Perennial pasture - phalaris"	1.48
	Avon Richardson LWMP "Phalaris"	2.17
	Hypothetical Example (MDBC 1996) "Perennial Pasture"	1.04
Perennial Pasture Est. (Lucerne)	Coorong and Districts Local Action Plan, 1997 "Permanent Pasture"	1.05
	Denimein Land and Water Management Plan, 1995 "Dryland Lucerne"	3.79
	Cadell Land and Water Management Plan, 1995 "Perennial Species (Lucerne) into Irrigated Annual Pasture"	14.75
	Campaspe, Catchment Salinity Action Plan "Lucerne Pasture"	2.77
	Avon Richardson LWMP "Lucerne"	2.12
	Hypothetical Example (MDBC 1996) "Perennial Pasture"	1.04
Lime	In a national review paper on the social and economic feasibility of ameliorating soil acidification (AACM, undated). Application of lime on unimproved pasture "extensive sheep production"	0.88
	High yielding cropping areas "beans"	11.1
	Unpublished work by Keys (Agronomist, Queanbeyan) looking at "improved pasture" found liming at 2.5t/ha was uneconomic over a 10-year period. (NSW Agriculture 1997).	
	Simpson on multi-purpose, (cropping/pasture option) class 1 and 2 land regards "liming as a superannuation investment if farm cash flow can support it." On land classes above 2 he finds it "difficult to interpret and apply acid soil recommendations" (NSW Agriculture 1997).	
Improved Cropping Practices	Coorong and Districts Local Action Plan, 1997 "Phase Cropping"	1.24
	"Improved Annual Cropping"	1.64
Fencing of Eroded Gullies	Cowra Cost Benefit analysis, based purely on productivity gains, found "quantified benefits do not exceed quantified costs" and added "insufficient data is available" (eg: on the benefits to downstream water quality, prevented soil loss etc).	…

Also of relevance is the cost benefit analysis work undertaken within the Cowra sub-catchments. Within its sub-catchments, the Cowra group is wishing to undertake similar remediation actions as those proposed for the Upper Billabong catchment. The results of their cost benefit analysis are summarised in Table 7.11

Table 7.11 Cowra District Land Degradation Cost Benefit Study
(Hassall & Assoc. 1998)

Degradation Types	**Benefit Cost Ratio of remediation**
Severe Salinity	1.94 - 1.98
Moderate Salinity	1.08
Soil Acidity	1.04
Soil Acidity and Soil Structure Decline	3.77 - 8.91

4. UPPER BILLABONG APPROACH: AN ALTERNATIVE TO COST BENEFIT ANALYSIS.

The Upper Billabong LWMP Working Group regarded standard cost/benefit analysis as having two inherent flaws:

(1) environmental and social components should be included in the analysis but are often undervalued or incapable of standard valuation;

(2) traditional cost-benefit analysis often involves handing the problem (and a large cheque) over to a firm of consulting economists, receiving an ‘answer’ and applying the ‘answer’, without real understanding of what it means to undertake a process of weighing costs against benefits.

In an attempt to grapple with these difficulties, the Working Group approached the issue from a different perspective. Working Group members made a subjective assessment of the issues. Table 7.12 reflects the average scoring obtained from the working group members. I t provides an indication of where the working group feels the main public and private benefits and costs lie.

This approach was taken because:

- numerous similar benefit cost studies have been undertaken already;
- the working group members themselves, rather than a consultant, wanted to obtain a sound understanding of the benefits and costs associated with the on-ground options for their catchment. Weighing up the costs and benefits involves a degree of responsibility that should be taken on by community representatives rather than being abrogated to outside consultants;
- no working group member was strongly opposed to any of the on-ground actions. Cost/benefit analysis is more relevant where the proposals are controversial. Novel or controversial proposals in the future may benefit from formal cost/benefit analysis.

For the benefits and costs working group members used a sliding scale from +3 to -3 to indicate the positive or negative effect an issue had on the catchment (and beyond), over a 30 year time frame.

An important characteristic of the Working Group’s approach is that it may tend to apply too much weighting toward the environmental gains as opposed to the economic gains (that is, the opposite weighting of a standard benefit cost analysis).

Table 7.12 Working Group’s estimation of the effect over 30 years of those on-ground works that potentially require cost-sharing

Postive numbers mean that the proposed on-ground work has a **net positive effect** on the outcome. In other words, the benefits outweigh the costs. **Negative numbers** mean that the proposed on-ground work has a **net detrimental effect** on the outcome. In other words, the costs outweigh the benefits. **1, 2, and 3** represent the strength of the effect, namely **small, medium and high**, respectively. 0 means that the net costs or net benefits are **nil or negligible**. In other words, neither the benefits nor the costs outweigh each other.

OUTCOMES	PROPOSED ON-GROUND WORKS					
	Fencing of Remnant Native Vegetation	*Planting with Native Species*	*Farm Forestry Planting*	*Perennial Pasture Est. (Phalaris)*	*Perennial Pasture Est. (Lucerne)*	*Erosion Control (Shaping and Structures)*
Improved Atmosphere (air)	+1	+1	+1	-1	-1	0
Increased employment/ population	0	0	+2	+1	+1	0
Increased habitat and biodiversity	+2	+2	+1	-1	-1	0
Increased regeneration (reduced revegetation required)	+2	+1	0	0	0	0
Reduced nutrient flows	+1	+2	+1	0	0	+1
Reduced salinity	+1	+2	+2	+1	+1	0
Reduced Soil Acidification and Nutrient Requirements	+1	+1	+2	0	-1	0
Reduced soil erosion	+1	+2	+1	+2	+1	+2
Totals	+9	+11	+10	+2	0	+3
Beneficial outcomes with both Private and Public Benefits						
Aesthetic	+2	+2	+1	0	0	0
Natural Pest Control (eg. Insects)	+2	+2	+1	-1	-1	0

+3 = high net positive effect
+2 = medium net positive effect
+1 = small net positive effect
0 = negligible positive or detrimental effect
-1 = small net detrimental effect
-2 = medium net detrimental effect
-3 = high net detrimental effect

Table 7.12 Working Group's estimation of the effect over 30 years of those on-ground works that potentially require cost-sharing cont...

Recreational	+2	+1	0	0	0	0
Reduced dieback	+2	+2	0	0	0	0
Water quality	+2	+2	+2	+1	+1	+1
Totals	+10	+9	+4	0	0	+1
Beneficial outcomes with primarily Private Benefits						
Stable fodder supply	0	0	0	+2	+2	0
Increased agricultural production	+1	+1	+2	+2	+2	0
Increased property values	+1	+1	+2	+2	+2	+1
Shade and Shelter	+1	+2	+2	0	0	0
Totals	+3	+4	+6	+6	+6	+1
Outcomes with both Private and Public Costs						
Adminn costs of Projects	0	0	0	0	0	0
Catchment Planning costs	0	0	0	0	0	0
Education, Technical Support and Training costs	-1	-1	-1	-1	-1	-1
Environmental Weed	0	0	-1	-1	0	0
Fencing	-1	-1	0	0	0	0
Fire Hazard	-1	-1	-1	0	0	0
Roadage	0	0	-1	0	0	0
Costs of planting/ direct-seeding of native trees and shrubs	0	-1	0	0	0	0
Costs of Soil Erosion works	0	0	0	0	0	-2
Ongoing Acidification	0	0	0	-1	-1	0
Structural adjustment	0	0	0	0	0	0
Reduced Water Quantity	0	0	-1	0	0	0
Totals	-3	-4	-5	-3	-2	-3
Outcomes with primarily Private Costs						
Extra livestock purchase costs	0	0	0	-1	-1	0
Increased Risk	0	0	-2	0	0	0
Loss of grazing or lost production	0	0	0	+1	+1	0
Establishment costs	0	0	-2	-1	-1	0
Maintenance costs	-1	-1	-2	-2	-2	0
Property Planning costs	0	0	0	0	0	0
Transport Costs	0	0	-2	0	0	0
Totals	-1	-1	-8	-3	-3	0
Grand Totals *	+18	+19	+7	+2	+1	+2

* These figures should not be used as a definate answer on best options. Rather, the important point to note is the process of setting priorities by an analysis of benefits and detriments. Also important to note is that a different analysis (eg: traditional cost-benefit analysis) may have produced a different weighting.

