BOOROWA REGIONAL CATCHMENT COMMITTEE

BOOROWA CATCHMENT ACTION PLAN

Boorowa River and Hovells Creek Catchments

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Natural Heritage Trust

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BOOROWA COMMUNITY LANDCARE GROUP

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Executive Summary

The Boorowa Regional Catchment Committee (BRCC) provides a forum for Landcare groups, state and local governments, and community organisations to work together to address natural resource issues in the Boorowa area. In 1992, funding from the National Landcare Program allowed work to begin on a salinity catchment plan. Ten years later the plan has been extended to include other related land and water degradation issues affecting the catchment. As current chairman of the BRCC, I am now pleased to present this plan.

The plan will assist all land managers with an interest in natural resource management to identify, quantify and prioritise the issues in this part of the Lachlan catchment. It will also provide a sound basis to justify and plan future investment in specific on-ground actions. While we recognise that work needs to continue to refine our data and to collect additional information, we are proud to lay the foundations.

This plan is the result of many hours of data collection, surveys, community consultation and research. Through their hard work, persistence and initiative, the community have made a significant contribution to the future sustainability of this catchment.

This catchment plan is the product of a cooperative effort from all partners. It demonstrates the commitment of those living and working in the Boorowa area to identify and address the most pressing natural resource issues. We thank our funding partners, the Commonwealth Government's Natural Heritage Trust, and the New South Wales Government.

We look forward to continuing our work with them in the Boorowa area catchment

Chairman
BRCC

1. INTRODUCTION

The Boorowa community has been actively addressing land and water degradation in the district. Since the first Landcare group was formed in 1989. Numerous Landcare programs, as well as both public and privately funded on-ground works have been successfully implemented throughout the region. Since 1992, over $5 million of government contributions and over $10 million in community contributions has funded this investment.

A salinity management plan for the area around the Boorowa Township was originally developed in 1992, which resulted in the implementation of several major salinity management projects. Preliminary work on a Catchment Action Plan to address other land and water degradation issues began in 1996. Information compiled since then has been used to support community applications for funding various projects.

The area covered by the Boorowa Catchment Action Plan has been defined to include the area within Boorowa River sub-catchment and Hovells Creek sub-catchment (Figure 1) of the Lachlan River Catchment.

The Lachlan Catchment Management Board (LCMB) recently released a Catchment Plan, titled the "Integrated Catchment Management Plan for the Lachlan Catchment 2002", also known as the "Lachlan Catchment Blueprint." The Lachlan Catchment Management Board was appointed under the *Catchment Management Act 1989* and the *Catchment Management Regulation 1999.*

The Blueprint commenced on the date of gazettal (February, 2003) by the Minister for Land and Water Conservation, for a term of 10 years. The Lachlan Catchment Management Board has provided an advisory document for co-ordinated and co-operative action that will assist the Lachlan community. The Management Targets and Management Actions developed for the Blueprint have been incorporated, where applicable, into this Boorowa Catchment Action Plan.

The new Catchment Management Authority (CMA) was established in May 2004, by the NSW Minister for Infrastructure and Planning and Minister for Natural Resources, to replace the existing LCMB. The Authority is designed to be a locally driven statutory authority with an accountable board responsible for making decisions about natural resources management issues, and coordinate activities throughout the Catchment.

1.1 Purpose of the Boorowa Catchment Action Plan

The Boorowa Catchment Action Plan arises from concerns of landholders and the general community about the increased land and water degradation problems in the area. This community-initiated Plan has been prepared to ensure that natural resources within the Catchment are managed in an ecologically sustainable manner. The plan has been developed, in part, by NHT funding for a Catchment Planning Officer.

The aims of the Catchment Action Plan are:

- Education, awareness and a support mechanism for funding applications
- Provide the community with current information on natural resources within the Catchment
- Identify priority issues for the Catchment

- Develop regional strategies and action for land managers
- Provide land managers with a set of best management practice guidelines
- Identify options for sharing the costs of implementing the plan
- Allow sustainable management of the catchment to be achieved by partnership of individuals, community groups and all spheres of government

Figure 1 Location of the Boorowa Catchment Action Plan area

The Catchment Plan will be a living document that responds to changing perceptions, needs and priorities, and it will provide directions for achieving a better future both for this generation and the generations to come. The Plan shall remain dynamic and open to a five yearly review.

1.2 Stakeholders

As part of the Catchment planning process, as many stakeholders as possible have been consulted. Stakeholders are people and organisations that have an interest in, are affected by, or are involved in an issue. They may have different ideas about the values of resources requiring protection, and how to address various issues. Stakeholders in the Catchment include: Land owners; Landcare groups; Community members and interest groups; Educational institutions and Research bodies such as schools and universities; Local, State/Territory, Commonwealth Government departments and agencies; Industry representatives; Environmental groups; Inter-governmental bodies, such as the Murray-Darling Basin Commission; and Coordination groups, such as the Catchment Management Authority.
This Plan is a community-owned document that fits under the broader scale of Lachlan Catchment Blueprint, and state and federal policies relating to natural resource and

environmental management (Figure 2). Governments have demonstrated their commitment through natural resource management programs in partnership with local communities. Emphasis has been placed on community action, on-ground works and developing practical solutions at a local level. While governments have provided national and regional frameworks, a large responsibility rests with communities to implement these policies.

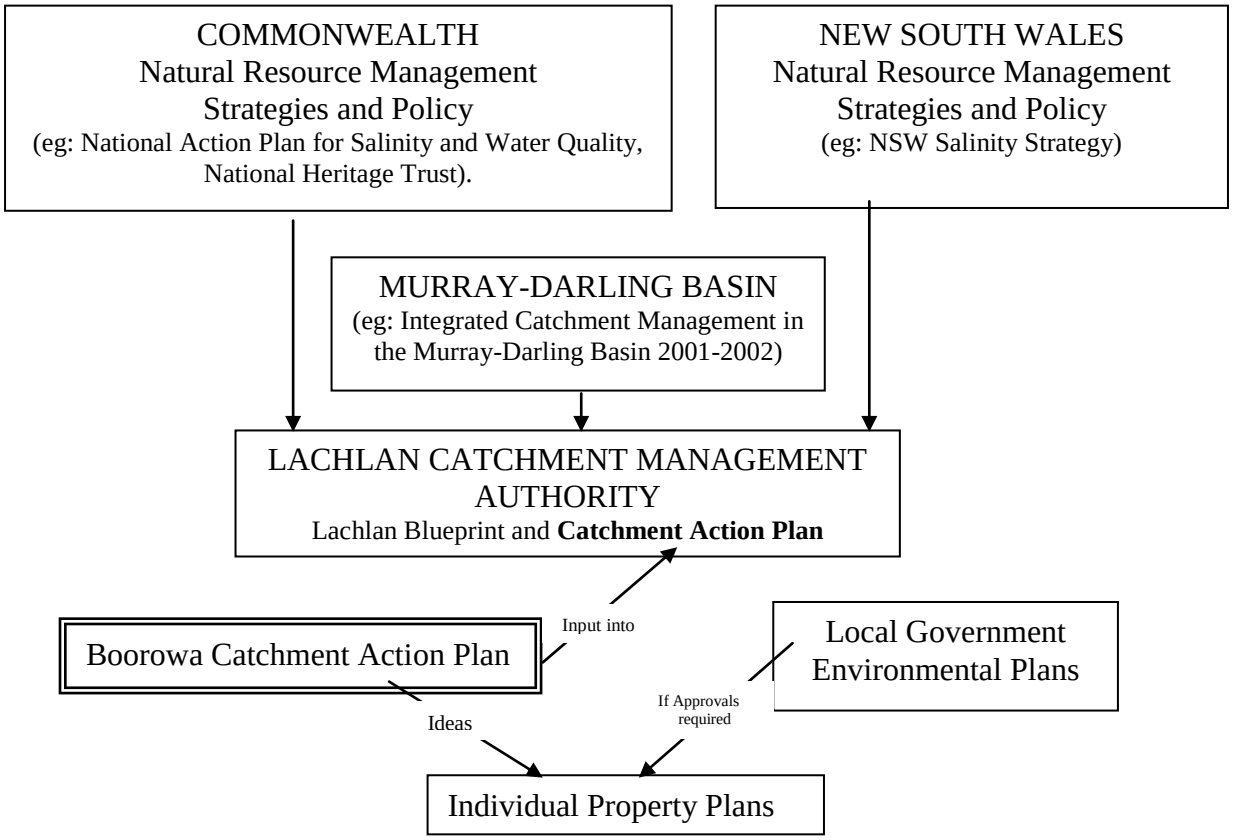


Figure 2 Context of the Boorowa Catchment Action Plan in National, State and Regional Policy and planning

1.3 Linkage to Lachlan Blueprint

The boundaries of the area covered by this Action Plan have been defined to comply with the sub-region boundaries adopted by the Lachlan Catchment Management Authority (Figure 3). The region in which The Boorowa Catchment is located is called the Lachlan Slopes. Many of the Management Actions advised in the Blueprint for this sub-region, such as re-vegetation and salinity abatement, soil health improvement and riparian protection have already been undertaken in the Catchment.

This plan has been developed to: Act as a tool to coordinate further on-ground activities; Assist in developing and implement strategies; Establish measurable targets; and to identify and encourage the use of best management practises in accordance with guidelines set out in LCMA Blueprint. Particular care has been taken in sections 6, to align targeted Management Actions, set out in the Lachlan Blueprint, with actions identified by the Stakeholders in the Boorowa Catchment. In so doing, a quick reference list of LCMA actions, addressed by proposed works, has been created. This will be a valuable tool for Stakeholders applying for funds allocated to specific issues by the LCMA and other funding bodies, who will utilise the standards set in the Catchment Blueprint.

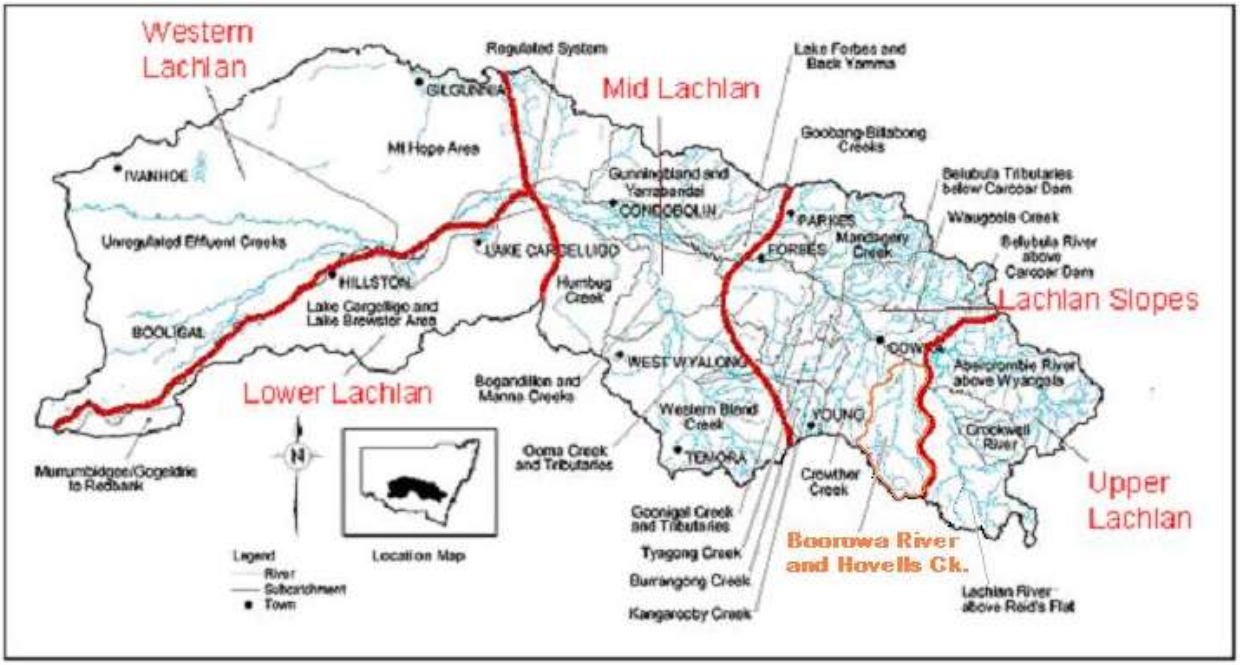


Figure 3 Sub-region boundaries adopted by the Lachlan Catchment Management Board (modified from DLWC, 1999)

1.4 CATCHMENT VISION

"A community actively maintaining a sustainable and productive Catchment."

2. PLANNING PROCESS

Work on a coordinated Catchment Action Plan began in 1992. A comprehensive Geographical Information System (GIS) mapping system was compiled for planning activities. Natural resources information of the Catchment, e.g. geology, soils, vegetation, biodiversity and land degradation has been entered into the GIS.

Public meetings have also been conducted over the years to identify the natural resource management issues of concern to the community. A series of best management practices and action plans have been compiled for each specific management issues.

2.1 Community Consultation

Community consultation is an on-going process, and has been conducted through are variety of forums including -

- Landcare meetings;
- Property and catchment planning workshops;
- Meetings with groups, government agencies and various catchment committees;
- Landcare newsletters and newspaper columns;
- Field days and farm visits;
- School education days;
- Liaison with Shire Councils.

2.2 Data Collection

Data has been provided from various government agencies, university and research groups, private consultants, and the local community. Data has also been compiled from mapping of existing on-ground works, soil and water analyses, field surveys, and mapping activities that have been conducted by the community over the last 10 years.

The Boorowa region has recently been the focus of numerous investigations, including studies on groundwater and salinity, native vegetation, biodiversity, social history, and soil and grazing studies. This information has been incorporated into the Plan.

Another important source of information are the Catchment Plans that have recently been compiled for areas surrounding the Catchment: Binalong area - Brown, 1997; Cowra area – Sly, 1998;Upper Lachlan area – Sticpewich, 2000; and the Yass area – Cosgrove and White, 2002;

2.3 Cost : Benefit Analysis

To address the need to target specific issues, the BRCC recently funded a cost:benefit economic analysis to examine the financial implications of actions and/or inaction associated with various forms of land degradation in the Catchment. Ivey ATP and Wilson Land Management Services undertook this analysis of the nature and cost of salinity, vegetation decline, soil acidity, soil erosion and soil sodicity. The study included a previous economic analysis of dryland salinity management in the Catchment conducted by Hill (1996), as well as the downstream impacts of salinity.

The non-market value of existing biodiversity in the Catchment, i.e. for greenhouse balance, water quality etc, has not been analysed. Figure 4 depicts the estimated annual costs of land degradation in the Catchment in 2000, and projected estimate of annual costs in 2050 based on no plan or actions.

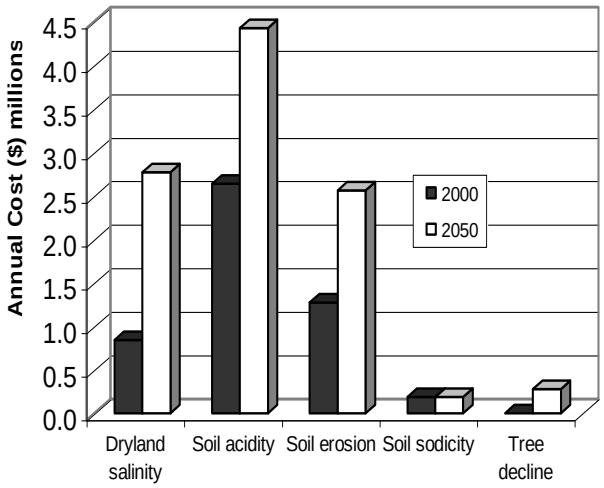


Figure 4 Cost of land degradation to the Boorowa Catchment (Ivey ATP and Wilson Land Management Services, 2000)

The benefit cost ratio for soil degradation indicates that prevention is far more cost effective than remediation. Hence, measures should be taken to ensure that areas currently experiencing only minor to moderate soil erosion are not allowed to deteriorate any further. The results of this analysis indicate that there are considerable benefits associated with lime application to prevent further soil acidification on acid soil types.