5. COST SHARING - CURRENT AND PROPOSED
(OR WHO PAYS NOW AND WHO SHOULD PAY)

The cost sharing tables and figures have been developed as a tool to initiate discussions with key stakeholder groups such as the community of the Upper Billabong, government (Local, State, Federal), corporate bodies, businesses, Catchment Management Boards, Murray Darling Basin Commission, Department of Land and Water Conservation, Greening Australia and EPA.

Table 7.13 provides an overview of current cost sharing arrangements and cost sharing desired by this Plan. Table 7.14 provides a summary of cost sharing over the next five years and as a total cost in the year 2030 - based on the desired plan targets. Figure 7.5 presents an example of landholder versus public cost sharing in the year 2001.

Beneficiary Pays Approach

A 'beneficiary pays' approach is being used in the development of cost sharing arrangements. Under a 'beneficiary pays' approach, anyone deriving a direct benefit should pay for the works. As well, anyone deriving an indirect benefit should also contribute. However, even the most thorough analysis could not accurately value every possible benefit and cost, particularly as many (such as aesthetics and maintaining biodiversity) are non-market intangibles.

Under a beneficiary pays approach, anyone deriving a direct benefit should pay for the works. As well, anyone deriving an indirect benefit should also contribute.

Due to the difficulty in valuing all of the benefits and costs and State Government's unwillingness to formally 'sign-off' on dryland Land & Water Management Plans, there has been a reluctance within the Working Group to pursue more formal and expensive cost sharing arrangements. To date the cost sharing arrangements are based on precedents in other regions, Natural Heritage Trust guidelines and discussions with the Holbrook Landcare Group and Upper Billabong LWMP Working Group (representative of the community at this point in time). Final cost sharing arrangements will be refined using general 'beneficiary pays' principles, negotiation and stakeholders' ability to pay.

The Cost Sharing Arrangements

The dollar figures in Tables 7.13 and 7.14 represent maximums for current and proposed costs. Where costs are less, the incentives provided will be less. Some explanations of other terms used in the tables:

"*Current Cost Sharing (who pays now)*" represents the cost sharing that is currently available. The cost sharing arrangements over the next five years ("Summary of Cost Sharing Over the Next Five Years" - Table 7.14) are based on these figures, which are derived from precedents set by the Natural Heritage Trust or other catchments and regions.

"*Proposed Cost Sharing*" represents the cost sharing levels that would be required to instigate higher level of on ground actions being undertaken - to more realistically acquire the targets that have been set within the plan.

"*Public*" refers to a 50:50 mix of funds from state and federal government.

"*Private*" refers to private landholders or managers.

"*Other*" refers to a mix of funds from local government, businesses, philanthropic trusts, corporate bodies and Roads and Traffic Authority. In the medium to longer term where applicable rate rebates, carbon credits and biodiversity credits will also be sought. The mixture of funds will vary from year to year. It is hoped that over time these costs may represent over 40% of the cost of the works that are not private.

In Table 7.14 (Summary of Cost Sharing Over the Next Five Years):

"*Other Landcare Associated Costs*" refers to the landcare costs where no cost sharing is currently being sought such as improved cropping practices; liming for pastures and crops; technical input from other organisational and consultative extension services; replanting costs; risk and roadage costs (particularly for plantations); maintenance and management costs; weed and pest control; property and business planning costs; lost grazing, and annual rates. Conservatively these "other landcare costs" represent a cost to the landholders in the catchment of approximately $1.9 million per annum.

"*Landcare Communications*" refers to landholder costs associated with employment support, project establishment and management, landcare and working group meetings, community meetings, presentations, field days, farm walks, seminars, surveys and sub-catchment/catchment planning workshops. Conservatively these represent a cost to the landholders in the catchment of approximately $144,000 per annum.

Table 7.13 Current and Proposed Cost SHaring for On-Ground Actions

(see notes below for further explanation)

On Ground Actions	Current Cost Sharing (Who Pays Now)		Proposed Cost Sharing (Who Should Pay)	
	Public Share	*Private Share*	*Public Share*	*Private Share*
Revegetation With Local Natives	Fence Establishment (see Note 1 below)			
	$1,200/km (32%) Covers part of the fence material costs (for an average fence). (See Note 2 below)	$2,500/km (68%) Covers the remaining fence material costs and all of the construction costs (for an average fence).	$1,500/km (40%) Covers most of the fence material costs (for an average fence). Particularly appropriate for large, biologically diverse, or threatened community sites.	$2,200 (60%) Covers part of the fence material costs and all of the construction costs (for an average fence).
	Establishment Of Plants (see Note 3 below)			
	$250/ha (31%) Part of plant material costs for native vegetation establishment. (See Note 2 below).	$550/ha (69%) Part of plant material, plus all ground preparation and planting costs for native vegetation establishment	$400/ha (50%) All plant material costs for native vegetation establishment.	$400/ha (50%) All ground preparation and planting costs for native vegetation establishment.
Better Management And Enhancement Of Remnant Native Vegetation.	Fence Establishment (see Note 1 below)			
	$1,200/km (32%) Covers part of the fence material costs (for an average fence). (See Note 4 below).	$2,500/km (68%) Covers the remaining fence material costs and all of the construction costs (for an average fence).	$1,850/km (50%) Covers all of the fence material costs (for an average fence). Particularly appropriate for large, biologically diverse, or threatened community sites.	$1,850/km (50%) Covers all of the construction costs (for an average fence).
	Establishment Of Plants (Enhancement) (See Note 5)			
	$250/ha (50%) Covers all plant material costs (see Note 4 below).	$250/ha (50%) Covers all ground preparation and planting costs.	$250/ha (50%) Covers all plant material costs (see Note 4 below).	$250/ha (50%) Covers all ground preparation and planting costs.
Establishment Of Alternate Watering Points	$1,200 (48%) Available for creek sites only for the establishment of an alternate watering point (based on average costs). (See Notes 6 and 7 below).	$1,300 (52%) For the establishment of an alternate watering point establishment (based on average costs).	$2,000 (80%) For establishment of alternate watering point (based on average costs). (See Note 7 below).	$500 (20%) For establishment of alternate watering point (based on average costs).