While benefits may be gained from lime and gypsum application in sodic cropping soils, in most areas, the effects of subsoil sodicity should be overcome as much as possible by management practises. This may include maintaining high levels of soil organic matter and minimising tillage operations that may expose sodic subsoils (Ivey ATP and Wilson Land Management Services, 2000).

2.4 Catchment Mapping

The catchment-wide Geographical Information System (GIS) has been developed as a basic information resource, and the decision support system for future planning. Maps were produced using ArcView® 3.3 GIS computer software. Many of the spatial layers of information have been purchased from government departments and have associated licensing agreements, (Table 1). These agreements generally preclude the release of data to third parties.

DATASET	CUSTODIAN	CONDITIONS	LICENCE AGREEMENT
Soil Erosion	DIPNR	Standard Condition	DIPNR Licence Agreement
Gully/Streambank Erosion	DIPNR	Standard Condition	DIPNR Licence Agreement
Land Capability	DIPNR	Standard Condition	DIPNR Licence Agreement
Soil Landscapes	DIPNR	Standard Condition	DIPNR Licence Agreement
Known Saline Sites (c2002)	DIPNR	Standard Condition	DIPNR Licence Agreement
Riparian Condition	DIPNR	Standard Condition	DIPNR Licence Agreement
Remnant Vegetation	NSW NPWS	Public data	NA
Geology	NSW Geol. Survey	Standard Condition	NSW Geological Survey Agreement
Cadastre & topographic data	LPI	Standard Condition	LPI Licence Agreement
Water Bore data	DIPNR	Standard Condition	DIPNR Licence Agreement
Satellite Imagery	SPOT Imaging	Special Condition	SPOT Licence Agreement

Table 1 Digital data set licensing agreements

Data includes complete coverage of the Catchment area by recent SPOT5 (18 November 2002), Landsat satellite data (1997, 1998), and base topographic and cadastre (land parcel) data. Metadata (information about digital data) for the GIS data sets has been compiled. The digital SPOT5 data is available to Landcare members, to aid farm and sub-catchment planning.

Further information regarding data availability can be gained by calling (02) 6385 1018.

The maps produced for this report are based on a variety of data sources at various scales. Sub-catchment information varies from 1:25 000 (1cm = 250 m) up to 1:250 000 (1 cm = 2.5 km) scale, depending on the scale and nature of the existing data and planning constraints. Property Management Planning generally requires scales of 1: 10 000 (1cm = 100 m) or larger.

3 BOOROWA NETWORK OF LANDCARE GROUPS

3.1 Landcare History

The first Landcare group in the area (Boorowa Community) was set up in 1989 to coordinate community environmental education and on-ground activities in the catchment. The first direct seeding trial in the area was established in 1990. In 1992, the Landcare Group was successful in gaining NSW Salt Action funds to employ a Project Officer who mapped salinity on 109 Landcare properties. Four sub-catchments surrounding the Boorowa Township were identified as the worst affected by dryland salinity, and a salinity management plan was developed (Powell, 1992).

During the 1990s several other Landcare groups formed within the Catchment. These included the Rye Park, Breakfast Creek, Frogmore Limestone / Kangiara Taylor's Flat and Hovells Creek Landcare groups. This Landcare network now covers over 75% of the Catchment area, and includes about 270 members (Table 2). The Catchment has one of the highest coverage of Landcare number within a Catchment in NSW.

Landcare Group	Membership No.
Boorowa Community	86
Breakfast Creek	28
Frogmore	26
Limestone / Kangiara	53
Rye Park	40
Taylor's Flat	26
Hovells Creek	13
Total	**272**

Table 2 Landcare Group membership in the Catchment Area

In 1993, the first Landcare Coordinator was employed to implement Stage I of a series of on-ground works programs directed at salinity affected areas in the Catchment. The programs included pH correction, and the establishment of high water use perennial pastures on recharge areas, upslope of identified saline discharge sites. Trees and salt tolerant grasses were also used to reclaim discharge sites (Hayman, 1996). Since the initial Stage I projects, several major salinity programs, and numerous other programs have been successfully implemented throughout the Catchment.

Boorowa Regional Catchment Committee

The Boorowa Regional Catchment Committee (BRCC) was established in 1995 to coordinate Landcare activities in the Boorowa area (Clark, 1995). The Committees provide support and direction to the Landcare Groups across the Boorowa Catchment area. This Action Plan has been produced under direction of the Committee to act a as tool for planning future on-ground works.

3.2 Achievements

On ground activities in the catchment that have been funded through Landcare have included:

- sowing of salt tolerant trees and pastures on discharge areas to reclaim salt affected areas
- establishment of perennial vegetation on recharge areas to control rising water tables and salinity
- re-establishment of native vegetation to provide habitat and enhance biodiversity
- fencing off remnant vegetation to allow natural regeneration and control grazing
- fencing off and rehabilitating riparian corridors to improve water quality in our rivers and creeks and to control bank erosion
- fencing off eroded areas and gullies and rehabilitating with native vegetation to control soil loss
- pH correction of pastures using lime to maintain productive soils

List of some Major Projects .

2002/03
Boorowa River Catchment Implementation Officer
Boorowa River Catchment Planning Officer

2001/02
Saltshaker 2
Boorowa River Catchment Implementation Officer
Frogmore Salinity Reduction and Biodiversity Project
Implementation of the Boorowa River Salinity Catchment Plan - Stage V

2000/01
Saltshaker 1
Boorowa River Catchment Implementation Officer
Extension of the Boorowa River Salinity Catchment Plan - Stage 2
Frogmore Salinity Reduction and Biodiversity Project
Implementation of the Boorowa River Salinity Catchment Plan - Stage IV
Stabilizing & Revegetation of Upper Callaba Creek
Boorowa Remnant Vegetation Project
Integrated Revegetation to Control Salinity & Erosion
Upper Lachlan Tributary Salinity - Stage 3
Implementation of the Boorowa River Salinity Catchment Plan - Stage V

1999/00
Implementation of Boorowa River Salinity Catchment Plan - Stage III
Extension of the Boorowa River Salinity Catchment Plan - Stage 2
Groundwater Discharge, Creek and Gully Erosion Control Program
Further Bed Control Structures and Log Revetments in Graham Creek
Implementation of the Boorowa River Salinity Catchment Plan - Stage IV
Aerial Photography for Farm & Catchment Planning
Boorowa Remnant Vegetation Project
Boorowa Community River Restoration and Revegetation Plan.
Boorowa Riverwalk

Upper Boorowa River Restoration and Revegetation Plan - Year 4
Integrated Revegetation to Control Salinity & Erosion
Upper Lachlan Tributary Salinity - Stage 3
Boorowa River Catchment Regional Facilitator
Frogmore Community Landcare Dryland Salinity Recovery Project
Implementation of the Boorowa River Salinity Catchment Plan - Stage V

1998/99
Implementation of Boorowa River Salinity Catchment Plan - Stage III
Extension of the Boorowa River Salinity Catchment Plan
Extension of the Boorowa River Salinity Catchment Plan - Stage 2
Groundwater Discharge, Creek and Gully Erosion Control Program
Graham Creek Land Degradation Amelioration Project
Soils GIS for Salinity Management in the Boorowa Region
Willow Survey of Boorowa River and Pudman Creek
Superb Parrot Revegetation & Education Project - SW Slopes, NSW
Implementation of the Boorowa River Salinity Catchment Plan - Stage IV
Boorowa Remnant Vegetation Project
Integrated Revegetation to Control Salinity & Erosion
Upper Lachlan Tributary Salinity - Stage 3
Boorowa River Catchment Regional Facilitator
Breakfast Creek Remedial Action Against Increasing Salinity and Rising Water Table
Upper Lachlan Tributary Salinity Control
Frogmore Community Landcare Dryland Salinity Recovery Project
Graham Creek Remnant Vegetation Fencing Project
Cost of Land Degradation in the Boorowa River Catchment and Downstream
Farm Forestry Demonstration Site for the Boorowa Region.
Soil pH mapping Boorowa Catchment
Boorowa River Catchment Dryland Salinity Hazard

1997/98
Implementation of Boorowa River Salinity Catchment Plan - Stage III
Extension of the Boorowa River Salinity Catchment Plan
Groundwater Discharge, Creek and Gully Erosion Control Program
Frogmore Salinity Reduction and Biodiversity Project
Graham Creek Land Degradation Amelioration Project
Farm Plan Mapping and Salinity Monitoring and Planning Project
Boorowa River Catchment Regional Facilitator
Breakfast Creek Remedial Action Against Increasing Salinity and Rising Water Table
Upper Lachlan Tributary Salinity Control
Frogmore Community Landcare Dryland Salinity Recovery Project
Graham Creek Remnant Vegetation Fencing Project

1996/97
Implementation of Boorowa River Salinity Catchment Plan - Stage II
Extension of the Boorowa River Salinity Catchment Plan
Farm plan mapping and salinity monitoring and planning project
Boorowa River Catchment Regional Facilitator
Breakfast Creek Remedial Action Against Increasing Salinity and Rising Water Tables

Upper Lachlan Tributary Salinity Control
Frogmore Community Landcare Dryland Salinity Recovery Project
Graham Creek Remnant Vegetation Fencing Project

1995/96
Implementation of Boorowa River Salinity Catchment Plan - Stage I
Implementation of Boorowa River Salinity Catchment Plan - Stage II

1994/95
Implementation of Boorowa River Salinity Catchment Plan - Stage I
Implementation of Boorowa River Salinity Catchment Plan - Stage II
"Allendale" Salinity Management Demonstration Site

1993/94
Implementation of Boorowa River Salinity Catchment Plan - Stage I

1992/93
Boorowa District Salinity Mapping

1991/92
Groundwater Level Monitoring
Farm Planning Workshops

4. BOOROWA RIVER CATCHMENT – AN OVERVIEW

4.1 Location

The Boorowa Catchment covers an area of about 2,200 km^2 (220,000 ha) in the headwaters of the Lachlan River (Figure 1). The boundaries of the Boorowa Catchment Action Plan have been defined to include the area within Boorowa River sub-catchment (~1,820 km^2) and Hovells Creek sub-catchment (~380 km^2). This area represents about 2.5% of the Lachlan River Catchment, which covers an area of 84,700 km^2. The north-south trending Catchment covers a length of about 85 km, and varies in width from roughly 30 km wide to less than 10 km wide near the Boorowa River junction with the Lachlan River, just below the Wyangala Dam.

The Catchment straddles the boundary between the Southern Tablelands and South-Western Slopes regions of New South Wales. The centre of the Catchment lies about 110 kilometres NNW of Canberra, between the towns of Yass and Cowra. The southern boundary of the Catchment is located about 15 km north of Yass, and the northern outlet of the Catchment, about 20 km southwest of Cowra. The main town of Boorowa is located in the middle of the catchment, with the smaller villages of Frogmore and Rye Park are located in the eastern part of the catchment (Map 1).

4.2 History

The original inhabitants of the Catchment were the Wallabalooa, who lived to the south of the Wiradjuri of the Lachlan River (Jackson-Nakano, 2002). The early explorers, Hamilton Hume, William Broughton and party, arrived in the area known as the Burrowa Plains in 1821. The Broughton family subsequently settled in the Boorowa District during the same year, in the first grant area surveyed at Broughtonsworth, on the Binalong Road..

By 1871, the Burrowa Police District alone had 3,865 residents, a combination of Free Selectors and miners. The aboriginal word "Burrowa" has been attributed to the bustard or plains turkey, which were common throughout the area. The name of the district was changed to Boorowa in the mid 1900s (Lyold, 1990). The rich historical significance of the District is reflected in entries placed in the Australian Heritage Commission, Register of the National Estate (Table 3)

Dendavilleigh, Scott St, Boorowa	Boorowa Courthouse
Bala TSR Remnant Vegetation Site	Clonoulty, Marsden St, Boorowa *
Frogmore Main Copper Mine & Smelters*	Frogmore Secondary Copper Mine & Smelter*
Frogmore Tungsten Mines*	Glenara, Marsden St, Boorowa*
Kangiara Pre 1909 Village Area*	Kangiara, Post 1909 Village*
St John the Baptist Church Group*	St Patricks Church*
Tarengo, Binalong Road*	Walla Walla Copper Mines*
Wallah Wallah Silver and Lead Mine and Smelter*	**Indicative list*

Table 3 Sites within the Catchment Registered of the National Estate

Although land clearing for agriculture and grazing started during the initial settlement in the 19th century, the greatest clearing activity is thought to have been during the 1920s. Prior to European settlement, Eucalypt species dominated and characterised the native vegetation of the region. Almost all native communities appear to have been cleared or modified to some extent by agriculture or grazing (Yates and Hobbs, 1997).

4.3 Community Profile

Throughout this document information on the study area is provided from two sources representing different boundaries; the Boorowa Local Government Area or the Boorowa Catchment Area.

Population Structure

The Australian Bureau of Statistics (ABS) Census data indicates that the population of the Boorowa Shire is decreasing, a common feature of most rural communities. In 1995, the population in the Shire was 2,630, whereas in 2001, the population was 2,321, with 1,184 males and 1,137 females. About 1,300 people live within the Boorowa township area.

Selected Averages	Value
Median age	40
Median monthly housing loan repayments	$600-$799
Median weekly rent	$50-$99
Median weekly individual income	$300-$399
Median weekly family income	$700-$799
Median weekly household income	$500-$599
Mean household size	2.5

Table 4 Community profile of selected averages in the Boorowa Local Government Area (2001)

A series of selected average from the 2001 Census (Table 4) show that the median age of people within the Shire was 40 years. In the 1996 Census the median age of people was 37 years, while in the 1991 Census the median age of people was 35 years. The population figures indicate that the area has an ageing population.

Occupation

The majority of people are employed in agricultural industries, directly on farms. The total number of people employed by agriculture has increased slightly between 1996 and 2001 (Table 5). There has also been a minor increase in people working in health, manufacturing and community and personal service industries.

Industry	1996	2001
Agriculture, Forestry and Fishing	453	466
Mining	6	6
Manufacturing	26	32
Electricity, Gas and Water Supply	4	9
Construction	31	54
Wholesale Trade	24	19
Retail Trade	58	69
Accommodation, Cafes and Restaurants	33	30
Transport and Storage	15	20
Communication Services	10	9
Finance and Insurance	11	9
Property and Business Services	10	19
Government Administration and Defence	59	34
Education	63	61
Health and Community Services	67	77
Cultural and Recreational Services	9	9
Personal and Other Services	6	17
Non-classifiable economic units	3	6
Not stated	34	38
Total	**922**	**984**

Table 5 Community profile of occupations in the Boorowa Local Government Area

Production Economics

Information on the value of agricultural commodities produced (VACP) in the Boorowa Shire has been collected over the years by the ABS. Part of the data is shown below in Table 6.

The value of most agricultural products has increased over the period 1992 to 2001, with the exception of 1993-94, which was a drought year. These figures do not take into consideration increases in input costs. The returns on livestock products, which in the Boorowa Catchment is comprised largely of sheep products such as wool and to a lesser extent meat, have not shown the increases that crop products have shown.

Although these results are not directly comparable across Censuses, due to differences in methodologies and inflationary factors, there is still an increase in the value of commodities produced in the District.