Soil Acidity Mitigation	Liming			
	$0	$180/ha (100%) For 2.5 tonnes/ha of lime. Currently all costs associated with application of ameliorants to mitigate soil acidity are met by the landholder.	$40 (22%) For the maintenance of a soil acidity level able to adequately maintain perennial pastures (applied at 2.5 tonnes/ha).	$140 (78%) For the maintenance and establishment of perennial pastures (applied at 2.5 tonnes/ha).
Perennial Pastures (eg: Phalaris, And Lucerne)	Perennial Pasture Establishment			
	$66/ha (13%) For part of the establishment costs. (See Note 8 below)	$449/ha (87%) For remainder of the establishment costs, (includes liming at 2.5 t/ha and fencing costs: see Note 9).	$130/ha (25%) For part of the establishment costs	$385/ha (75%) For remainder of the establishment costs, (includes liming at 2.5 t/ha and fencing costs see Note 9).
Farm Forestry Plantations	Plantation Establishment (see Note 10 below)			
	$0 (See Note 11).	$1,435/ha (100%) For all establishment costs. (See Note 9 below).	$800/ha (66%) For plants, deep ripping and some other establishment costs.	$635/ha (44%) For the remaining establishment costs. (See Note 9 below).
	Annuities (see Note 10 below)			
	Annuities are currently available through State Forests based on land values, rainfall, soils, topography and road access.		It is hoped that annuities and or carbon credits greater than those currently available can be obtained.	
Perennial Native Grasslands	Fence Establishment (to allow for improved management)			
	$0	$3,700/km (100%) All fencing costs	$1,500/km (40%) Covers most of the fence material costs (for an average fence).	$2,200 (60%) Covers part of costs of materials and all of the construction costs (for an average fence).
Erosion Control Earth And Structural Works	Earth And Structural Works (See Note 12 below).			
	$15,000 (38%) For part of the earth and structural costs of effective remediation of erosion in an average sub catchment. (See Note 13 below)	$25,000 (62%) For remaining earth and structural costs of effective remediation of erosion in an average sub catchment. (See Note 13 below)	$20,000 (50%) For part of the earth and structural costs associated with the effective remediation of erosion in an average sub catchment.	$20,000 (50%) For the remaining part of the earth and structural costs associated with the effective remediation of erosion in an average sub catchment.

Explanatory Notes to Table 7.13:

1. An average fence cost has been used. A sheep proof fence costs on average $3,000/km to construct whilst a cattle proof fence costs on average $4,400/km to construct.
2. Represents funds available through Holbrook Landcare (Rebirding Project 2000-2001).
3. A larger number of plants (~900/ha) would be required in areas where limited or no remnant native vegetation remains
4. Represents funds available through Holbrook Landcare (Rebirding Project 2000-2001); Greening Australia (Fencing Incentives 1999-2000 and Vegetation Enhancement Projects 1999-2001) and Department of Land and Water Conservation (Native Vegetation Program 1999: under exceptional circumstances extra funding can be made available through this program).
5. In general a reduced number of plants (~500/ha) would be required within areas of remnant native vegetation through vegetation enhancement works.
6. Funds available through Greening Australia (Billabong Creek Renascence Project 2000-2001). This program is due to be wound up in 2001.
7. Funds for an alternate watering point can be obtained only where access to a creekline with water available at most times is removed.
8. Based on funding available through Holbrook Landcare's *Perennial Pastures Incentive Program*.
9. Assumes on average one kilometre of fencing will be required for every 20 hectares of plantation or perennial pasture established.
10. It is desirable that a combination of both annuities and establishment incentives be provided for farm forestry.
11. There is no general funding for farm forestry. Occasionally funding has been available for a limited number of trial sites and some timber growers (eg: State forests) have reached agreements with a small number of landholders for joint ventures and share-farming arrangements. The Heartlands project is providing funds for a small number of trial plantations, with the incentive based on a rainfall gradient.
12. It is difficult to derive accurate figures on earth and structural works to mitigate erosion as they will be site specific costings, preferably obtained on a sub-catchment by sub-catchment scale to maximise the integration of works. The figures are based on average sub-catchment costs (there are 13 sub-catchments in the Upper Billabong).
13. Based on funds sought by sub-catchments and some individuals through the Natural Heritage Trust and Rivercare Program. The cost sharing in previous projects for earth and structural works has been 3:5 (public: private)

Table 7.14 Summary of Cost Sharing Over Five Years (2000 -2004) and as a Total in 2030. (Figures in $'000. A 3% per year incremental increase in the cost of works has been used).

	2000			2001			2002			2003			2004			Totals in 2030		
On-Ground Works	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other
Fencing of Remnant Vegetation	56	114	3	63	128	3	27	57	9	27	56	13	36	70	26	754	1,763	226
Enhancing of Remnant Vegetation	76	76		89	89	10	37	37	8	36	36	12	46	46	24	1,057	1,181	148
Fencing for Revegetation	84	175	4	95	193	5	27	57	9	27	56	13	36	70	26	1,269	2,797	288
Revegetation with Local Natives	114	250		137	307	10	45	99	16	45	97	23	48	108	38	1,881	4,365	438
Fencing of creeklines/tributaries	56	117	3	56	114	3	22	50	2	25	52	9	21	43	14	278	456	55
Alternate Stock Watering Points	15	15		15	15		10	10		10	10		11	11		101	101	
Soil Erosion Structural and Earth Works	33	52		30	51		30	50		31	52		32	53		624	1,032	
Farm Forestry Establishment	0	0		250	468		450	842		464	867		453	849	68	7,384	13,047	3,122
Perennial Pasture Establishment	0	0		132	897		92	625		95	644		98	663		834	5,658	
Other Landcare Associated Costs		1,900			1,957			2,014			2128			2,185			57,000	
Subtotal (On-Ground Works)	434	2,699	10	867	4,219	31	740	3,841	44	760	3,998	70	781	4,098	196	14,182	87,400	4,277
Subtotals as a percentage	14%	86%	0%	17%	83%	0%	16%	83%	1%	16%	83%	1%	15%	81%	4%	14%	82%	4%

Table 7.14 Summary of Cost Sharing Over Five Years (2000 -2004) and as a Total in 2030 cont...

	2000			2001			2002			2003			2004			Totals to 2030		
Education and Marketing	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other
Landcare Communications		144			148			152			156			159			4,944	
Ext. Materials	7			9			10			10			10			309		
Investigation of Options	13	20		13	21		13	22		13	23		12	24		201	355	
Landcare Shop Front		6	5		6	5		6	5		6	5		6	5		185	154
Landcare Support Officer	41			58			59			61			63			1,850		
LWMP Implementation Officer	32			45			47			49			51			1,545		
Rebirding Research Biologist	13															190		
Rebirding Project Officer	17			23			24			24			25			772		
Monitoring and Evaluation	9	20		7	21		7	22		7	23		7	24		216	710	
Subtotal (Edu. and Marketing)	132	190	5	155	196	5	160	202	5	164	208	5	168	213	5	5,083	6,194	154
Subtotals as a percentage	40%	58%	2%	43%	55%	2%	44%	55%	1%	44%	55%	1%	44%	55%	1%	44%	55%	1%

	2000			2001			2002			2003			2004			Totals to 2030		
On Costs and Administration	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other
Travel	25	35	5	25	35	5	21	36	10	13	37	15	12	38	15	370	1,173	464
On Costs	24			30			31			32			32			989		
Administration	1	22		14	23		15	24		15	25		16	26		330	535	
Employee Training	4	3		5	4		5	4		5	4		6	5		187	155	
Auditing				9	9					9	9					139	139	
Subtotal (Admin. and On Costs)	54	60	5	83	71	5	72	64	10	74	75	15	66	69	15	2,015	2,002	464
Subtotals as a percentage	45%	51%	4%	52%	44%	4%	49%	44%	7%	45%	45%	10%	44%	46%	10%	45%	45%	10%

	2000			2001			2002			2003			2004			Totals to 2030		
Totals	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other	Public	Private	Other
Subtotal (On-Ground Works)	434	2,699	10	867	4,219	31	740	3,841	44	760	3,998	70	781	4,098	196	14,182	87,400	4,277
Subtotal (Edu. and Marketing)	132	190	5	155	196	5	160	202	5	164	208	5	168	213	5	5,083	6,194	154
Subtotal (Admin. and On Costs)	54	60	5	83	71	5	77	64	10	88	75	15	82	69	15	2,015	2,002	464
Totals	620	2,949	20	1,105	4,486	41	977	4,107	59	1,012	4,281	90	1,031	4,380	216	21,280	95,596	4,895
Totals as a percentage	17%	83%	0%	21%	79%	0%	19%	80%	1%	19%	79%	2%	18%	78%	4%	17%	79%	4%

Figures for 2000 and 2001 have been based on a combination of figures from the Holbrook Landcare Rebirding Project, Upper Billabong LWMP Implementation Project, Mirrabooka Lane project, Little Billabong Erosion Control Project, Mountain Creek Erosion Control Project and 25% of the Billabong Creek Renascence Project (Greening Australia).

Figure 7.5 An Example of Private vs Public Cost Sharing (2001)

NB. "Other Landcare Associated Costs" and "other contributors" have not been included

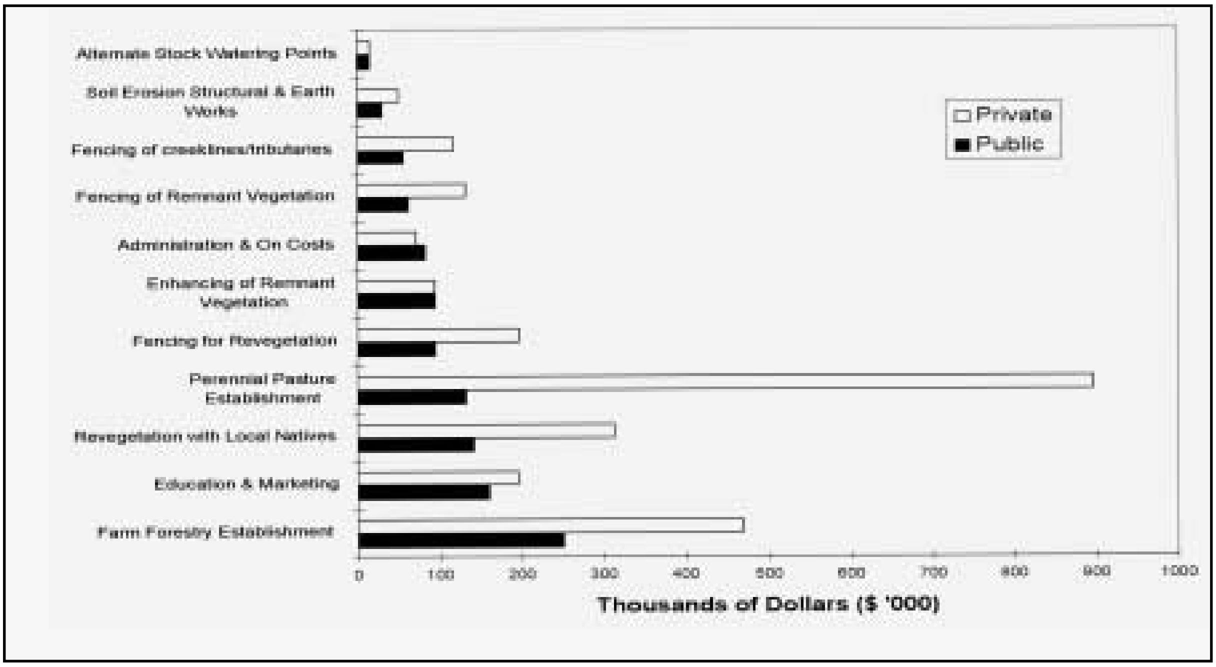


Table 8.1 Regular Short-term Monitoring and Evaluation

(at least once every five years)

The tables below show the main monitoring and evaluation that has either occurred historically or should be continued. Regular short-term monitoring is listed in Table 8.1 and regular long-term monitoring in Table 8.2. Monitoring and Evaluation of the Plan is necessary to:

- Determine we are implementing the desired actions according to the targets
- Determine whether the actions are having a positive effect on the catchment issues
- Ensure the actions are socially, environmentally and economically acceptable.

Subject of Monitoring	Location and Description of monitoring	Who monitors and how often	Who interprets the data and conveys the information	Recommendations
Water Quality (Streamwatch)	Historically, 37 sites within the catchment have been monitored for salinity, pH, and turbidity. 6 of these sites were also monitored for Total Nitrogen (TN) and Total Phosphorous (TP).	Landholders undertook the pH, salinity and turbidity tests on a monthly basis. The landcare coordinator took the samples for TN and TP once every 6 months	Kate Browning (Resource officer – Water Quality - DLWC, Deniliquin). The information was conveyed through workshops and newsletters as statistical data and maps.	The Program has fallen into disrepute with landholders because of lack of feedback that connects landuse and water quality. The Program should be continued with improved regular updates, taking into account the concerns listed above.
Water Quality (Water Reform)	Sampling is being proposed by the DLWC on the Billabong Creek at Culcairn and Walbundrie. A range of sampling/ monitoring will be undertaken including; EC, pH, temp., turbidity, (through remote continuous sensors). Total P and N tests will also be undertaken. There may also be some investigation of riparian zone flora and fauna.	DLWC as part of the water reform program.	Peter Huhta (DLWC - Albury). Not yet known how the information will be conveyed.	Support and formalise the establishment of these stations. Establish a formal monitoring point at Morven as a test point for landuse change in the catchment.
Water Quality (DLWC)	Sampling is being undertaken by DLWC at Walbundrie. A range of sampling/ monitoring is being undertaken including stream flows. Water Quality Monitoring Strategy being developed – will act as 'umbrella' for above mentioned programs, providing	DLWC undertakes the monitoring. Sampling is usually monthly. Although varies depending on the analysis being undertaken	Kate Browning (Streamwatch Coordinator - DLWC, Deniliquin). The information is conveyed through reports, workshops and newsletters as statistical data and maps.	Continue to support. Establish a formal monitoring point at Morven as a test point for landuse change in the catchment.

Table 8.1 Regular Short-term Monitoring and Evaluation cont...

Subject of	Location and Description Monitoring	Who monitors and of monitoring	Who interprets the data and how often	Recommendations conveys the information
	catchment health reports on a subcatchment by subcatchment basis.			
Community Attendance and Involvement	Throughout the catchment monitor the number of community members attending; community meetings, field days, workshops, seminars. Maintain a record of landcare members.	To be undertaken by the project officers. Data to be collected and maintained on a day by day basis.	Implementation Officer, Support Officer, Holbrook Landcare Group and LWMP Working Group.	
Groundwater Monitoring (Waterbalance Modelling)	A groundwater monitoring officer has been employed. That person monitors 83 strategically determined bores, wells and piezometers throughout the catchment. All have been globally positioned with a differential GPS. Depth to watertable and EC are recorded.	Alison Jowett undertakes the monitoring every 3 months.	Baden Williams (consultant - Canberra) and Nimal K. (DLWC, Albury) interpret the data. It is hoped waterbalance modelling and trends can be determined over time (5 years+)	Continue to support. Encourage more strategic monitoring outside the catchment, eg: Morven to Walbundrie.
Groundwater Monitoring (Community)	Subcatchment leaders throughout the catchment were taking depth to watertable and EC readings of 220 bores, wells and piezometers throughout the catchment.	Landholders undertook the monitoring every two years during the summer since 1991.	DLWC and Baden Williams have attempted to interpret the data to date. Anomalies in the data have made this difficult.	Only continue if the data can be readily used and provide identifiable benefits. Encourage on farm (slandholder) monitoring, particularly in areas of salting and landuse change.
Flora and Fauna (Community and other organisations)	Landholders and various departments have been involved in varying flora and fauna surveys	Varies – needs-be basis. On-going	Landholders including Beverly Geddes, Sue Pugh, Charles Sturt Uni. (Albury and Wagga), NPWS (Canberra), State Forests (Tumut).	Continue to support.
Flora and Fauna (Biologist)	As part of the Rebirding Project to mitigate dieback, bird and flora/ habitat surveys will be undertaken	Future monitoring recommendations to be determined by the Rebirding	Stuart Collard - biologist employed by the landcare group, as well as a specialist	Continue to support.