Selected commodities	1992-93 $'000	1993-94 $'000	1994-95 $'000	1995-96 $'000	1995-96 $'000	2000-01 $'000
Crops						
Pastures and grasses	694.2	642.7	290.3	769.4	586.8	368.6
Cereals for grain	2,827.5	2,822.8	1,454.6	5,936.2	6,802.0	5,539.7
Crops for hay	51.7	50.6	117.9	103.2	21.2	27.6
Nurseries etc	111.1	91.1	121.2	159.6	158.7	219.3
Fruits (inc grapes)	94.2	109.2	243.7	177.0	27.8	76.6
Other crops	457.7	601.5	214.7	738.8	858.8	2,087.3
Total crops	*4,236.4*	*4,318.0*	*2,442.4*	*7,884.5*	*8,454.4*	*8,319.1*
Livestock slaughterings/disposals	6,822.8	8,151.2	9,116.1	7,533.3	7,491.9	11,083.9
Livestock products	17,970.3	15,084.5	20,156.1	15,562.3	18,984.2	19,963.9
Total agriculture	**29,029.5**	**27,553.7**	**31,714.6**	**30,980.2**	**34,930.5**	**39,366.9**

Table 6 Value of agricultural commodities produced (VACP) (Agricultural Census, ABS)

4.4 Climate

The Boorowa River Catchment has a Temperate climate with long summers and cool to cold winters (Figure 5). The annual average maximum temperature in Boorowa is 20.6 °C and the average minimum is 6.2°C. The maximum temperature recorded in Boorowa is 42.8° and the minimum -8.9°.

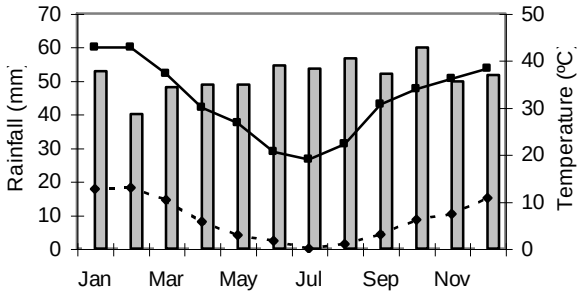


Figure 5 Mean monthly rainfall and minimum and maximum temperature for the Boorowa Post Office (Bureau of Meteorology)

Areas of high elevation generally experience lower temperatures. However, cold air drainage exerts an influence on temperature variation in the region, affecting the lower lying areas within the landscape. Aspect (the direction a slope faces) also exerts an influence over temperature; northwesterly aspects are generally warmer than the opposite southeasterly aspects (Hird 1991).

Rainfall

The average annual rainfall in the Catchment ranges from 570mm in the north to 770mm in the southeast (Hird 1991). The Boorowa township has an annual average rainfall of 619 mm, and Frogmore has an average is 601 mm. Rainfall distribution is slightly winter dominated (Figure 5), and areas of higher elevation have generally higher rainfall.

Long-term Rainfall

The long-term variation in rainfall, compared to the average rainfall at the Boorowa Post Office rainfall station, is shown in Figure 6. The lower graph shows the annual rainfall over one hundred years. The maximum annual rainfall during the period was 1092 mm and the minimum rainfall was 246 mm.

The upper graph shows the cumulative difference between the average rainfall for a year and the actual amount of rain that fell for that year. When a string of years has above average rainfall, i.e. wet years, the cumulative difference will increase (adding a string of positive numbers). A string of years has a below average rainfall, the cumulative difference will decrease (adding a string of negative numbers). Similarly, when there is average rainfall for a period, the cumulative difference will be relatively steady.

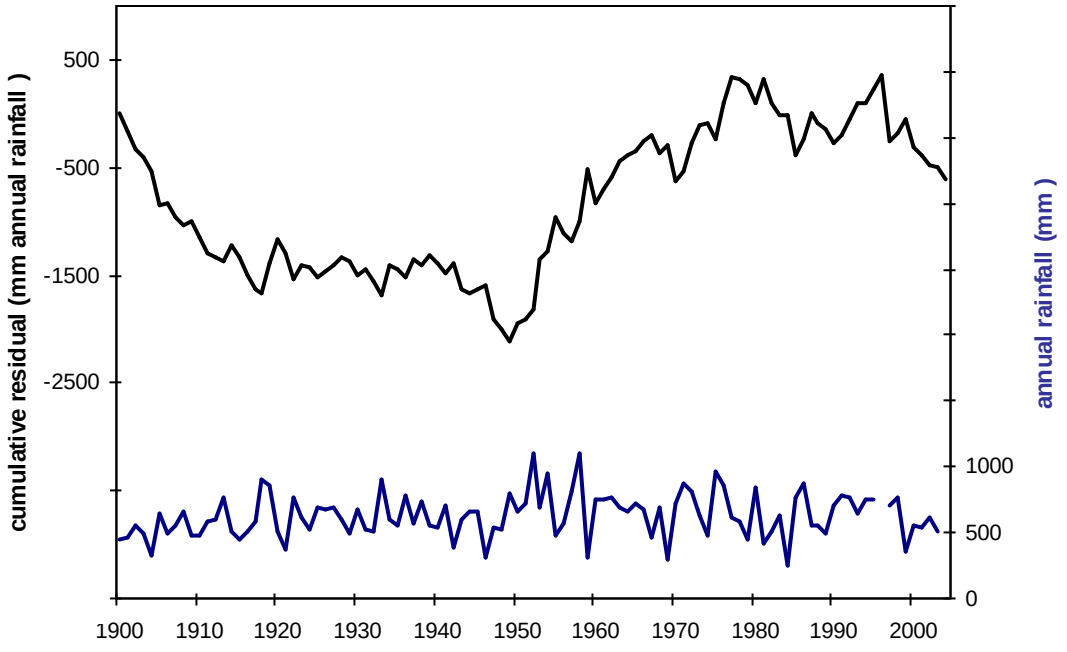


Figure 6 Long-term annual rainfall trends, Boorowa Township

The cumulative trace on the graph shows a distinct change in rainfall occurring at about 1947. Prior to this time monthly rainfall was generally below average, whilst after this time rainfall was above average until the early 1970s. Since then, the rainfall has generally fluctuated around the average rainfall, except for during drought years.

4.5 Physiography and Drainage

The elevation of the catchment ranges from 796 m at the Mount Hume trig station in the southeast, to about 320 m where the Boorowa River enters the Lachlan River. The catchment varies from high relief to gently undulating areas in the headwaters of the Boorowa and Hovells sub-catchments, to low to moderate relief along the Pudman Creek, around the Boorowa Township and in the north. Relief along the middle reaches of the Boorowa River increases to over 150 m where the river has cut a narrow incised valley in granitic material.

The surface drainage network differs from little to no incision, to over hundreds of metres in the headwaters of the Boorowa River. This variation in level of incision has implications for both the interaction of the surface and groundwater, and distribution of salinity outbreaks in the catchment. The Boorowa River flow rate varies from less than an ML/day to over 10,000 ML/day in peak flow conditions. (Evans & Bradd, 2001).

The Catchment can be subdivided into the Boorowa River and Hovells Creek sub-catchments, and a series of eight local sub-catchments (Map 1). The main sub-catchments from south to north are; Pudman Creek, Kangiara Creek, Langs Creek, Yellow Waterhole, Castles Creek, Gunnary Creek, Narallen Creek and Breakfast Creek in the northwest. It is probable that the nature of the Catchment drainage network has changed as a result of human activities. The creeks and streams were initially a series of chain of ponds; many are now incised channels and perennial streams (Eyles, 1977).

4.6 Geology

The Boorowa River Catchment lies within the Palaeozoic Lachlan Fold Belt of southeastern Australia. The Catchment's hard rock geology can be ascribed to four main types, Ordovician sedimentary rocks, Ordovician volcanic and sedimentary rocks, that include the Kenyu Formation, Silurian volcanics and minor sediments, and Siluro-Devonian granites intrusions. Some minor Devonian age acid volcanics occur in the central west of the Catchment, and a small Tertiary basalt flow is preserved in the north (Map 2).

The oldest rocks in the catchment are metamorphosed Ordovician sandstones, siltstones and shale that form the hill country to the east and northeast of Rye Park. These rocks form poor soils and are prone to erosion if not carefully managed. In the central northern part of the Catchment, another sequence of Ordovician volcanic and sediments, representing remnants of a volcanic arc, runs from Frogmore in the east around the edge of the granite country towards Breakfast Creek (Evans & Bradd, 2001).

Most of the Catchment is dominated by Silurian ignimbrites and tuffs with associated interbedded sediments of the Douro Group, which is dominated by the Hawkins Volcanics. These volcanics run in a belt through the main part of the Catchment, then further north through the western parts of the Catchment towards Breakfast Creek. A major fault zone separates the Douro Group from the sedimentary rocks of Ordovician age to the east.

The northeast parts of the Catchment are comprised of granites of the Wyangala Batholith that intrude both the Ordovician and Silurian sequences. West of Boorowa Township a small granite body outcrops, part of the larger Young Granodiorite.

Since the end of the Palaeozoic, the geological history of the region has been that of regional uplift during the Cretaceous (~100 my) followed by weathering and erosion to form the present day topography. A series of major faults and shear zones have influenced the topography of the catchment, many of the creeks in the Catchment are structurally controlled.
The most recent deposits are the Quaternary deposits of colluvium derived from weathered bedrock that are deposited on hillslopes in the catchment. Sands, gravels and fine-grained alluvium accumulated along narrow floodplains, adjacent to the major drainage systems.

4.7 Soils

The soils of the Catchment area are highly variable and generally of moderate to low fertility. The surface texture of the soils is usually correlated to the underlying rock materials, e.g. coarse-textured surface soil horizons derived from granites and coarse-textured sediments. Soils generally display an acid reaction trend, becoming more alkaline in poorly drained and lower lying areas. The principal soils are described as lithosoils, gradational soils and duplex soils, which exhibit a strong texture contrast between the A and B horizons.

- *Lithosoils* are characterised by shallow stony soil profiles overlying rocky parent material on hills and ridge crests, where erosion is the dominant landscape process, irrespective of parent material e.g. lithosols and siliceous sands. These profiles generally have a high stone and gravel content and a low moisture holding ability. They are nutritionally poor and on the steeper slopes are liable to erosion when native vegetation is removed or they are disturbed by mechanical means. Minor areas of poorly structured alluvial soils occur along narrow floodplains adjacent to drainage lines.
- *Gradational soils* are characterised by profiles having a gradual increase in clay content with depth e.g. red and yellow earths. They are common where soils are derived from acid parent materials and develop on well-drained sites in upper parts of the landscape. They are common in the central and southern part of the Catchment. These are deep, relatively fertile soils and are relatively resistant to erosion, except in areas where slope is a factor, they will erode if the land is cleared.
- *Duplex* soils dominate the Catchment. They are characterised by a distinct change in particle size at a depth of 15-30 cm. The topsoil is light in colour, coarse textured and often quite sandy. The subsoils tend to be reddish on the hills and yellow in the valleys, quite clayey and often shrink and swell with water content change, which sometimes presents engineering problems.

  Mid-slope soils are generally deeper, with Red and Yellow Podzolic soils commonly associated with acid parent materials. On foot-slopes, neutral Soloths and alkaline trending Solodic soils are characterised by profiles with strongly leached upper horizons (Hird 1991). Well-structured and fertile Non calcic Brown soils, derived from basic parent materials (e.g. basalts), and are suited to more intensive agriculture

  The surface structure of most these soils are fragile and, if overgrazed or poorly cultivated, the topsoil becomes relatively impermeable and hard setting. With poor infiltration of rainfall, water tends to run across the surface and, if focused in depressions, soon forms erosion gullies. These soils are particularly vulnerable to erosion on the slopes and where native vegetation has been cleared and the surface left unprotected. In addition, their clay subsoil often contains sodium salts, making this soil type dispersible if exposed by mechanical means or by erosion after clearing. Much of the turbidity of rivers in the Catchment after heavy rain is caused by erosion of these soils.

Soil Landscapes

Regional Soil Landscape maps (Map 3, pg 94) are useful for grouping soil types that are related to similar climatic zones, geology, landforms, vegetation and existing land use (Hird 1991). Each soil landscape is characterised by a dominant soil type within the Soil Landscape unit. Although several soil types (e.g. Lithosols, Yellow Podzolic) may occur within an individual Soil Landscape unit, major changes in individual soil types cannot be mapped at a regional scale. The following is a summary of the main features of the Soil Landscape units within the Catchment, derived from Hind, 1991.

- **Shallow Soils** - *Lickinghole*,
  Soil on steep (over 30% slope) Ordovician metasediments terrain; mainly lithosols, i.e. little or no structure or soil horizon formation with abundant rock fragments, or red or yellow earths on upper slopes with local podzolics on lower slopes. Associated with extensive outcropping rock; Prone to erosion
  Oak Creek
  Soil on steep (over 30% slope) Silurian volcanic terrain; Lithosols, or red or yellow earths on upper slopes with local podzolics on lower slopes.
  Pine Mountain
  Soil on very steep (over 30% slope) granitic terrain; Sandy lithosols, or siliceous sands with large granitic tors, with local podzolics on lower slopes.

- **Alluvial Soils** - *Goulburn*,
  Minor alluvial soils developed along mid to upper Hovells Creek; local red podzolics developed on adjacent river terraces.

- **Siliceous Sands** - *Pipe Clay Creek*.
  Sandy (quartz-rich) alluvial fan deposits formed on rhyolitic Silurian volcanics; Low relief and slopes, stony siliceous sands on slopes with solodics in some drainage lines profiles; Prone to erosion.
  Wyangala
  Soils developed on rolling low granitic hills with slopes ranging from 10-30%; Siliceous sands and red earths on crests and upper slopes with red duplex soils on side slopes and yellow duplex soils in some drainage lines.

- **Solodic** Soils - *Illunie*.
  Undulating to rolling Silurian volcanic hills; Yellow earths and lithosols on upper slopes and crests; Solodic soils with strong textural differentiation with a very abrupt boundary between A and B horizons in lower slopes and drainage lines; Soils associated with poorly drained sites, such as in enclosed basins, capable of producing soluble salts. Possible salinisation.

- **Soloths** - *Blakney Creek*.
  Soils developed on undulating to rolling terrain, footslopes and valley floors; Moderately to slightly acid throughout the profile and usually have significant amounts of soluble salts or exchangeable sodium in the lower B horizons; Possible salinisation.

- **Yellow Earths** - *Binalong*,.
  Soils developed on undulating low relief volcanic terrain; Yellow brown to yellow (locally red) massive predominantly sandy texture with earthy fabric, weak profile differentiation on

crests and upper slopes. Minor non-calcic brown and podzolics on lower slopes with soloths or solodics on valley floors; Possible salinisation.

Cockatoo

Soils developed on rolling to low hills Silurian volcanic terrain; Bright yellow and red earths and minor duplex soils or lithosols on crests and upper slopes.

Midgee

Soils developed on rolling low hills in Ordovician metasediments terrain; commonly acid stony yellow earths and yellow podzolics on crests and sideslopes; Possible salinisation.

- **Euchrozems and Non Calcic Brown**- *Cudal*

  Deep soils developed on basalt flows; Red to reddish-brown euchrozems, well-structured soils with a high clay content and weak horizontal texture differentiation on crests and upper slopes.