	on about 70 strategically chosen sites. Further fauna surveys (primarily mammals) will also be undertaken on some of these sites in the near future.	Project. Stuart Collard and Landholders	technical support team.	
Photo points at revegetation sites	As part of the incentives to be provided for landcare activities such as fencing of existing vegetation, revegetation, farm forestry erosion control and perennial pasture establishment, photo points be established where practicable.	To be undertaken by individual landholders annually.	Landholders. Extension staff utilise these photos as required for field days, newsletters etc.	
Weeds	The Shire weed inspectors and landholders are continually evaluating weed problems. The inspectors make regular recommendations, amendments and additions to the noxious weed listing.	Varies – needs-be basis.	Shire Weed Inspectors. Landholders	
Auditing and inspection of Project Works	Undertake the inspection of projects funded by landcare incentives to ensure the works have been adequately undertaken in accordance with the project specifications. The provision of original receipts (for materials and or contract labour) will be mandatory prior to the provision of funds. Take note of project failings and successes so that these can be taken account of in future projects.	Project Officers will undertake the inspections. Any landholder receiving >$2,500 (incentive) will be inspected. One in three landholders receiving <$2500 will be randomly inspected.	The project officers will report works to the Landcare Group. In the case of grievances the Landcare Group will have the final say on whether the works proposed have been adequately undertaken.	Auditing of projects, obtaining of receipts for works undertaken and inspection of works be a mandatory component of landcare activities.
Evaluation of plan actions	Plan actions (particularly new ‘on ground’ actions) will be evaluated to ensure they are meeting the community’s vision and values. Actions will need to be environmentally, socially and economically acceptable. Formal Cost Benefit analysis work may assist in providing guidance.	Implementation Officer and specialist consultants (where required) with input from the LWMP Working Group, Holbrook Landcare Group and community. On a needs be basis every year.	Implementation Officer to relevant groups	
Review of the plan and its	Internal (Landcare Group and LWMP Working Group) and External review	Landcare Group meets monthly. LWMP working group meets	Landcare Support Officer will be responsible for establishing	

Table 8.1 Regular Short-term Monitoring and Evaluation cont...

Subject of	Location and Description Monitoring	Who monitors and of monitoring	Who interprets the data and how often	Recommendations conveys the information
implementation by internal and external review groups.	groups oversee the development of the catchment's plan and its implementation. External review group to be established comprising representation from relevant organisations (eg: Greening Australia, DLWC, CSIRO, NSW Ag, Murray Farm Forestry, State Forests, Murray CMB, MDBC)	every three months. External Review Group will meet yearly	the external review group, ensuring all these groups are kept informed of relevant information and that desired changes are instigated.	
Evaluation of Funds	Keep up to date records on the funds being expended through various projects and Landcare incentives. Determine the level of funds that are required to adequately undertake the works desired and cost sharing arrangements (with the public sector) that could evolve.	Landcare Funds Manager; Landcare Support Officer.	Landcare Support Officer and Funds Manager will be responsible for determining the levels of funds used and required. This information will be interpreted and conveyed to relevant groups and employees.	
Landholder Uptake	Throughout the catchment monitor the number of landholders actively undertaking desired landcare activities. Would primarily be based on the uptake of projects, incentives and 'best bet' practices. Data would be maintained in spreadsheet and GIS databases. Compare this against targets desired	To be undertaken by the Implementation Officer. Data to be collected and maintained on a day-by-day basis.	Implementation Officer, Landcare Group and LWMP Working Group.	A GIS database be set up on which all landholders obtaining incentives can be placed.

Table 8.2 Regular Long-term Monitoring and Evaluation (every five years or more).

Subject of Monitoring	Location and Description of monitoring	Who monitors and how often	Who interprets the data and conveys the information	Recommendations
Soil: • Acidity (pH) • Elec. Cond. (EC) • Exchangeable Cations (Ca, Mg, Na, K) • Texture, stability, dispersion	Through the Acid Soils Project 326 soil samples were taken throughout the catchment by 50 landholders representing an area of >13,000 hectares. Samples were taken at 0-10cm and 10-20cm. The main purpose of analysis was for pH (CaCl and water). Maps will be produced of the results. Sub soil sampling to one metre is also being instigated.	Landholders within the catchment. This is instigated by the Acid Soils Project Officer. It is recommended this be done every 5-15 years.	Anthony Fanning - Acid Soils Project Officer (Albury) and the Acid Soils Project working group. The information is conveyed through workshops and newsletters as statistical data and maps	That this work continue and that the Acid Soils Project be supported.
Salinity Surveys (EM31 transects and soil salinity mapping)	10 strategically determined EM31 transects have been walked across subcatchments within the catchment. Visual soil salinity has also been mapped from orthodigitised aerial photography, field checked and placed on GIS	Landcare Group and LWMP Working Group to instigate the collection of data. Every 15 years.	Woodward Clyde (Consultants - Canberra) and Stuart Lucas (DLWC - Albury)	Continue on needs be basis
Erosion	Erosion (gully, stream bank and sheet) has been mapped from orthodigitised aerial photography, field checked and placed on GIS	Landcare Group and LWMP Working Group to instigate the collection of data. Every 15 years.	Woodward Clyde (Consultants - Canberra) and Stuart Lucas (DLWC - Albury)	Continue on needs be basis
Financial Study	31 landholders within the catchment were surveyed to determine their ability to afford improved landuse practices and attitudes to best bet practices.	Continue on needs be basis Working Group to instigate the collection of data. Every 15 years.	Hassall and Associates undertook the study in 1998. It is recommended the LWMP project officer undertake the work in the future.	Continue on needs be basis. Use ABARE derived figures instead of consultants - if accepted by the community.
Social and Economic Data	Australian Bureau of Statistics data can be used to provide information on population change, incomes, age	Landcare Group and LWMP Working Group to instigate the collection of data. Every	This information was gathered by the LWMP project officer in 1998. It is recommended the	

Table 8.2 Regular Long-term Monitoring and Evaluation (every five years or more). cont...

Subject of	Location and Description Monitoring	Who monitors and of monitoring	Who interprets the data and how often	Recommendations conveys the information
	distribution, employment, unemployment, welfare benefits, agriculture etc.	10 years.	LWMP project officer undertake the work in the future.	
Landscape Changes	10 transects were walked across the catchment. As well as the EM31 data, soils data, comprehensive field notes and photos were taken. This information should act as a benchmark for assessment of landscape change.	Landcare Group and LWMP Working Group to instigate the collection of data. Every 15 years.	Woodward-Clyde undertook the work in 1998. It is recommended the LWMP project officer undertake the work in the future.	
Attitudinal/ Educational Change	Conduct a survey within the catchment to determine peoples understanding and attitude of natural resources and landcare activities.	Engage specialist consultants. Every 15 years.	The consultancy or survey team that is employed.	To be instigated by the LWMP project officer.

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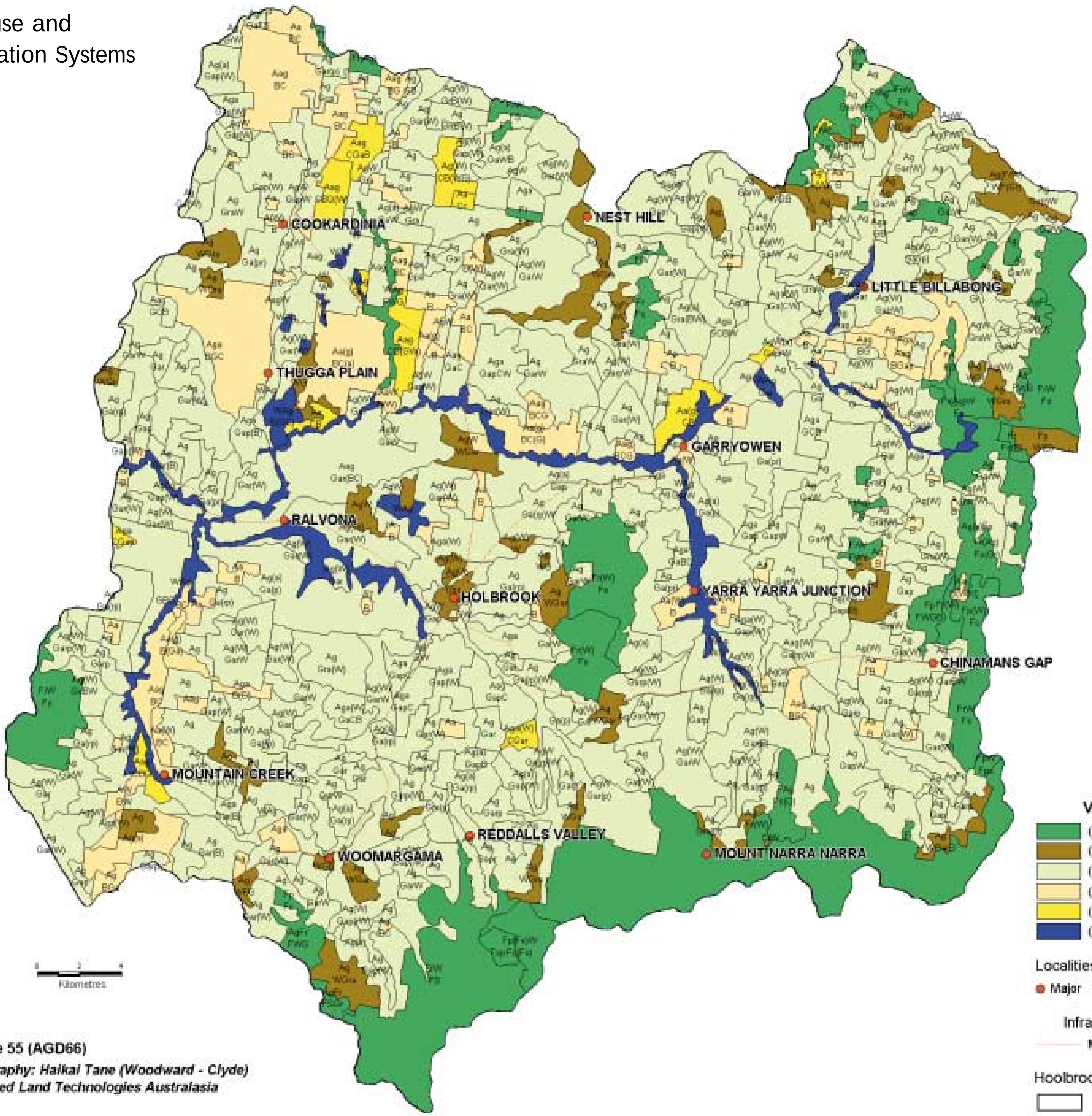
SOME COMMON ACRONYMS

ABARE	Australian Bureau of Agricultural Resource Economics
ABS	Australian Bureau of Statistics
ACF	Australian Conservation Foundation
AFG	Australian Forest Growers
ATCV	Australian Trust for Conservation Volunteers
CMB	Catchment Management Board
CMC/TCM	Catchment Management Committee/Total Catchment Management Committee
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSU	Charles Sturt University
DLWC	Department of Land and Water Conservation
DPIE	Department of Primary Industries and Energy
DSE	Dry Sheep Equivalent
EA	Environment Australia
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EM	Electromagnetic
EPA	Environment Protection Authority
FFF	Farming for the Future
GA	Greening Australia
GIS	Geographical Information System
LWMP	Land and Water Management Plan
MAI	Mean Annual Increment
MCMB	Murray Catchment Management Board
MCMC	Murray Catchment Management Committee
MDBC	Murray Darling Basin Commission
NFF	National Farmers Federation
NHT	Natural Heritage Trust
NPWS	National Parks and Wildlife Service
NSW Ag	New South Wales Agriculture
PMP	Property Management Planning
RAP	Regional Assessment Panel
RLPB	Rural Lands Protection Board
SAP	State Assessment Panel
SCS	NSW Soil Conservation Service
SOE	State of Environment
TN	Total Nitrogen
TP	Total Phosphorous
TSR	Travelling Stock Route

MAP 1
HABITATS: Landuse and
Vegetation Systems



CATCHMENT HABITAT LEGEND

Habitats = LAND USE / VEGETATION

(Due to the scale of this map not all polygons may be labelled)

LAND USE CODES

(A) AGRICULTURE
a - arable, annual crops
h - horticulture, berry farms
g - grazing, pastoral livestock

(F) FORESTRY
f - tree crops, farm forestry
p - plantation forestry
r - natural regeneration forestry
e - environmental protection

(M) MINING & INDUSTRY
q - quarrying
m - manufacturing, storage
c - corridors, transportation

(U) URBAN
b - business areas, urban
s - surburban, residential
o - open space

(R) RESERVES & PARKS
n - nature reserves
r - recreation reserves
w - wildlife reserves

Vegetation Codes
(F) Forest
(W) Woodland
(G) Grassland
(B) Bare Ground
(C) Crops
(W) Wetlands, Waterways

VEGETATION ATTRIBUTES
a - annual pasture
c - crops, cereal, seed
d - dense woodland
o - open woodland
p - permanent pasture
r - rangeland
s - scherophyll, self-sown