  Kenyu

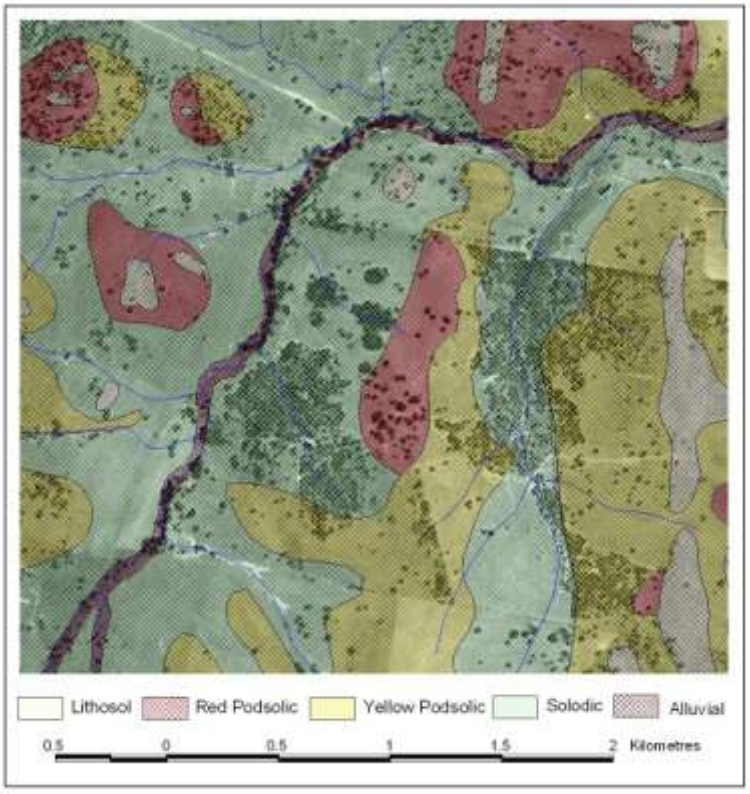
  Soils developed on undulating to rolling hills on Ordovician volcanic units; Non calcic brown, red duplex soils or red earths on upper slopes, with euchrozems or yellow podzolics on lower slopes.

- **Yellow Podzolic** - *Boorowa.*

  Soils from siliceous parent material in rolling to gently undulating volcanic terrain under poor drainage conditions; Generally strongly differentiated profiles; Yellow to light red duplex soils on crests and slopes that are often hard setting, with solodic soils in drainage lines; Possible salinisation.

  Garland

  Soils developed on low lying rises and valleys between rolling hills in granitic terrain; Yellow duplex soils on mid to lower slopes with light red podzolics or yellow/red earths on upper slopes with siliceous sans in drainage lines.



Over the past 10 years students, from the Australian National University and University of Canberra have mapped the soils types around the Boorowa Township at a scale of 1:10,000. An extract from some of the mapping is shown in Figure 7.

Figure 7 Distribution of soil types in the *Boorowa* Soil Landscape unit. Note the changes in soil type from crests of hills (lithosols and red podzolics) to slopes (yellow podzolics) and valley floor and drainage lines (solodics and alluvial soils)

4.8 Land Capability

Land capability is the ability of land to accept a type and intensity of use permanently, or for specified periods under specific management, without permanent damage. Land capability mapping by the NSW Soil Conservation Service during the late 1980s classified rural land into 8 classes, defined by Roman numerals (I to VIII). The classification has a hierarchical sequence, ranging from land with the greatest potential for agricultural or pastoral use (Class I), to that which is entirely unsuitable for either (Class VIII). Table 7 below defines the main elements of this classification system.

The direct application of land capability boundaries to individual properties is not recommended, as the mapping is based on 1:100,000-scale mapping. Most of the Catchment area can be ascribed to Class IV and Class V, i.e. suitable for grazing and occasional cropping, (Map 4).

Class	Land Use	Management Options
I	Mainly cropping	Wide variety of uses – vegetables and fruit production, grain crops, energy crops and fodder, sugar cane. No special soil conservation works or practices necessary.
II		Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotations.
III		Structural soil conservation works such as graded banks and waterways are necessary, together with soil conservation practices as in Class II.
IV	Mainly grazing	Occasional cultivation, better grazing land. Soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or re-establishment of permanent pasture, maintenance of good ground cover.
V		Similar to IV, structural soil conservation works such as diversion banks and contour ripping, together with the practices in Class IV like the maintenance of good ground cover.
VI	Grazing	Not capable of cultivation. Soil conservation practices including limitation of stock, broadcasting of seed and fertiliser, promotion of native pasture regeneration, prevention of fire and destruction of vermin. This may require some structural works and maintenance of good ground cover.
VII	Tree cover	Land best protected by trees. Very important habitat areas for protecting biodiversity.
VIII	Unsuitable for agriculture	Cliffs, lakes or swamps and other lands where it is impractical to grow crops or graze pastures.

Table 7: Rural Land Capability Classes (Emery, undated)

4.9 Land Use

There are no large reserves of Crown or public land in the Catchment, and consequently the majority of land is privately owned. The area supports varied agricultural enterprises, although most of the Catchment is used for grazing. A majority of farms support sheep for wool production, or in breeding programs for prime lambs or beef cattle on improved, or unimproved

pasture. Dryland cropping includes wheat, winter oats, lucerne, canola, triticale and lupins. Cropping is mainly restricted to the flat-lying areas around the Boorowa Township, and the extent of cropping varies annually, depending on commodity prices and climate.

The following land use figures (Table 8) are based on Landsat satellite land cover classification in the Boorowa Catchment (Newham & Field, 1999). Classification of native, annual and perennial pasture types is difficult due to the composite nature of pasture species, and varying environmental conditions. Recent advances in land use mapping, using remote sensing techniques enables more accurate determination of land use patterns across the landscape, (Keith Emery pers. com. 2003).

Land use (BRC)	Area (%)	Area (ha)
Annual Pasture	34	73,424
Native Pasture	36	77,323
Perennial Pasture	15	33,303
Crop	7	15,444
Woodland	7	16,124
Lucerne	<1	1,925
Water bodies	<0.001	3

Table 8 Land cover in the Boorowa Catchment Area (from Newman and Field, 1999)

Remnant woodland covers an area of about 7% of the Catchment based on Newham & Field, (1999). Improved mapping techniques utilised by NSW NPWS suggest a remnant woodland cover of about 15%, which includes grassy woodland remnants.

4.10 Native Vegetation

A recent study by the NSW National Park and Wildlife Service (NPWS) of native vegetation in the Boorowa Shire has shown that over 85% of the Shire has been cleared (Priday and others, 2002). The study identified nine vegetation communities within the Shire. The vegetation communities in the southern-most part of the Catchment (i.e. not within the Boorowa Shire boundaries) were mapped on a more regional basis by a State and Commonwealth Governments regional forest agreements program (Thomas et al., 2000).

The distribution of vegetation in Boorowa Shire strongly relates to soil type, geology, and position in the landscape (i.e. valley floor or ridge top). Three broad plant communities occur: riparian forests, grassy woodlands and dry forests. The vegetation communities have been named according to the dominant species (e.g. White Box Woodland). The communities, their current extent and their estimated pre-clearance cover within the Shire boundaries are shown in Table 9. It should be noted that the figures of total existing area, include all representations of a particular vegetation type, regardless of individual patch condition.

Pre-clearing extent

Riparian forests of Red Gum or She Oak occurred along the rivers and major creeks. Woodland communities, dominated by Blakely's Red Gum and Yellow Box, occur along most creek lines and lower slopes. A Red Stringy-bark – Long Leaved Box forest occurs on sedimentary rocks on the lower slopes in the south-east of the Shire. White Box woodlands with a grassy understorey formerly occupied most of the undulating slopes in the Shire, while a grassland/open woodland occupied much of the broad basin centred on Boorowa. Ridge-lines and upper slopes support dry forest in which Red Stringy-bark is always a dominant species.

Name of Vegetation Ecosystem	Pre-1750 Area (ha)	Existing Area (ha)	% Cleared
River Red Gum forest	3,063	577	81%
River Oak riparian forest	738	111	85%
Blakely's Red Gum – Yellow Box Woodland	50,071	4,093	94%
Kangaroo Grass – Red Leg grassland/open woodland	24,269	418	98%
White Box Woodlands	39,700	2,204	96%
Red Stringybark/Long-leaved Box/Candlebark Open Forest/Woodland	17,297	2,197	87%
Callitris endlicheri-Red Stringybark-Red Box shrub forest	2,379	828	65%
Red Stringybark Dry Shrub Forests	72,955	9,492	87%
Red Stringybark -Joycea grass tussock open forest	47,205	8,965	81%
TOTAL	**257,659**	**28,862**	**88%**

Table 9 Vegetation communities in the Boorowa Shire (Priday et al., 2002)

Remnant Vegetation Loss

Satellite data analysis has shown that about 1,390 ha of remnant vegetation, i.e. about 0.6% of Catchment, was lost from remnant patches in about 27 years, from 1973 to 2000. There has also been an increase of the vegetation in the Catchment of about 220 ha in the same period, i.e. 0.1% of Catchment (Rassoul Mahiny, ANU, pers. comm.). These figures were generated through a comparative analysis of satellite images of area, taken over the time frame indicated.

Current extent

Most of the remaining large blocks of vegetation are dry forests on rocky ridgelines unsuitable for agriculture. These large blocks have been rated as "near pristine" to "some disturbance". These patches were generally characterised by sparse to dense shrub cover and significant amounts of regeneration. These areas tend to be located on the eastern margin of the catchment, with isolated pockets on the higher elevations within the Catchment. The rest of the woodland cover consists of isolated paddock trees and small patches of less than 2ha (200m x 100m). Understorey is non-existent in most areas; particularly those used for the grazing of stock. These patches have been categorised as "disturbance evident, some regeneration" to "severely degraded, no regeneration". The majority of native vegetation is restricted to ungrazed roadsides and reserves. The vegetation of Boorowa is highly fragmented and dysfunctional. The remaining remnants are under considerable stress from increased salinity, over fertilisation, grazing, herbicide drift and soil compaction.

Native Vegetation Communities

The perilous state of the Shire's vegetation means that its retention, regeneration and rehabilitation on private land are crucial to its survival. The NPWS report provides information that can be used as a guide to the selection of suitable species for planting, and contains specific conservation advice. It also provides further justification for the allocation of Landcare and Natural Heritage Trust funding to the Catchment. Roadsides and Travelling Stock Reserves are generally the areas that retain the greatest plant diversity within the Shire. Council has the key responsibility for protecting remaining roadside vegetation, while rural Lands Protection Boards are responsible for the stock reserves.

Endangered Vegetation Communities

Given the extent of vegetation clearing, it is not surprising that many threatened plant and animal species occur within the Catchment. The habitat for most of the threatened species is predominantly woodland. Threatened flora species are provided in Table 10. The most threatened vegetation communities are White Box woodland, Blakely's Red Gum – Yellow Box woodland and Kangaroo Grass – Red Leg grassland/open woodland communities are listed below. Retention and enhancement of woodland remnants and their understorey is the key issue for retaining viable populations of the threatened species within Boorowa Shire.

Common Name	Species	Status in Catchment area
Tarengo Leek Orchid	*Prasophyllum petilum*	The Terengo TSR supports the largest known population of this species.
Yass Daisy	*Ammobium craspedioides*	Requires relatively undisturbed grassy woodlands, and is under threat due to grazing pressure.

Table 10 Threatened flora in the Catchment area (from Priday et al., 2002)

4.11 Native Fauna

A recent survey in the Catchment by CSIRO (Freudenberger, 2001) reported that "*The Boorowa River catchment in not a biological desert. It may only have 7% cover of remnant woodland, but 115 species of birds were recorded across a diversity of woodland types, remnant sizes and habitat structures within the catchment."* The following (Table 11) is a list of threatened fauna in the Boorowa Shire.

Common Name	Species	Status in Catchment area
Birds		
Bush Stone Curlew	*Burhinus gralarius*	Extremely Rare; southern part of its range
Superb Parrot	*Polytelis swainsonii*	Adopted as a symbol of the Boorowa region
Swift Parrot	*Lathamus discolor*	Autumn/winter visitor, feeds on Whitebox & Red Ironbark
Barking Owl	*Ninox connivens*	Rare, southern part of its range
Speckled Warbler	*Cthonichola saggitata*	Recorded in several sites
Hooded Robin	*Melanodryas cuculatus*	Few sightings, inhabits grasslands & woodlands
Black-chinned Honeyeater	*Melithreptis brevisrostis*	Rare, although reported in several sites
Painted Honeyeater	*Grantiella picta*	No formal sightings, feeds on Mistletoe species
Regent Honeyeater	*Xanthomyza phrygia*	No formal sightings, Inhabits Box-Ironbark woodlands
Grey-crowned Babbler	*Pomatostomus temporalis*	Several families in region, inhabits gassy woodlands
Brown Treecreeper	*Climacteris picumnus victoriae*	Recorded in several sites, requires large remnants of native vegetation for survival
Diamond Firetail Finch	*Stagonopleura guttata*	Rare, Inhabits grasslands and woodlands
Mammals		
Squirrel Glider	*Petaurus norfolcensis*	Rare, southern part of its range
Koala	*Phascolarctos cinereus*	Few sightings, inhabits woodlands & forests in east
Large-footed Myotis Bat	*Myotis adversus*	Rare, western part of its range, inhabits riparian zones
Common Name	**Species**	**Status in Catchment area**
Insects		
Golden Sun Moth	*Synemon plana*	Recorded in several Travelling Stock Reserves
Perunga Grasshopper	*Perunga ochracea*	Rare, restricted to grasslands/open woodlands

Table 11 Threatened fauna in the Catchment area (from Priday et al., 2002)

The removal of fallen timber and nesting trees, including isolated paddock trees and roadside trees, are all contributing factors in the reduction of biological diversity in the Catchment. A reduction in foraging habitats due to land clearing poses the most serious threats to species in the Catchment. Predation by the feral animals such as foxes and cats, also poses a major threat.

5 BOOROWA CATCHMENT ISSUES

Environmental issues such as land and water degradation are complex and often interrelated. The main environmental issues that affect the Boorowa Catchment are:

- **Dryland salinity**
- **Native vegetation and biodiversity decline**
- **Soil acidity, erosion and soil structure decline**
- **Water quality decline**

Downstream water users from the Boorowa Catchment are also affected due to declining water quality in the Lachlan River, as the result of salt and sediment load from the Catchment.

5.1 Dryland Salinity

Dryland salinity is a widespread problem, and has occurred where saline watertables rise, bringing salt to the soil surface. Indicators of dryland salinity are waterlogged areas that establish salt tolerant plants such as couch grass, sea barley grass, strawberry clover and spinney rush. Dead or dying trees in depressions or bare ground (scalding) are also significant indicators of dryland salinity outbreaks. Salt crystals on the soil surface are often evident during dry periods.

The main issues for management are: Loss of productivity from affected sites; and offsite impacts. When considering the affect of salinity management actions on our landscape and river systems, it is important to think about the impact of increased vegetation on reducing runoff, thus increasing stream salinity concentrations. Another consideration worthy of thought is the possible impact of extracted/drained groundwater on stream salinity concentrations. It is important to consider the affect of remediation works in relation to Catchment scale issues such as this, and come to a balanced strategy or approach. A clear understanding of water balance within our Catchment is also required to enable the formation of useful, targeted, salinity abatement strategies.

There are several definitions of 'saline' water. The Australian desirable standard for drinking water is 800 EC. Although water starts tasting salty around 1700 EC, it is safe to drink, but not for long periods of time. Aquatic biologists define water as saline at 5000 EC. If salinity is 10,000 EC or above the growth of trees is severely impeded.

What causes dryland salinity ?

The reduction of vegetation, through clearing or grazing, over the last 200 years, has reduced the amount of rainfall being utilised by vegetation on the surface. The rainfall then leaks below the root zone (recharge), and adds to the water tables. As water tables rise, salt is bought to the surface (discharge) killing vegetation and leading to soil erosion and degradation (Nicholson and Wooldridge, 2000).

To achieve widespread (catchment scale) control of dryland salinity, it is recognised that recharge control is the most significant factor in addressing the cause of this issue. In understanding why the current landscape is "leaking" we must look at the base resource - our soil. Although current Best Management Practice focuses on vegetation as the key to control recharge, the soil plays an equally major role. Through improving soil structure and organic

matter, our soils will become healthier and provide a 'sponge' to retain and use water in the landscape and support more vegetation to restrict recharge.

The challenge in dryland salinity management is to decrease groundwater recharge rates and to identify the key salt storage areas and flow paths in the landscape. Various management options can then be employed to target exactly where management strategies such as planting deep rooted trees, healthy perennial pastures, and using engineering solutions such as drainage control, will be most effective. This will enable the most efficient use of funds by very specific targeting of the areas at greatest risk of salinisation.