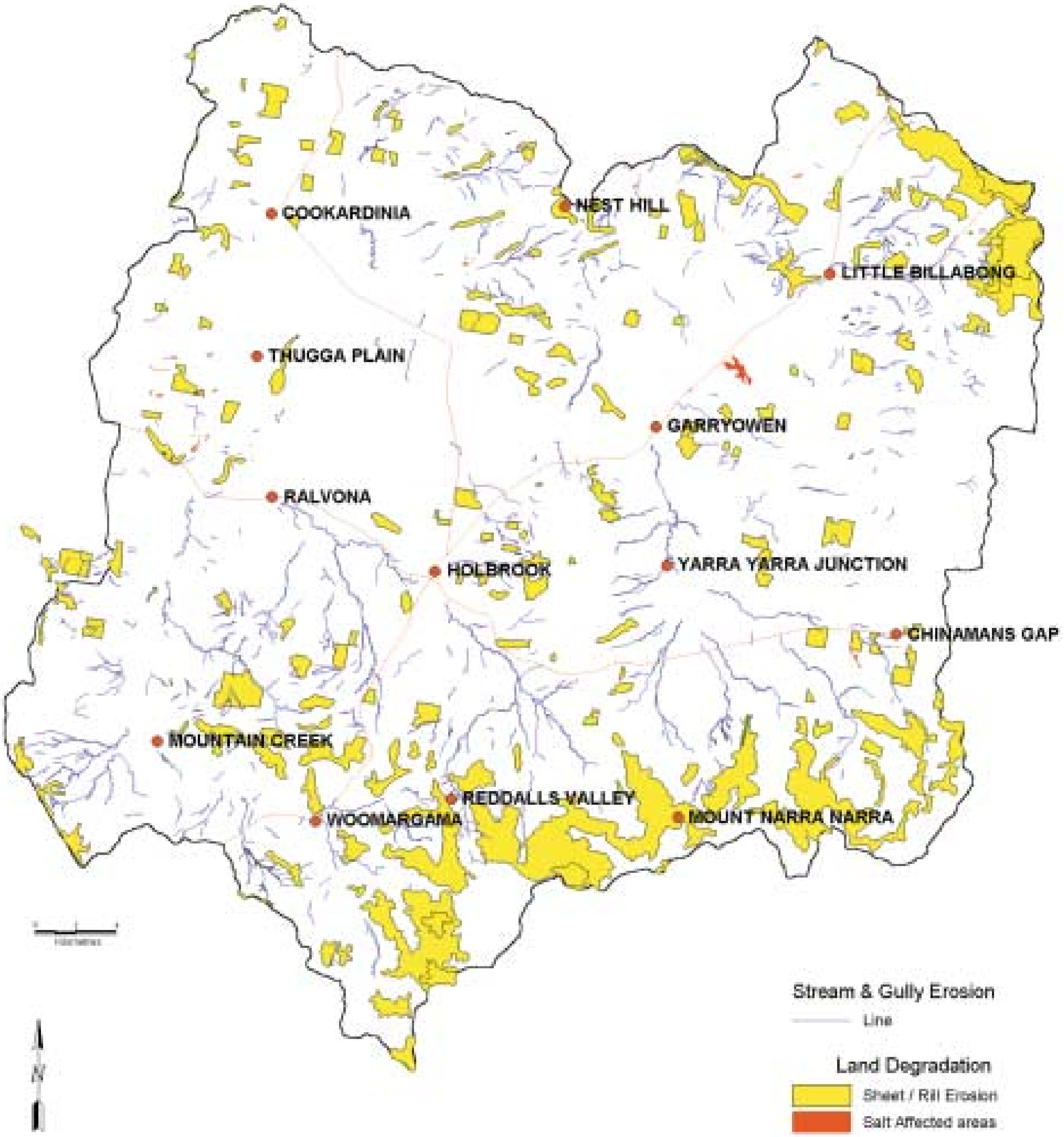
Localities
Major

Infrastructure
Major Roads

Hoolbrook Landcare
Boundary

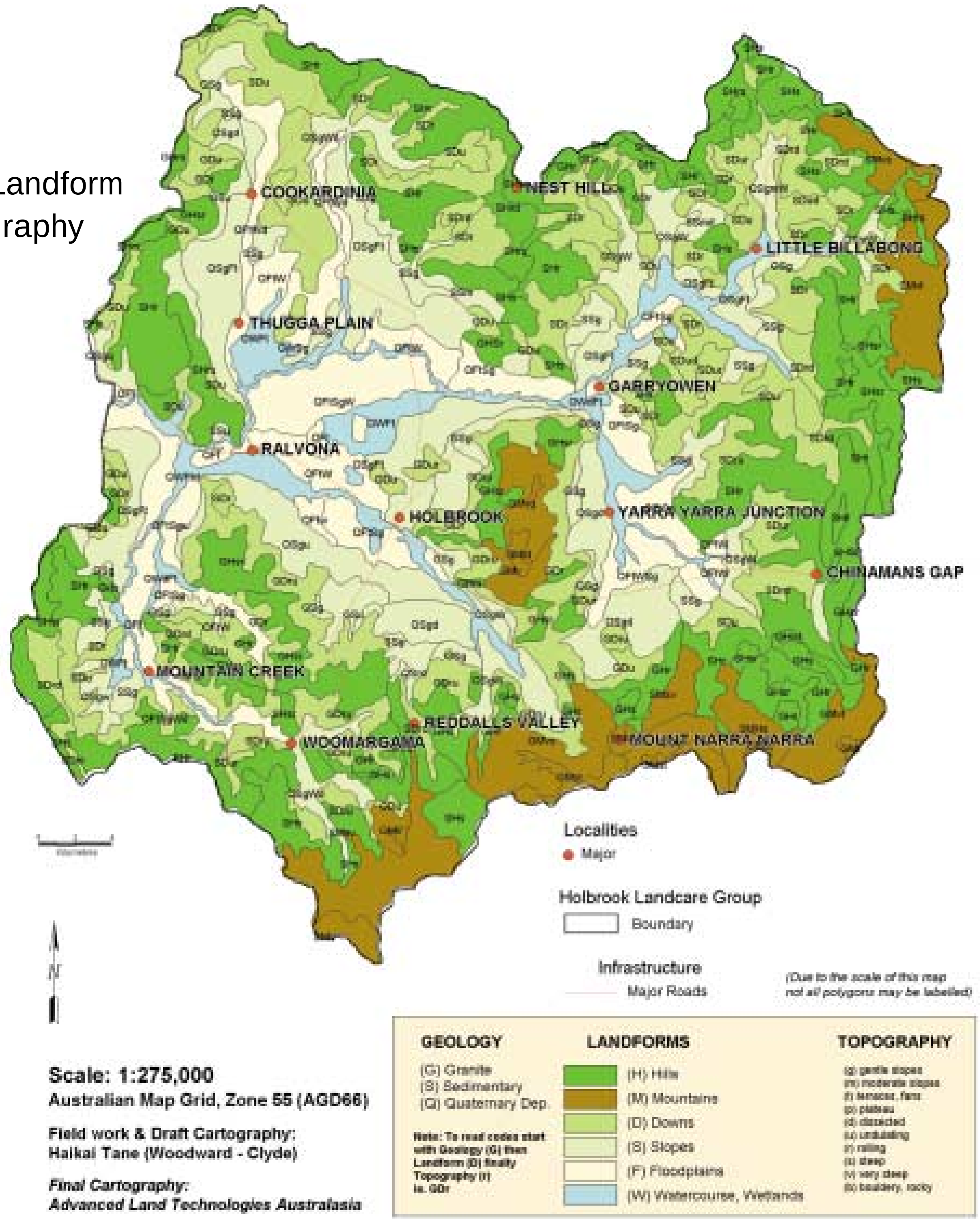
Scale: 1:200,000
Australian Map Grid, Zone 55 (AGD66)
Field Work & Draft Cartography: Haikai Tane (Woodward - Clyde)
Final Cartography: Advanced Land Technologies Australasia

MAP 2
Land Degradation



Scale: 1:275,000
Australian Map Grid, Zone 55 (AGD66)
Field Work: Haikai Tane
Draft Cartography: Heather Sedgeman
Final Cartography: Advanced Land Technologies Australasia

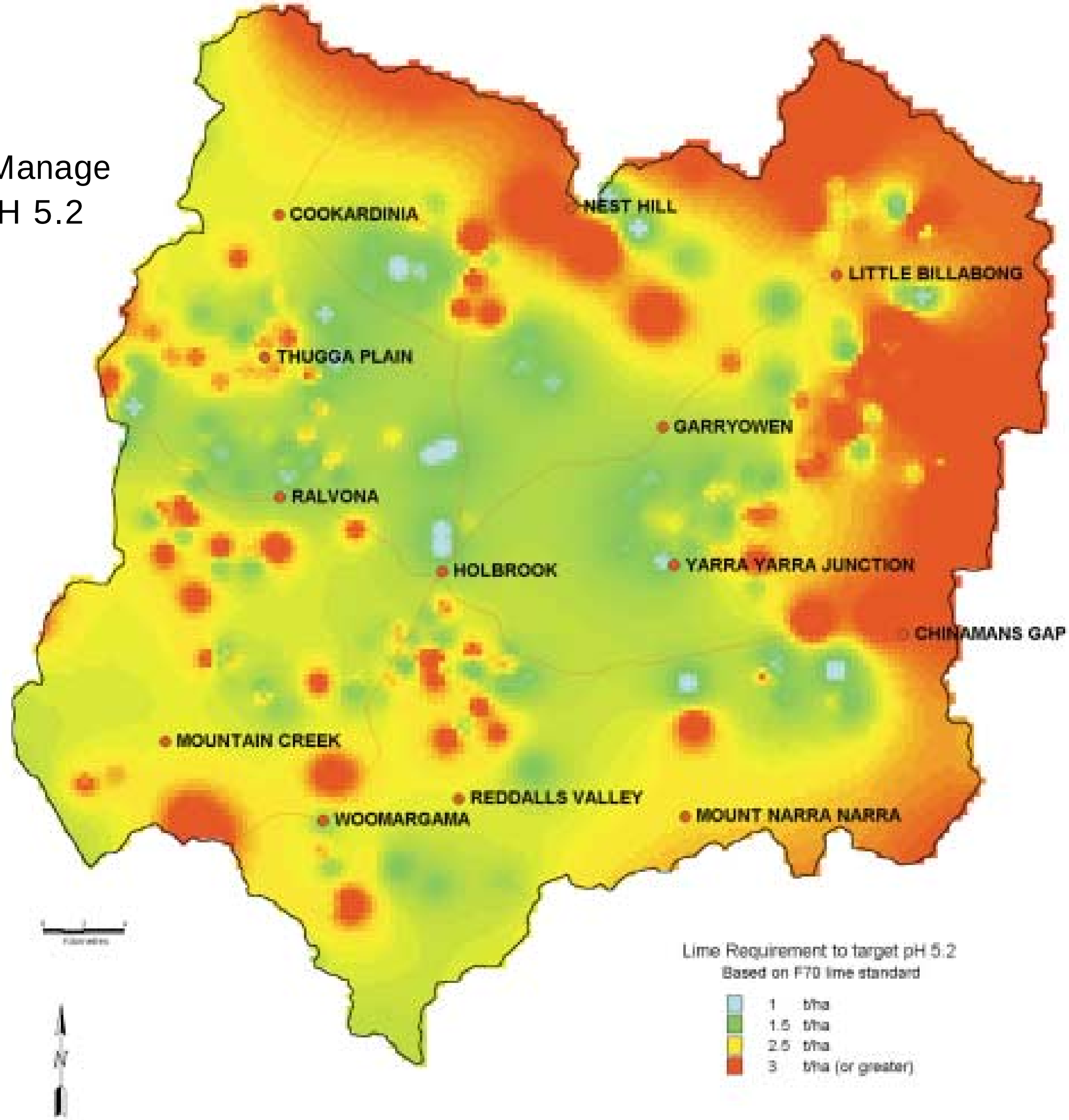
MAP 3
REGOLITH: Geology, Landform and Topography



MAP 4

Lime Requirement to Manage

Soil Acidity - Target pH 5.2



Scale: 1:275,000

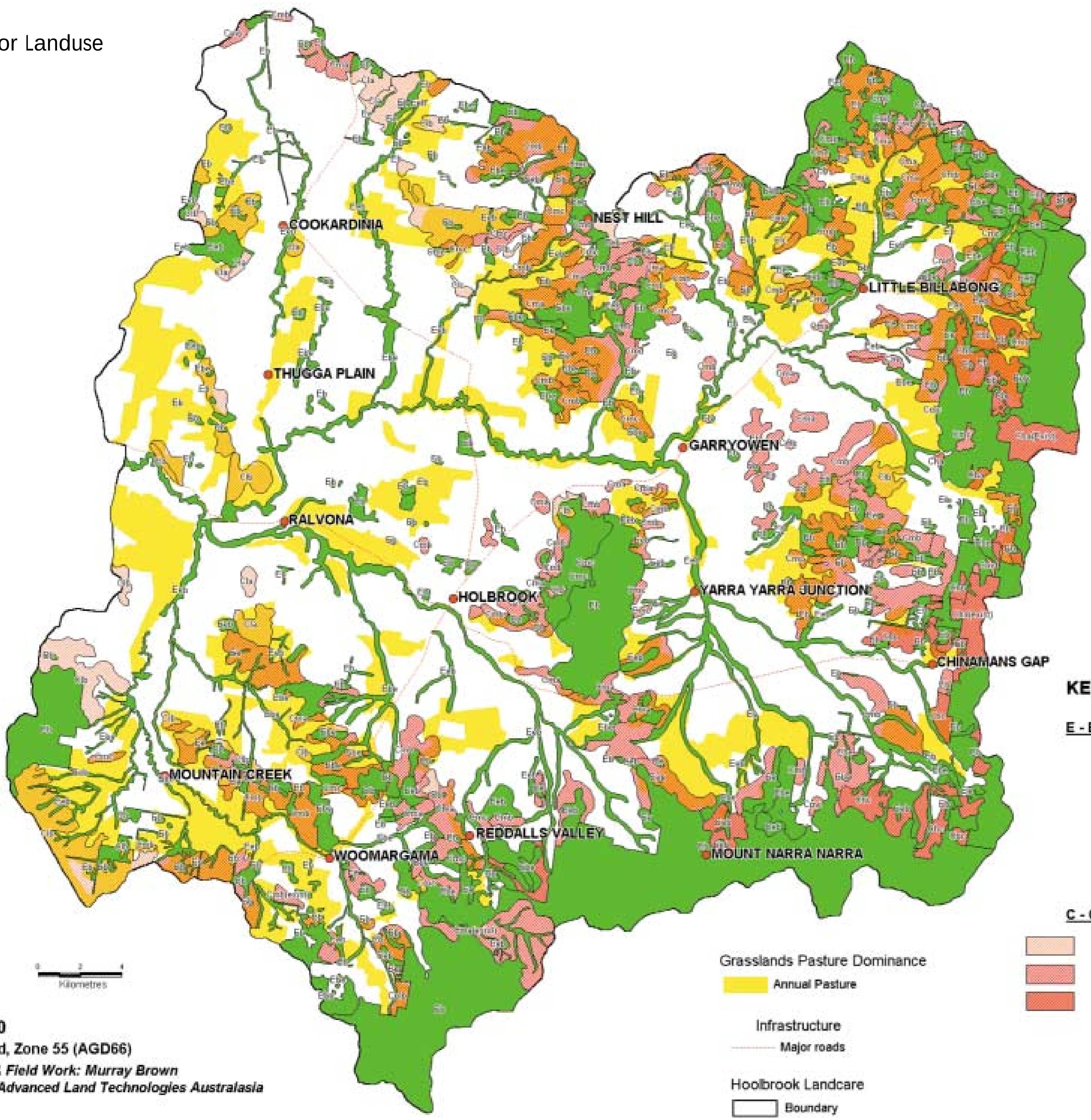
Australian Map Grid, Zone 55 (AGD66)

Final Cartography:

Advanced Land Technologies Australasia

This map is based on NSW Agriculture lime requirement formula. Based on work by Dr Keith Helyar. Data was collect as part of the South West Slopes Community Acid Soils Project during winter 1998.

MAP 5
Target Areas for Landuse



Areas with potenial for farm forestry based on:

Having adequate rainfall and terrain.
Being of marginal grazing potential.
Predominantly cleared.

Areas with potential for maintanance or improved management of existing remnant vegetation based on:

Having good existing native vegetation.
And / or erosion hazards.

Areas with potential for having perennial vegetation cover based on:

Having a predominance of annual pasture

KEY TO CODES:

(Due to the scale of this map not all polygons may be labelled)

E - Environmental

- e - management for erosion
- b - management for biodiversity benifits
- be - dominantly biodiversity benefits, but with erosion benefits
- eb - dominantly erosion benefits, but with biodiversity benefits

(Eeb, Eb etc.)

C - Commercial Plantation Forestry

- l - low productivity (Rotation ~35-40yrs, MAI ~12m3/ha/yr)
- m - medium productivity (Rotation ~30-35yrs, MAI ~16m3/ha/yr)
- h - high productivity (Rotation ~25-30yrs, MAI ~19m3/ha/yr)

- a - low access cost. minimum area 20ha
- b - medium access cost. minimum area 40ha
- c - high access cost. minimum area 60ha
- d - very high access cost and to steep for machinery

(Cmc, Clb etc.)

Grasslands Pasture Dominance
Annual Pasture

Infrastructure
Major roads

Hoolbrook Landcare
Boundary

Scale: 1:200,000
Australian Map Grid, Zone 55 (AGD66)
Draft Cartography & Field Work: Murray Brown
Final Cartography: Advanced Land Technologies Australasia