The signs and symptoms of a rising watertable and surface salts are:

- *Reduced yields and productivity*
- *Decline in plant growth*
- *Decline in water quality*
- *Waterlogging*
- *Change in species, favouring salt tolerant varieties*
- *Increased erosion hazard*
- *Dead and dying native vegetation.*
- *Bare patches - scalding*

Saline areas (discharge) areas are very visible and are a concern to the community, however there are many management strategies that can be applied to regain some economical return from the land (Packer, 2002). Moderately affected areas can support highly productive salt-tolerant pastures.

Groundwater Systems

The groundwater system in the Catchment is characterised by a large number of small, local flow systems, usually correlating very closely with topographical catchments. Two distinct types of aquifers have been identified.

- Shallow soil/weathered zone system
- Deeper fractured rock system

Both aquifers can be unconfined to semi-confined in nature, and are local in distribution. That is, the aquifers recharge and discharge in close proximity (usually within 2-5 km), and this generally means that inter-valley or Catchment flow of groundwater is non-existent (Evans & Bradd, 2001).

Soil/weathered zone aquifer system

The upper weathered bedrock and overlying soil form a shallow, unconfined aquifer system. It is generally discontinuous and restricted to the mid to lower parts of the landscape, with a maximum thickness of about 10 metres. The aquifer can contain a series of perched aquifers in the upper levels of the aquifer, due to presence of basal clay aquitards, with low permeability. This aquifer system contains the major salt store in the catchment.

Fractured rock system

The fractured rock aquifer system can be found over the entire Catchment. The three main rock types of the catchment - volcanics, sediments and granites –are all fractured to the extent that they will transmit water and function as aquifers. The granites generally have higher lateral hydraulic conductivity than the volcanic units.

Generally, bore yields are low, usually less than 1 L/sec everywhere. Some exceptions exist, usually related to cavernous interbeds of limestone found in the volcanic sequences. Here yields may vary up to 10 L/sec or so. Bores range in depth from 10 to 100 m below ground level (Evans & Bradd, 2001). As with studies elsewhere in fractured rock aquifers of the central and southern parts of New South Wales most bores intersect their major water supplies in the top 50m or so.

Recharge and Discharge

Recharge to the fractured rock aquifer occurs over most of its surface extent. The soils of the Boorowa Catchment are such that they are all reasonably permeable and will allow some form of deep drainage to occur below the root zone. Generally, the more permeable soils can be found on the higher slopes and these are implicated as being sites for very high rates of recharge. Bore hydrographs in these places will show rapid filling response to winter rainfall, equally rapid draining during summer months. This water is transmitted to lower parts of the landscape, and added to by deep drainage from the soils in these lower parts.

Groundwater discharges from the aquifer generally in the lowest parts of each small catchment. This discharge will generally be by seepage to ephemeral and perennial creeks and streams. When the hydrologic balance is disturbed, groundwater discharge will be much greater than previously, so areas of land will become waterlogged and salinised, and water will be discharged via direct evapotranspiration pathways (Evans & Bradd, 2001).

Groundwater recharge occurs in all parts of the landscape and causes saline groundwater discharge to land and to streams, mainly where the hydraulic gradient reduces with slope and bedrock variation. Where these discharge zones occur in the landscape, varies due to changes topographic slope, soil and rock types. The extent of land salinisation in the Catchment varies in relation to the level of incision of the river system and the topography of the landscape surrounding the streams. Low lying flat landscapes are prone to extensive salinisation.

Groundwater levels

Several groundwater level surveys of water bores in the Catchment have been undertaken. The surveys found that although the SWL (Static Water Level) in most bores had risen since the time they were constructed, the SWL of a several bores had fallen (Evans & Bradd, 2001).
Further analysis of chemical data collected in these studies is currently being conducted by hydrogeochemists at the Australian National University.

Salinity Mapping

John Powell undertook the first salinity distribution study of the Catchment in 1992. The study was based on fieldwork and aerial photography, and covered Landcare member properties in the Rye Park and Boorowa areas. Of the 76,014 ha surveyed, about 1.5% of the area was shown to have varying levels of salinity; 865 ha were affected in a minor way, 189 ha moderately affected and 60 ha severely affected. The areas most at risk were identified as the low relief areas within a 15 km radius of the Boorowa Township (Powell, 1992). These locations are included on Map 7.

A Salinity Catchment Plan for the catchment was prepared that recommended a monitoring program, farm planning, and planting of perennial pasture and trees in ways to control the expansion of dryland salinity. These recommendations have been implemented in a series of salinity management programs (Stage I to Stage V).

In October 2002, the Dryland Salinity Outbreak Mapping group, a part of the DIPNR, provided a copy of their salinity mapping in the region (Map 7). Although the Outbreak mapping usually relies heavily on airphoto interpretation, the mapping group had access to the existing community mapping and local knowledge. Further community consultation and site investigations may enhance the accuracy and extent of saline outbreaks mapping within the Catchment. The saline discharge sites were digitised using the existing topographic base maps. Several attributes related to the severity and management of the sites were also digitally stored.

Approximately 5000 ha (or about 2.5% of the catchment area) have a surface expression of dryland salinity based on the Outbreak Mapping data. The area affected by salinisation from Outbreak Mapping is possibly an overestimate, as the width of the area displaying early stages of salinity along the creeks was drawn at about 50 metres wide. The Outbreak Mapping was designed for 1:100,000 scale map output.

Four classes of salinity (including areas at risk) were mapped by DIPNR according to the criteria shown in Table 3.

Salinity class	**Categories**	**Criteria**	**Common salt tolerant grass species**
1	At Risk	Salt tolerant species not necessarily present. Minor reduction in yield on pasture or crops. New waterlogged areas appear. Approx soil salinity EC_{1-5} range is less than 300 µS/cm.	subterranean clover and other clover species declining.
2	Early Phase	Incipient salinity. Productivity of pastures and crops noticeably affected. Crop species stunted. No bare patches or salt fluorescence. Approx soil salinity EC_{1-5} range is between 300 and 600 µS/cm.	wallaby grass; sea barley grass; couch.
3	Low-Moderate	Salt tolerant species dominate the plant community. Some plant species show signs of stress. Salt stains are visible, and small areas (less than $1m^2$) are present. Soil salinity EC_{1-5} range is between 600 and 1400 µS/cm.	sea barley grass; couch; spiny rush; tall wheat grass.
4	Severe	Only highly salt tolerant species are left or ground is bare, active erosion. Extensive areas of bare ground are present with fluorescence present. Trees are dying or dead. Approx soil salinity EC_{1-5} range is greater than 1400 µS/cm.	Trees are dying or dead

Table 12 Dryland salinity class categories, criteria and indicator species
(adapted from MDBC Dryland Salinity Mapping brochure)

The recent mapping will provide a basis for future targeting of salinity abatement site within the Catchment. An example of this salinity mapping is provided in Figure 8.

Figure 8 Dryland salinity occurrences in the vicinity of the Boorowa Township: orange - early phase of dryland salinity; pink – low- to moderate; red - severe salinity; blue circles location of groundwater monitoring piezometers (from DIPNR, 2002)

Urban salinity

Urban salinity has been identified in over 80 towns throughout Australia. Salinity in towns is the result of a combination of dryland salinity processes and over irrigation of urban areas. Irrigation of lawns and gardens on permeable soil types that overlie saline material mobilise salts, and groundwater flow redistributes these salts down slope. Towns are often located in low points in the landscape, and are adding water to those landscapes (Wooldridge, 1999). The Boorowa Township has obvious symptoms of salinity, such as:

- *dying and dead trees*
- *salt tolerant species of grass appearing in gardens and playing fields, especially couch grass*
- *bare patches in lawns and playing fields, often with white crusting on the surface*
- *cracked, broken and deteriorating concrete paths and gutters*
- *road surfaces breaking up*
- *rising damp in building – private and public*
- *deterioration (fretting) of bricks and mortar*
- *salt crusting on brickwork, concrete and pavers*
- *deterioration of house foundations*
- *corrosion of underground services, such as gas and water pipes, sewerage systems etc.*

A recent survey of the Township revealed that at least 25 houses (or about 5% of houses in the Township) were currently displaying some damage from high saline watertables (Ivey ATP and Wilson Land Management Services, 2000). Damage to infrastructure can be costly to repair and can affect property values.

The Boorowa Council Engineering Group monitors a series of piezometers in the Township area for groundwater elevation on a monthly interval. Figure 9 depicts the response of groundwater level to rainfall events over a 10-year period; note the effect of the recent drought. This clearly demonstrates the need for recharge

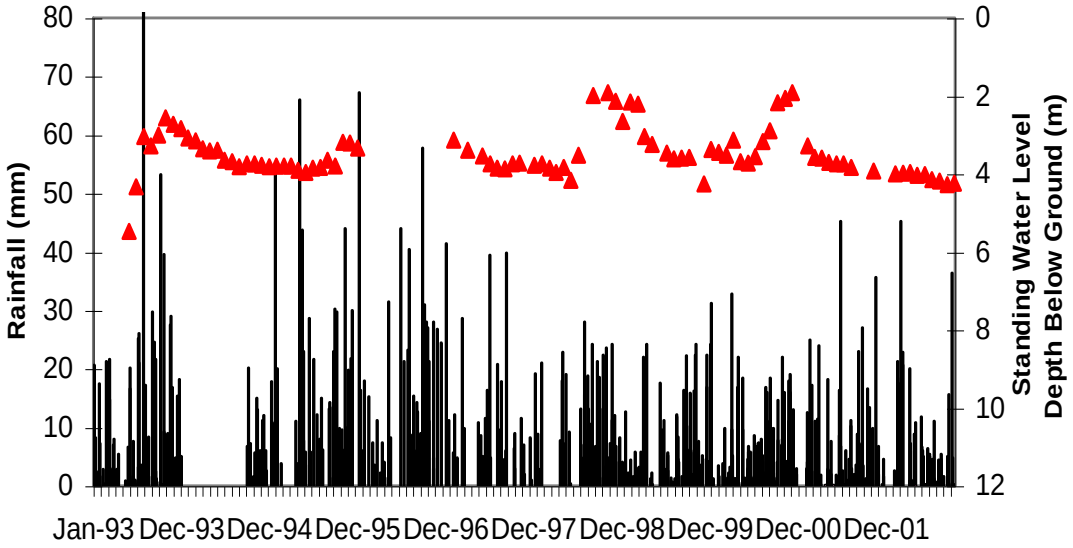


Figure 9 Boorowa Weir 2 hydrograph and bar graph of monthly rainfall (Bureau of Metrology) 1993 - 2002

5.2 Vegetation and Biodiversity

Native vegetation management is the management of native trees, shrubs and grasses to maintain biodiversity, increase the viability of rural communities, and to prevent land and water degradation.

Remnant vegetation does not necessarily refer to 'untouched' vegetation, as much of the catchment has been ringbarked, cleared, grazed or burnt since settlement. Much of the vegetation that remains today represents regrowth from this era, with many of the stands showing evidence of these past activities. It is recomended that these areas are preserved, as they may represent important samples of Boorowa area vegetation communities.

Why is native vegetation important ?

Protecting and managing areas of native remnant vegetation can have multiple benefits in promoting sustainable catchment health. These include:

- *providing windbreaks, shade and shelter for stock*
- *enhancing economic value (agroforestry, firewood, property value)*
- *providing a source of seed for regeneration*
- *reducing groundwater levels and recharge*
- *filtering nutrients and pollution in the stream bank zone*
- *controlling erosion*
- *increasing and maintaining biodiversity*
- *providing wildlife habitat and corridors.*

Shade and shelter provided by native vegetation can increase production. Sheep on sheltered plots produced 35% more wool and 6kg more liveweight than those without shelter, during a five-year study at Armidale. Native vegetation also provides an important aesthetic function in attracting tourism to farming areas, and plays an important role in local and regional cultural history.

What causes native vegetation decline?

Native vegetation decline has occurred through *direct loss* of vegetation, *fragmentation* of vegetation and *degradation* of those areas.

Clearing, continuous grazing and dieback are the primary causes of native vegetation decline in the Boorowa area. Clearing in the catchment dates back to 1800s with much of the remaining vegetation consisting of small remnants or individual paddock trees. These small, segmented remnants are generally not protected from grazing pressure and as a result, are more susceptible to the pressures influencing dieback and tree decline. This can affect reproduction, species diversity and exposure of remnants to weather and the impacts from adjoining landuse (fertiliser/herbicide drift, weeds and stock) known as the 'edge effect'. Many isolated paddock trees in the catchment are also old and in their later stages of life, reducing their ability to recover from dieback.

Weeds

Annual weeds generally increase when competition from desirable perennial plants is weakened or removed and/or an imbalance of nutrients occurs in an area. The main problem weeds species found in the Catchment area are: (For a more complete list see Appendix 2)

- Serrated Tussock - *Nassella trichotoma*
- St John's Wort - *Hypericum perforatum*
- African Boxthorn – *Lycium ferocissimum*
- Scotch thistle -
- Paterson's Curse - *Echium plantagineum*
- Sharp Rush - *Juncus acutus*

Environmental Weeds (from Priday et al., 2000 NSW NPWS)

Exotic plant species are widespread throughout Boorowa Shire, particularly in the areas used for intensive agricultural activities. Although many species with reputations as serious weeds occur in the Shire, few appear to occur in large numbers. Some of the worst weeds in the southwest slopes region, such as Paterson's Curse (*Echium plantagineum*) and St Johns Wort (*Hypericum perforatum*) occur mostly in scattered infestations. Thistle species appear to be widespread but reasonably well contained. Serrated Tussock (*Nassella trichotoma*), a serious weed of the southern highlands and southern tablelands, was recorded only in the north east of the shire in the vicinity of Wyangala Dam. African Lovegrass (*Eragrostis curvula*) was observed at a small number of locations along the Lachlan Valley Way. Sharp Rush (*Juncus acutus*) was generally restricted to areas that appeared to be subjected to waterlogging and possibly high salinity.

In native vegetation remnants, the most common weeds recorded were ubiquitous species such as Flatweed (*Hypochaeris radicata*) and Quaking Grass (*Briza maxima*). Also prevalent in the majority of remnants, particularly those on more fertile soils, was Rough Dog's Tail Grass (*Cynosurus echinatus*). This species formed a dominant component of the understorey in a large number of plots. It may represent a threat to the integrity of some of the native vegetation remnants in the shire. Some exotic pasture species, particularly Cocksfoot (*Dactylis glomeratus*)

and Phalaris (*Phalaris* spp.), were also common in native vegetation remnants, particularly roadside remnants in more fertile areas.

Other potentially problematic species that were not obvious because of the timing of the surveys are also likely to commonly occur in the shire. Among these is Onion Grass (*Romulea rosea*), which is an invasive species that commonly occurs in native grasslands and grassy woodlands.

The Southern Slopes Noxious Plants Authority has identified 46 noxious plants within the Southern Slopes County Council control area, which includes Yass, Boorowa, Harden and Young Shires (Appendix 2).

Weed Management

Infestations can occur from poor land management such as:

- over grazing which leads to a decline in desirable perennial species allowing annual grasses and weeds to establish
- uneven distribution of soil nutrients from set stocking in large paddocks
- salt tolerant weeds such as sea barley grass or spike rush in salinised areas

The best way to prevent weeds on grazing lands is to look after native and/or introduced perennials and manage these to avoid over-grazing and to maintain ground cover. Herbicides can be strategically used to control weed infestations.

Threatened Species Management in Boorowa Shire

There are no reserves within Catchment currently managed solely for flora or fauna conservation and/or endangered ecological communities. The future of threatened species and endangered communities is dependant on suitable management of habitats on private properties, roadsides and public lands such as travelling stock reserves and cemeteries.

The most important legislation applying to the management of threatened species and endangered ecological communities in NSW is the *Environmental Planning and Assessment Act 1979*, the *Threatened Species Conservation Act 1995* and the *National Parks and Wildlife Act 1973*. These acts provide for various mechanisms for the management of threats to threatened species and endangered ecological communities. However, most activities on agricultural lands are exempt from restrictions applied under the *TSC Act 1995*. Thus outcomes towards the management of threatened species and endangered ecological communities are largely reliant on action from Boorowa Shire Council and local landholders.

A critical issue in the conservation of fauna and flora is awareness within the community. Although the level of awareness of environmental issues in Boorowa Shire is high, understanding of specific issues such as the conservation and management of endangered ecological communities and threatened species will need to be further developed. It is hoped that the report from the NSW NPWS is of assistance to the people of Boorowa gaining greater understanding of fauna and flora issues across the Shire (Priday et al., 2000).

Riparian Vegetation

In 1998 an assessment of Riverine Corridor Health in the Lachlan Catchment (Massey 1998) looking at eight riverine environment attributes assessed in this study including an overall assessment.

Data was collected at 41 riparian sites throughout the Boorowa and Hovells Creek Catchment. Tributaries included in the survey area were; Boorowa River, Breakfast Creek, Buffalo Flat Creek, Castles Creek, Flakeney Creek, Forest Creek, Gunnary Creek, Harrys Creek, Hovells Creek, Langs Creek, McKays Creek, Narrallen Creek, Pudman Creek and Water Hole Creek.

Willows

A survey of the willow population along the Boorowa River and some of its major tributaries, such as Pudman Creek, found that the willow population was relatively stable. The survey found that there was almost no evidence of seeding willow population, with the recommendation that the willow population in the township of Boorowa required monitoring, as potential seeding willows occur in the same location. The species of willows found in the catchment are:

- *Salix babylonica* – Weeping willows
- *Salix fragilis* – Cracked willows
- *Salix alba variety vittlina* – Golden Upright
- *Salix matsudana x alba* – N.Z. Hybrid
- *Salix matsudana tortuosa* – Tortured willow

Although there is possibly no seeding willows in the catchment there are still locations where willows are causing structural problems with streambeds and banks. This is mainly where willows have established in mid-stream and are causing flow to be diverted into stream banks, where major erosion has been occurring. Another problem with willows is that many of the species present have been rapidly spreading vegetatively causing major stream blockages as flood debris becomes lodged in the intertwined limbs.

The specific objectives for willow management will vary from sub-catchment to sub-catchment, and include the following situations:-

- In most situations willows may be retained.
- Where willows are growing in the stream bed, they often deflect high flows into adjacent banks, creating bank erosion. These willows should be removed.
- Overhanging branches and broken limbs which trap water-borne debri, can create bank erosion or infrastructure damage downstream during high flows. These branches can be trimmed or trees removed to minimise this occurrence.
- When willows drop their leaves in autumn, they decompose in the water, depriving aquatic organisms of oxygen. This can have a major effect on aquatic ecology. Tree removal strategies should take this into consideration.
- In some situations, with high ecological value, it may be desirable to entirely remove all exotic species.

In NSW , it is necessary to obtain approval from DIPNR before removing any vegetation from within 20 metres of a river or watercourse. You may also need to submit a plan for replacement vegetation in order to prevent bank erosion. Before starting a willow control program, seek advice from your local Landcare group or Council. A strategic approach to willow control, starting upstream and working methodically downstream (to avoid reinfesting treated areas) is recommended. Such strategies are possible through Landcare networks or though local interest groups such as fishing clubs etc.

5.3 Soil Structure, Soil Acidity and Erosion

(*Modified from Packer, 2002*)

Soil Structure

A simple way to understand soil structure is to think of the terms soil and dirt. Dirt is the end product when you over cultivate and overgraze soil. Dirt has had all or most of the porosity, organic matter and soil biology removed from it.

Soil on the other hand is a living organism with minerals (dirt), soil organisms, organic matter, air and water. The common technical definition of how these aspects are arranged is soil structure - the arrangement of the soil particles (clay, silt, sand, gravel and organic matter) and the arrangement of pores lying between them. These pores are important for the storage and movement of water and air in the soil. It can be quantified by many parameters such as rainfall infiltration/runoff, the degree of surface crusting/sealing, slaking and dispersion, soil strength/friability and soil compaction (bulk density). Good healthy soil can be felt walking across a paddock and has a rich earthy smell.

Soil Nutrients

It is important that soils have the correct balance of the major cations and adequate supply of major and minor nutrients for maximum plant productivity. Although this balance will differ for different species of plants, many soils need addressing to get cations and nutrients into the 'ball-park'. The benefits of improved soil organic nutrients to help achieve this balance should not be underestimated.

Soil Biology

Over-cultivation and overgrazing of soils has severely depleted or altered the soil biology from the undisturbed soil condition. The mass of soil biology is often forgotten when talking about 'biodiversity'. In a healthy soil the mass of the soil biology in the top 10 cm can be more then 5 times the above ground biomass, which would include things such as the animals, trees and grasses. A healthy and diverse soil biology is essential for the break-down of organic products into soil organic matter.

Unfortunately many of our soils are 'biologically dead' from many decades of abuse. This poses a real problem when adopting new farming systems, which are based on the introduction of organic 'food' matter such as stubble and perennial pastures. To encourage the build up of sufficient numbers necessary for rapid and complete breakdown there is a need to adjust our farming systems. This means providing an environment, which addresses the food supply, temperature and moisture environment, and providing protection from the elements and predation.

Acid Soils

pH is a measure of acidity and alkalinity. Acid soils (Table 13) are often leached of many soluble ions and are commonly deficient in major plant nutrients such as calcium, magnesium, nitrogen, phosphorus and molybdenum. Acid soils may also increase the solubility of metals such as aluminium, which are toxic to plants in high concentrations.

<3.7 (extreme)	3.7 - 4.2 (v.strong)	4.3 - 4.7 (strong)	4.8 - 5.2 (medium)	5.3 - 5.7 (slight)

Table 13 Acidity ranges measured in 1:5 pH (0.01mol $CaCl_2$) solution.

Excessive soil alkalinity reduces the availability of some essential plant nutrients such as iron, manganese, copper, cobalt and zinc. Acidity and alkalinity may both result in a reduction of plant growth due to trace element deficiencies and toxicities.

Surface soil acidification hazard is the amount of acid that needs to be added to bring soil pH to critical level. It is now recognised that a soil pH level less than 5.5 in a Calcium Chloride solution ($CaCl_2$) is the critical point where nutrients become limiting and/or toxic to plant growth. To appreciate the changes in availability of nutrients with changes in pH refer to Figure 10. Animal productivity is also limited by extremes in soil acidity/alkalinity because the essential nutrients are not as plentiful in the herbage they eat.

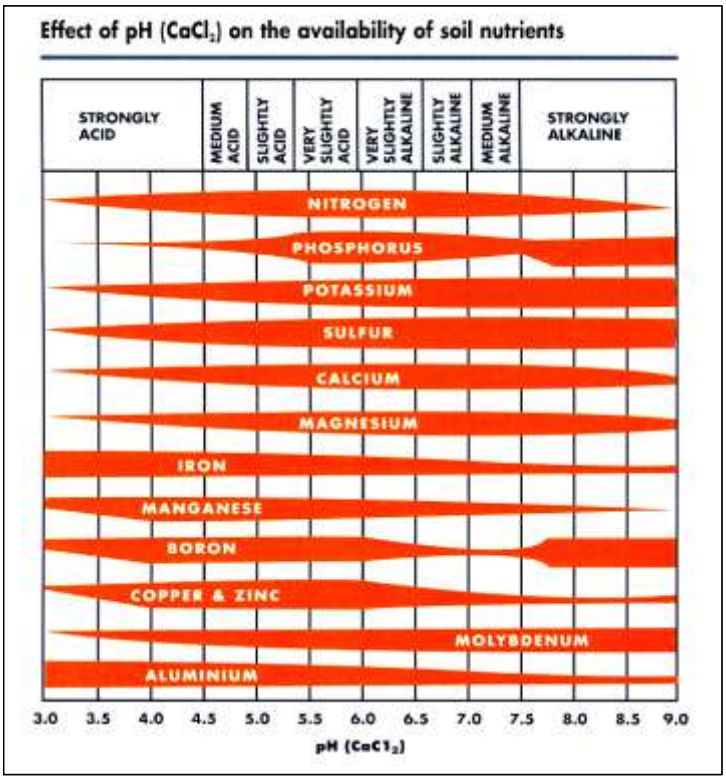


Figure 10 The Availability of Nutrients for Plant Growth as pH ($CaCl_2$) changes

The main problem with agricultural soils in the Catchment is a majority of them have surface soils (0-10 cm) less than pH 5.5 (Figure 11). Recent survey studies have also revealed in old cropping and pasture paddocks, the acidity problem has moved to 20 and 30 cm in the soil profile. Soils have become acidic from the production of excess nitrogen by legume-dominant annual pastures. When this excess is leached in the form of nitrates, the soil is acidified.

Figure 11 also shows the relationship between the pH measured in water and calcium chloride solution. i.e. $pH_{(water)} \times 0.9 = pH_{(CaCl_2)}$. This is a useful relationship when the field pH indicator kits are being used to measure paddock pH

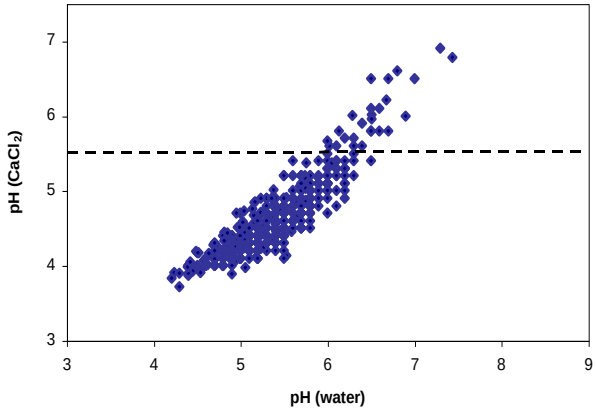


Figure 11. Top soil pH variation in the Catchment

Whilst a majority of these soils are naturally acid. However, past and current land management practices have made acid soils more acid in these areas and many areas of NSW.

Short-term treatment is the correct application of lime and use of perennial, acid-tolerant pasture species. In the long term, production systems, such as balanced perennial grass/legume pastures, need to be developed, I order to use excess nitrogen.

Sodic soils

A sodic soil contains sufficient exchangeable sodium to adversely affect plant growth and soil stability. Many sodic soils are sodic because they have been saline. As the salt leached away some sodium remained attached to cation exchange sites on negatively charged soil particle surfaces. Today the sodium remains and these previously saline soils are still sodic.

Sodic soils are prone to dispersion, are often highly erodable and have low wet bearing strength. Sodic soils are also relatively impermeable to water, reducing productivity and increasing run-off and erosion problems.

When dry, sodic soils are often dense and set hard. As sodic soils collapse when wet, surface seals and crusts often inhibit seedling emergence. Sodic soils are prone to soil structure decline and require careful management

Soil Erosion

Sheet and rill erosion is caused by rainfall runoff and severe wind events (wind erosion). This erosion typically occurs in cropping areas and is often observed in recently cultivated paddocks. It is an indication that soils have land management practices that need to be modified. Conservation farming and grazing practices, such as no tillage and cell grazing play an important role in maintaining groundcover and reducing soil structural damage. Orchards and vineyards can also adopt techniques such as sod culture for erosion protection. Properly designed windbreaks can reduce wind velocities and provide protection to livestock crops and pastures.
Gully and stream bank erosion occurs where runoff and seepage water is concentrated into flowlines. This problem occurs throughout the region and is a result of the same causes for sheet and rill erosion. Another factor exacerbating the problem is the destruction of the natural riparian vegetation in these flowlines and allowing stock access. About 30% of the drainage network in the Catchment shows signs of streambank or gully erosion. The total length of drainage lines is 4,637 km Gully erosion has been recorded on 1,537 **km**.

Where Does the Sediment Come From?

Sediments originate from erosion of hillslopes and from gully and stream bank erosion (channel erosion). The management of these two erosion types differs. It is important to determine which is the dominant source of sedimentation at the paddock/local scale. This allows a targeted approach for management of this issue (see Map 8). Channel erosion is best managed by preventing stock access to streams, protecting vegetation cover in areas prone to channel erosion, revegetating bare banks, and reducing sub-surface seepage in areas with erodible sub-soils. Hillslope erosion is best managed by promoting groundcover, maintaining soil health and structure, and promoting deposition of eroded sediment before it reaches the stream. Engineering solutions, which divert flows from eroding gullies, slow down flow velocities, or protect prone/steep banks, thus reducing erosion may be required in severe situations. Always seek professional advice for the design and construction of such works. (see Who can help)

5.4 Water Quality Decline

Turbidity and nutrients: critical water quality issues

Turbidity and nutrient load, like salinity, are critical water quality issues in Catchment. They are also features of the natural biophysical environment, to which the native flora and fauna are partly adapted. They have become problems because of the uses to which the Catchment has been put since European settlement and because their levels have been significantly increased.

Turbidity

Turbidity is a measure of water clarity and an indicator of the presence of suspended material such as silt and clay, and to a lesser extent, phytoplankton and zooplankton. The very fine clay particles that characterise the soils of much of the Catchment are the main component. Turbidity is a natural phenomenon and has long been a feature of the district, but past and some current land management practices, have exacerbated it. As with salinity, turbidity is strongly influenced by river flows and runoff from the land. Turbidity is measured in NTU (Nephelometric Turbidity Units).

DLWC has a gauging station on the Boorowa River at Prosser's Crossing. The results from the 96/97 data collected for salinity, phosphorous and turbidity is shown in Table 14. It should be noted that the data is only from one gauging station, and it would be preferable to have a number of sites monitored.

Site	EC (µS/cm)	Turbidity (NTU)	Total Phosphorus (mg/L)
Minimum	335	1.7	0.020
10 percentile	335	1,7	0.020
Median	976	4.2	0.035
90 percentile	1455	28	0.073
Maximum	1455	28	0.090
No of samples	9	9	10

Table 14 Water quality Boorowa River at Prosser's Crossing 1996-1997

Turbidity - The water in the Boorowa River at Prosser's Crossing is relatively turbid, with a Median NTU of 4.2 NTU. This is the average for 96/97 and although it is less than the guideline maximum of 10 NTU (ANZECC & ARMCANZ, 2000), it is still quite high. During the recording period a maximum of up to 28 NTU were taken, which is well above the maximum guideline. Erosion due to landuse practices has greatly impacted on turbidity as soil erosion has increased. This increased turbidity is likely to be associated with erosion within the catchment.

Phosphorous – Measurements taken by DLWC taken from the gauging station at Prosser Crossing on the Boorowa River show that the river waters phosphorous levels are relatively low. The average phosphorous content for 96/97 was 0.035 mg/L, which is well below the maximum guideline value of 0.1 mg/L.

Recent baseline water analyses at sites on the Boorowa River and Ryans Creek were undertaken as part of an Urban Stormwater program conducted for the NSW Environmental Protection Agency. General water quality parameters such as temperature, pH, salinity and ammonia, were generally within acceptable ranges for aquatic systems (Boorowa Shire Council 2001). However, nutrient and most microbiological levels exceeded the recommended levels. The water quality data is based on a limited number of samples; further analyses are required to determine more reliable observations.

A major source of sediment, nutrients and faecal (microbiological) contamination in our waterways is derived from stock camps and watering points along creeks and rivers**.** In order to limit erosion and the movement of sediment to the rivers, it is important to maintain a vegetative cover on land and to keep livestock away from riverbanks. Fencing stock out, to reduce traffic on creek and river banks, and providing alternative watering points (troughs, or safe bank access) is a viable solution in most cases. A catchment wide understanding of this issue has lead to an abundance of funding to assist in designing and implementing these types of onground works. Your local Landcare network or the Lachlan CMA should be able to assist in gaining funds for these types of projects.

Water bores Monitoring

A series of water bores have been selected from the registered water bores in the Catchment for annual groundwater elevation monitoring. Both the SWL (Static Water Level) and salinity level are been collected as part of a DIPNR regional monitoring program. Groundwater level monitoring is generally conducted in Feb - March each year. Contact your local LCMA Natural Resource Officer for more information regarding this data. Boorowa Council has been monitoring a number of bores throughout the Boorowa Township every month for several years. Contact Council for more information.

6 BOOROWA CATCHMENT ACTION PLAN

6.1 DRYLAND SALINITY ACTION PLAN

Why Do Anything?

Protect our landscape from further salinisation, to ensure that our farmland remains productive. Minimise the impact salinity has on our natural resource base, and the local community, and communities downstream of our catchment.

What Can We Do?

We need to manage our landscapes in a way that reduces the volume of water reaching the watertable.

How Will We Do It?

The Government has created Catchment Management Authorities, which have delivered Blueprints to assist in targeting actions focused at particular priorities. Dryland Salinity is one of these priorities. The codes you see in italics, in brackets, beside the actions, relate to which Salinity Management Target that action parallels in the Lachlan Catchment Blueprint.

Identify the problem

1. Develop 'user-friendly' tools such a Salt Identification Kit to assist in early recognition of salinity symptoms. *(PA10 and SA37)*
2. Maintain and improve links with expert advisors to assist in ascertaining local causes and developing focused solutions. *(SA04 and PA12)*
3. Target priority areas using current salt mapping technology (Nick Henry DIPNR) and Landholder knowledge (see Dryland Salinity BMP).
4. Identify and map local groundwater systems to assist in identifying likely causes, and apply best relative solutions (See Dryland Salinity BMP). *(SA01)*

Plan a strategic approach to applying Management actions

5. Plan management actions on a sub-catchment scale to ensure continuity of management action application, and to maximise natural resource outcomes. *(PA05 -06)*
6. Plan on-ground works to implement above management actions at the Property Plan Scale. (*PA01 – 04)*
7. Extend Network of Landcare members to fill any gaps in sub-catchment scale management actions.

Implement management actions

8. Manage grazing to promote ground cover and pasture species diversity. This will ensure good groundcover all year, reducing groundwater recharge and erosion. *(SS03, SS04, SA24, SA30).*
9. Replace annual pastures with perennial species, including native species that are well adapted to region.
10. Maintain soil health to enable the establishment and maintenance of pastures. eg: Lime applications to reduce pH. Encourage soil health through maintenance of soil-based biodiversity. *(SS02)*
11. Develop best management practices for the protection and enhancement of remnant vegetation. The planning of these practices should occur at the sub-catchment Scale *(VA10).*

These practices should abide by the conservation ideals presented by NSW National Parks in their report: Native Vegetation of the Boorowa Shire *(VA19 - 20*). Consider the functionality of the remnant in question relative to biodiversity outcomes, and the ability of the vegetation present to reduce recharge. *(VA23 - 24).*

12. Identify areas in which Intercept plantings would assist in discharge reduction. *(SA01).*
13. Plan such plantings at the sub catchment scale to maximise groundwater response as well as providing stock shelter, riparian protection and corridor links with above mentioned remnant vegetation and other existing or planned plantings *(SA08)*
14. Revegetate identified high recharge country.
15. Rehabilitate high priority saline discharge areas by fencing to control stock, revegetate with salt-tolerant pasture and tree species, promote groundcover using fertiliser and gypsum application, mulching and earthworks where necessary. Graze to encourage water use where appropriate. *(SA37, SA38, SA41).*

Promote and educate

15. Promote practices that minimise recharge to groundwater, and reduce salt in streams, in both urban and rural situations by developing educational and awareness raising material/activities. Target audiences should range from School children, (encourage further development of Junior Landcare Groups in our schools), to Landholders and Local Government Members. All stakeholders need to be continually challenged. *(PA08 -PA09)*
16. Encourage and facilitate continued participation of University Students and Post Graduate students in research and mapping projects within the region. *(PA08)*

Monitor

17. Develop Discharge Site and River Monitoring programs. This will enable the measurement of success rates and allow for the evolution/improvement in Management Practices employed. Learn from failures, promote successes, and encourage innovation.

6.1a SALINITY BEST MANAGEMENT PRACTICES

RECHARGE

The strategy you adopt to reduce recharge on your property will depend on the severity of the problem, your resources, the physical characteristics of the site, and most importantly, what system of groundwater flow is operating beneath the surface.

Before you start planning your approach to Recharge management, you should consult an expert (Refer Appendix 1). The strategy you might employ will be some combination of the following management practices:

1. **Pumping Pastures:**
   Maintain pasture cover all year round. Most effective pastures contain a large component of deep-rooted perennial grasses. Manage grazing to benefit the plants that are working for you. Allow time for your pasture to recover between grazing episodes. Encourage (through grazing control) the re-establishment of native perennial pastures that are well adapted to utilising the rainfall zones that they have evolved in.

2. **Multifunction Tree Plantings:**
   Plant deep-rooted trees and shrubs up-slope from the salinity out-break, high enough out of the discharge zone to allow ease of establishment. These plantations may double as shelter belts, fodder, biodiversity links or farm forestry enterprises. Similar (larger) plantings may be useful at the top of the landscape where other forms of farm enterprise are often difficult anyway.

3. Careful Management:
Engage in appropriate management practices. Avoid inefficient irrigation, long fallow periods and cropping practices that could lead to rainwater leaking into the groundwater system. Over-grazing will result in poor plant health, which reduces the pumping ability of the pasture over the entire area.

4. Maintain Good Soil Health:
This is imperative to enable all other aspects of best management practices.

DISCHARGE:

The management for discharge sites revolves around the idea reducing the chance of soil erosion on the affected area. This can be done with a combination of several Best Management Practices.

1. Fence off the Site.

Early stock exclusion will reduce the damage caused by hard hooves and mouths (licking salt crystals). Fences should be placed at least 20 metres from the edge of the affected area (as indicated by salt tolerant species range).

2. Create a Seed Bed

Broadcast Gypsum to improve the soil structure, add calcium, improve drainage and break the surface crust. DO NOT Deep Rip. Organic matter and nutrients can be added in the form of straw mulch, turkey/chicken litter or other fertilisers. Care must be taken to avoid adding fertilisers too "hot".

3. **Plant Salt tolerant Grass species**.
   This should be done with absolute minimal soil disturbance to reduce the risk of erosion. Light harrowing or "Bag dragging" may be used to "open the crust" to allow seed penetration. Seed should be broadcast or direct drilled. Some advances have also been made on the use of tree and shrub species on discharge sites (see salt tolerant species list pg.***..??..***).

4. **Manage and Monitor the Site.**
   Stock access to the site should be limited to when they will do the least damage and when the pasture established can stand crash grazing. Desirable species should be allowed to go to seed. High numbers of stock should be used over a very short time period. This ensures all plants are lightly grazed. It also lays vegetative matter and manure all over the site where it replenishes the biological material in the soil system.
   The site should be monitored for signs of spreading. Placing survey pegs at the outermost physical signs will facilitate this. Piezometers may be utilised to track the rise and fall of groundwater levels more closely.

NB: It should be noted that even a seemingly successful discharge management program is only dealing with a symptom of a much bigger problem. A combination of Recharge and Discharge Best Management Practices need to be employed to truly address the full extent of the problem causing your discharge issue. This often involves cooperation and planning across more than one property. Active Landcare networks should enable this sort of cooperation.

FACT SHEET

WHAT ARE THE SIGNS OF DRYLAND SALINITY?

Even though dryland salinity is a well-known problem, it is sometimes hard to recognise the early signs of salinity until the impact becomes severe. Here are some events that may indicate salinity. If you recognise one or more of these on your property and believe you have a salinity problem, you should seek advice on early action you can take to prevent the problem becoming more severe. (see contacts below). These signs are likely to occur at the bottom of slopes and in drainage depressions and be known as 'discharge' sites.

1. **Waterlogged soil and areas of new wet patches.**
   Waterlogging does not indicate salinity in every case, but is an early warning sign.

2. **Trees dying**
   As the saline groundwater table rises, trees begin to die for no apparent reason, usually before any impact on pastures is evident.

3. **Loss of productive annual and perennial vegetation species**
   As the ground becomes more saline, annual and perennial species die. Often, in their place grow more salt tolerant plants, such as sea barley grass, couch, annual beard grass, spike rush and/or strawberry clover.

4. **Bare patches of soil**
   Bare areas of soil appear and become larger. The soil may also set hard as it dries out. Often referred to as a 'salt scald'.

5. **The area attracts stock**
   Stock love to lick the salt from the ground, and usually gather together around the saline area.

6. **Visible salt crystals**
   When the surface is dry, salt crystals appear on the surface of the soil. It may look like white dust or powder.

7. **Puffy soil**
   When dry, the surface of the soil is "puffy" and shatters when walked on.

8. **Excess water runoff**
   The area is eroding from large quantities of water runoff.

9. **Clear dam water**
   Water in dams close to the site tends to be quite clear as the salt settles the sediment.

10. **A salty smell**
    Salt can be smelt in the area.

Who can help?
Department of Infrastructure, Planning and Natural Resources,
Yass Office. Phone (02) 6226 1433;
Lachlan Catchment Management Authority, Cowra Office. Phone (02) 6341 1600

FACT SHEET

HOW TO MANAGE SALINE DISCHARGE SITES

What is a saline discharge site?

A saline discharge site is an area where the water table has risen and salt has affected vegetation and soil on the surface. Its impact varies, but usually results in

- a reduction in pasture and crop performance,
- bare scalded areas,
- dead trees,
- salt crystallisation and
- excessive erosion.

How do I manage it?

The appropriate way to manage a discharge site will vary depending on the severity of the problem. The main options are below, but also ask the local extension officer from agencies such as the Department of Infrastructure, Planning and Natural Resources office for advice (contact details below).

1. Fence the site

Stock should be kept off the site (they like to lick the salty ground). The fence should be at least 20 metres from the edge of the salt affected area. Vegetation changes will indicate the boundaries of the salt affected site. If the land is flat around the site, the fence should be placed further away as salt is likely to spread.

2. Carry out earthworks

Earthworks are usually needed for more severely affected areas. The type of earthwork will depend on the site, but some options include creating diversion banks to divert the flow of water away from the site, gully control structures, and deep ripping to assist in revegetation.

3. Plant salt tolerant grass species

Grasses, rather than trees, are usually more successful in revegetating saline areas. However, trees are useful in planting above and around the site to contain it. Good grass species include Tall Wheat Grass, Puccinella and Strawberry Clover (see the *Salt Tolerant Species Fact Sheet*).

4. Apply straw mulch, gypsum and fertiliser

Straw mulch protects the bare soil and reduces evaporation. It also protects seed for revegetation and provides organic material. Gypsum improves the soil structure, drainage, adds calcium and breaks the surface crust on bare soil. Fertiliser should also be applied on all saline sites to improve nutrient levels.

5. Manage and monitor the site!

Stock access to the site should be limited to when they will do least damage and when the area can stand some grazing ('crash' grazing method can be used ie high stock numbers for short periods). The site should be monitored for any spreading and any increase in salinity level. Piezometers may be useful to assess and measure the depth of the ground water. Once productive species are established, keep them well grazed so they use as much water as possible.

Who can help?

Department of Infrastructure, Planning and Natural Resources,
Yass Office. Phone (02) 6226 1433;
Lachlan Catchment Management Authority, Cowra Office. Phone (02) 6341 1600

FACT SHEET

HOW TO MANAGE SALINE RECHARGE SITES

What is a saline recharge site?

Recharge areas are the points at which water (rainfall) enters the groundwater table. Recharge occurs in all parts of the landscape except for discharge sites. Highest rates of recharge are usually in the higher parts of slopes or hills and where the vegetation has been cleared or altered.

How do I manage it?

There are many options for managing recharge sites. Your choices will depend on the severity of the problem, how it fits your whole farm plan, your resources (time, money), and the physical characteristics of the site such as access. Some options are to;

1. Revegetate
   Revegetate the area with deep-rooted trees, shrubs and grasses.

2. Establish perennial pastures
   Increase water use on the rest of your property by ensuring growth of deep-rooted perennial grasses and pasture. Ensure you carry out appropriate weed, pest and disease control, as well as fertiliser treatment to maintain good growth. Graze well to maximise water use.

3. Native grasses
   In areas where pasture improvement is not suitable, ensure good growth of native grasses.

4. Engage in appropriate management practices
   Avoid inefficient irrigation, long fallow periods and poor cropping practices in recharge areas.

Further Reading

Dryland Salinity 8. Options for Control DLWC 1994

Who can help?

NSW Department of Agriculture, Yass Office (02) 6226 2199
NSW Department of Infrastructure, Planning and Natural Resources,
Yass Office (02) 6226 1433;
Lachlan Catchment Management Authority, Cowra Office. Phone (02) 6341 1600

PASTURE MANAGEMENT

Pastures are a dynamic system. They include native and introduced species and are subject to grazing, pest and disease attacks, as well as varying inputs, such as rainfall.

The management of pastures to address and prevent dryland salinity means using pastures to increase water use. The choice of pasture must fit the site on-farm taking into account soil type, pH, depth, drainage, degradation or erosion, and enterprise (wool, beef etc).

Seek advice about which option will best suit the different areas on your property.

What can you do?

- Sow pasture species that are suited to the land capability. eg. salt tolerant, acid tolerant.
- Plant pasture species that use more water than annual pasture species, such as lucerne, phalaris, cocksfoot.
- Don't fallow. Recharge is increased if left to long fallow periods.
- Take advantage of extra moisture for opportunity cropping when conditions are appropriate, but make sure the land is able to sustain such activities.
- Use a phase cropping system. Rotate annual crops with perennial pastures for example, after 5-7 years of continuous cropping plant 5-10 years of perennial pastures
- Use the alley cropping method. Plant annual crops in alleys among rows of perennial plants that will provide shelter, increase water use and provide other benefits such as fodder and habitat.
- Ensure existing native and introduced pastures are productive and self-sustaining. It is important to have a significant component of perennial pasture.
- Plant and maintain trees, particularly near grazing pastures.
- Fertilise pastures to maximise growth and therefore water use.

Who can help?
NSW Department of Agriculture, Yass Office (02) 6226 2199

SALT TOLERANT TREE & GRASS SPECIES FOR THE BOOROWA AREA

The tree and shrub species listed below have varying levels of tolerance to salinity. Trees and shrubs generally should not be planted directly into scalded discharge areas (i.e. bare salty patches), but rather on the boundary of the affected area (see also the Fact Sheet; *How to Manage Saline Discharge Areas*). Bare saline sites are best managed by sowing salt tolerant pasture species (listed below).

SALT TOLERANT TREES AND SHRUBS

BOTANICAL NAME	COMMON NAME	SALT TOLERANCE	GENERAL COMMENTS
Acacia longifolia	Sydney golden wattle	slight-moderate	tolerates wet sites, frost tolerant
Acacia mearnsii	Black wattle	Slight (varies with provenance)	fast growing
Acacia melanoxylon	Blackwood	slight-moderate *(varies with provenance)*	tolerant of periodic waterlogging, slow growing
Acacia retinoides	Swamp wattle	moderate-high	tolerant of wet sites with saline sub-soils, frosts
Casuarina glauca	Swamp she-oak	moderate-high (varies with provenance)	tolerates waterlogging, mild-moderate frost tolerance
Eucalyptus aggregata	Black gum	slight	good in wet areas
Eucalyptus camaldulensis	River red gum	moderate (large variation in provenance)	tolerates waterlogging
Eucalyptus camphora	Swamp gum	slight-moderate	good in wet areas
Eucalyptus melliodora	Yellow box	slight-moderate	slow growing
Eucalyptus ovata	Swamp gum	slight	tolerates waterlogging, frost tolerant, slow growing
Melaleuca ericifolia	Swamp tea-tree	moderate	highly frost tolerant

OTHER REVEGETATION SPECIES USEFUL FOR SALINE AREAS

BOTANICAL NAME	COMMON NAME	SALT TOLERANCE
Callistemon citrinus	Crimson bottlebrush	medium salt tolerance
Casuarina obesa	Swamp she-oak	highly salt tolerant tolerates waterlogging & mild frosts
Eucalyptus astringens	Brown mallet	slightly salt tolerant
Eucalyptus botryoides	Bangalay	low-moderate salt tolerance tolerant of waterlogged soils
Eucalyptus leucoxylon	Yellow gum	slight/moderate salt tolerance sub-species variation in tolerance
Eucalyptus robusta	Swamp mahogany	moderately salt tolerant highly tolerant waterlogging
Eucalyptus sideroxylon	Mugga ironbark	slightly salt tolerant
Melaleuca bracteata	River tea-tree	moderately salt tolerant moderately frost tolerant
Melaleuca decussata	Cross-leaf honey myrtle	highly salt tolerant highly frost tolerant

SALT TOLERANT PASTURE MIX

For slightly saline sites - 2-4 dS/m*

COMMON NAME	RATE OF MIX
Australian phalaris	2 kg/ha
Tall wheat grass	4-6 kg/ha
Demeter fescue	4 kg/ha
Trikkala or gosse sub clover	2 kg/ha
Perennial ryegrass	2 kg/ha
Palestine Strawberry clover	1 kg/ha
Paradana Balansa clover	1 kg/ha
Fertiliser - nitrogen and phosphorus mix with sulphur present, eg Starter 15	125 kg/ha

For moderately saline sites - 4-8 dS/m*

COMMON NAME	RATE OF MIX
Australian phalaris	2 kg/ha
Tall wheat grass	4-6 kg/ha
Demeter fescue	4 kg/ha
Puccinellia	2-4 kg/ha
Perennial ryegrass	1-2 kg/ha
Palestine Strawberry clover	2 kg/ha
Paradana Balansa clover	2 kg/ha
Fertiliser - nitrogen and phosphorus mix with sulphur present, eg Starter 15	125 kg/ha

For severely saline sites - 8+ dS/m*

COMMON NAME	RATE OF MIX
Tall wheat grass	6-10 kh/ha
Puccinellia	2 kg/ha
Palestine Strawberry clover	2-3 kg/ha
Fertiliser - nitrogen and phosphorus mix with sulphur present, eg Starter 15	125 kg/ha

* *deci-Siemens per metre*

FURTHER SALINITY READING

Assessing the Texture of Your Soil. Save Our Soils. NSW Agriculture and NSW Department of Infrastructure, Planning and Natural Resources.

Detecting Dryland Salinity on the Southern Tablelands of New South Wales, DIPNR and Salt Action

Dryland Salinity, Salt Action Series, DLWC , 1993, 1994
1. The Causes
2. How Severe is Your Discharge Area
3. Piezometers - How and Why
4. Productive Use of Salt Affected Land
5. Crop Management for Central and Southern NSW
6. The Role of Vegetation Management
7. The Economic Picture
8. Options for Control

Identifying and Treating Dryland Salinity Lachlan Soil Management Guide. NSW Agriculture, NSW Department of Land and Water Conservation & National Landcare Program. Nicholson, A. and Wooldridge, A. (2000)

Dryland Salinity - a land management issue, not a disaster, in Rising Water Tables and Salinity in the Yass River Valley, J.Franklin, DLWC 1999 (pp 31-55)

NSW Salinity Strategy, NSW Department of Infrastructure, Planning and Natural Resources, 2000

Dryland Salinity and its Impact on Rural Industries and the Landscape. Prime Minister's Science, Engineering and Innovation Council, Occasional Paper No 1, Department of Industry, Science and Resources, Canberra 1999

Productive Solutions to Dryland Salinity GRDC Canberra, July 2001.

Trees, Water and Salt: An Australian guide to using trees for healthy catchment and productive farms. Joint Venture Agroforestry Program, Rural Industries Research and Development Corporation 2000.

6.2 NATIVE VEGETATION ACTION PLAN

WHAT WILL WE DO ?

Retain and enhance remnant vegetation and increase the area of native vegetation

WHY WILL WE DO IT?

To maintain and improve ecological health. To protect areas of high conservation value. To ensure sustainable productivity. Native vegetation provides ecological, social and economic benefits. It contributes to biodiversity, protects against land degradation, maintains water quality, acts as a carbon sink, and provides for recreation, natural heritage, and research. It provides fodder, products such as timber and honey, and habitat for beneficial pest predators. It also has important social, economic and cultural values for Aboriginal people.

HOW WILL WE DO IT?

The Government has created Catchment Authorities, which have delivered Blueprints to assist in targeting actions focused at particular priorities. Protecting Native Vegetation and Biodiversity is one of these priorities. The codes you see in italics, in brackets, beside the actions, relate to which Native Vegetation and Biodiversity Management Target that action parallels in the Lachlan Catchment Blueprint.

Identify the problem

1. Identify and target areas of high conservation value and areas of threatened vegetation using The Native Vegetation of the Boorowa Shire (NSW National Parks and Wildlife, 2002), as a guide. (*VA01*)
2. Develop user-friendly kits to help asses the functionality of remnant vegetation. (*VA02*)
3. Seek expert advice to establish local reasons for decline (eg dieback).

Implement management practices

4. Develop a Sub-catchment scale plan to address the issue (*VA10*)
5. Develop and trial new best management practices to improve the functionality of existing vegetation blocks.
6. Communicate Best Management Practices with resource users like firewood collectors, and timber millers. These people should be part of the solution.
7. Identify and communicate with stakeholders with ownership of, or interest in, areas of remnant vegetation, (This will include landholders, resource users, and the wider community), to assist in implementation of best management practices.
8. Implement best management practices for remnants at the farm plan scale. *(VA15, 16 and 19*). This process should be an integral part of farm planning and should be done with the assistance of an accredited person.
9. Encourage the adoption of Voluntary Conservation Agreements or Joint Management Agreements with NPWS.
10. Develop and encourage the use of "chain of custody" approach to seed collection to ensure improvement of endemic gene pool. Establish provenance based plantations for seed collection purposes. (*VA27, VA28 and VA29*).
11. Create an extensive network of vegetation to link revegetation and isolated remnants. These should utilise wide corridors and "stepping stones" of vegetation, maximising the multi-benefits possible through well designed plantings.

12. Promote revegetation of native ecological communities listed as threatened or endangered, through fencing, reducing competition etc.
13. Look for ways of incorporating all tree plantings into Remnant Vegetation Management Practices.

On-ground works

14. Enhance the health of remnants by encouraging natural regeneration and re-introducing a large range of local native understorey plants. (*VA30*)
15. Manage weeds and feral animals. (*VA38*)
16. Selectively retain dead standing and fallen timber for habitat.
17. Fence areas of important native vegetation & manage grazing appropriately.
18. Support more research on germination of native vegetation especially native grasses.
19. Encourage more research into causes of remnant vegetation decline, ecology, and landscape function. Factor results into best management practices. (*VA32 and VA33*)
20. Encourage the continued evaluation of vegetation extent using GIS and Ground-truthing.

Promote and educate

21. Raise awareness of the importance of remnant vegetation. This should occur at and above Primary School level.
22. Encourage local government to actively participate in the protection of high quality vegetation, particularly where it will be affected by development.
23. Identify and Encourage financial rebates or incentive schemes for revegetation works.
24. Develop identification information sheets for native perennial pasture management – grazing techniques, fencing, fires, allowing for seed set.
25. Promote native farm forestry through trial farm forestry sites.

Monitor

26. Develop user friendly protocols to monitor revegetation and remnant management activities to improve techniques, species selection and practices.
27. Utilise GIS technology to review remnant linking and replan approach to reducing remnant isolation.

6.2a NATIVE VEGETATION BEST MANAGEMENT PRACTICE

Manage remnant native vegetation to improve its condition. Incorporate management strategies for these areas in your farm plan. Think about where they will provide the most benefit to your farming system. They might be to provide livestock shade and shelter, protect buildings, prevent groundwater recharge, stabilise stream banks or provide wood production.

How do I do it?

Plan

- Seek professional advice to assist in devising a management plan for your remnant vegetation blocks.

Retain

- Retain large trees, standing/fallen hollows, leaf litter, sticks and understorey vegetation for habitat.

Protect

- Fence native vegetation areas to protect from stock
- Avoid fragmenting existing areas of vegetation by roads or fences.
- Keep a buffer between native vegetation remnants and other intensive land uses

Manage

- Manage grazing to allow regrowth of vegetation. Don't graze in seed setting/flowering, or germination periods.
- Look after existing patches of remnant vegetation to allow natural regeneration
- Use appropriate native species when planting vegetation, particularly in existing vegetation areas.
- Control weeds
- Minimise disturbance of soil and vegetation to maintain ground cover, keep weeds out and allow the understorey plants to establish.
- Reduce chemical and fertiliser drift from adjacent farm activities.

REVEGETATION ESTABLISHMENT

Why should I establish native vegetation ?

Native vegetation provides many environmental benefits to flora and fauna through providing habitat and food sources. However, it also contributes to farm productivity through providing shelter, alternative grazing areas and providing habitat for beneficial pest predators.

What can I do ?

- Use local native species including trees, shrubs and grasses.
- Concentrate on expanding and enhancing existing vegetation remnants.
- Retain existing clumps of remnant vegetation. Where trees already exist it is easier and cheaper to fence them off and encourage regeneration.
- Link shelterbelts together and with existing vegetation to provide additional food, shelter and corridors for wildlife.
- Revegetate along creeks and gullies.
- Include local native understorey plants (shrubs) that flower at different times throughout the year to attract a variety of wildlife.
- Revegetated areas can become a shelter and habitat for pest species. Develop pest animal management plans for these areas and consult local agencies regarding appropriate control measures.
- Consider fencing drainage lines for multi benefits (erosion reduction, biodiversity, and stock shelter).

Who can help ?

- Contact your local Landcare group, Greening Australia or the list of local nurseries for local plant selection.
- Refer to Greening Australia “Green Notes” for plant establishment guidelines.

VEGETATION ESTABLISHMENT TECHNIQUES - TUBESTOCK

Fencing and weed control are vital for successful vegetation establishment

TUBESTOCK

Tubestock are seedlings grown in narrow tubes of between 10-30 cm high and approximately 6-9 months old. They will establish and grow quickly under the right conditions.

When do I plant ?

Plant seedlings in early spring when soil moisture is high. If the soil tends to dry out in late spring, planting in early autumn is suitable. The site should be already ripped (usually best done in summer), along contour lines if planting on a hill. Run the tractor rear tractor wheel over the rip line to minimise channelling. Sites should be sprayed with non residual herbicide at least twice in the preceding autumn and spring.

Where and what do I plant ?

Greening Australia has site specific species lists outlining species suitable for different areas, for example wet or dry areas, stony hills, deep soils, acid and saline soils. See contact details below.

What to remember when planting tubestock

- Water seedlings well before planting.
- Make sure the planting hole is as close as possible in size to the tubestock.
- Break-off any roots sticking out the bottom of the tube before planting.
- Remove the seedling from the tube (holding it upside down) with one knock, trying to minimise damage. Do NOT brake up root ball.
- Ensure the stem of the seedlings is no deeper in the soil than in the tube.
- Leave a small depression around the seedling to allow water to collect.
- Water immediately after planting.
- If mulching, keep mulch away from direct contact with the stem.
- Fence the area to protect seedlings from stock and pest animals.
- Remember to keep free of weeds.
- Blocks of plantings or lanes of at least 20m wide are much more beneficial to the landscape than narrow tree lanes.
-

It is best to plant close to existing patches of vegetation than in an open location.

VEGETATION ESTABLISHMENT TECHNIQUES - DIRECT SEEDING

Direct seeding is where seed is directly drilled into the ground. It is significantly cheaper than planting tubestock, and takes a lot less time. Historically, it is slightly less successful than planting tubestock. Greening Australia will do direct seeding on a contract basis, or a direct seeding machine can be hired from the Boorowa Regional Catchment Committee.

When do I plant?

It is recommended that herbicide applications up to 12 months before planting are necessary to reduce competition from weeds and grasses, and to build up soil moisture. Spring is the best time to carry out direct seeding. Fence the area before planting.

Where and what do I plant?

See Greening Australia or Boorowa Landcare for site-specific species recommendations (contacts below). A seed mix of 30-40 species is recommended with seeding rates of 0.5 to 1kg per hectare or 200 to 400 grams per kilometre of tree line. Seed can be bought or collected from nearby remnant vegetation.

Pre-Seeding Weed Control

Experience in the Boorowa area has shown that the major cause of poor results from direct seeding is excessive weed and grass competition. Surface scalping (restricted to the non-erodable soils) and chemical control are the preferred options. Ploughing is not recommended for machine planting, unless done well in advance of seeding, and often has the effect of increasing the weed & grass competition.

Chemical control generally involves strip (1 to 1.5m wide) spraying of tree lines up to 12 months ahead of seeding with a knockdown herbicide. Repeat about 6 months later (depending upon seasonal conditions) to remove new weed and pasture germination and ensure maximum moisture retention in the soil. Bear in mind that 1 hectare is equivalent to about 7 kms of a 1.5 m wide strip. Finally respray immediately prior to seeding.

Many residual herbicides can seriously effect tree seed germination and should be avoided. Sites with particular weed problems may need to be treated with specific herbicides.

All herbicide applications should be accompanied by treatment for red legged earth mite. Try using either LeMat or Saboteur in the early sprays and one of the endosulfan-based compounds (up to 140 days residual effect) in the final spray or immediately before seeding.

Grasses between sprayed tree lines are available for grazing (subject to the pesticide conditions of use) and if possible should not be let go to seed during the spray programme. The grassed areas play an important role in controlling downslope water movement during heavy rain and in saline areas, minimise groundwater recharge.

Soil Preparation

The seeds of most native tree and shrub species best germinate on or just below the soil surface. Machine seeding generally requires no soil preparation. Ripping is not necessary on most sites to be machine seeded (undesirable in recharge areas) and there is some evidence that ripped sites, if not graded or rolled well ahead of seeding, result in substantial seed loss, poor germination and development of inferior

seedling root systems. Heavy clay based soils with high water tables, little organic matter and poor structure may need some preparation.

Fencing
Most direct seed sites are intended as permanent belts or blocks of vegetation. Fences generally need to be permanent and stock proof. If rabbits or hares are a problem, netting or adequate electric fencing may need to be considered. Light grazing or overnight off-shears yarding is often possible after 3-4 years.

Species Selection/Seed Supply
Direct seeding provides the opportunity to establish a mix of tree and shrub species. A variety of suitably selected species will ensure a satisfactory germination regardless of seasonal conditions.

As a general rule, the species occurring naturally in the remnant vegetation on the property or nearby provide the best chance for successful direct seeding. To this mix might be added small quantities of specific purpose out-of-area species seed to cater for problem areas or specific objectives ie: salt tolerance, fast growth, bird & insect habitat etc.

Nearby vegetation provides the preferred source of seed can be collected and stored progressively ahead of seeding. Commercial suppliers may also be able to provide locally collected seed. The cost of seed can be a major component of project expenditure at $60-80 per km, depending on species.

At the present time the recommended seeding rates for machine direct seeding in Southern NSW range from 0.5 to 1 kg per hectare or 200 to 400 grams per kilometre of tree line. The seed of some trees and shrubs will need to be treated to break dormancy, i.e. wattle seeds need to be soaked in boiling water. At time of seeding it may be necessary to add ant repellent to the seed mix.

Time of Sowing
The technique of direct seeding seeks to emulate the natural vegetation processes while increasing the chances of success by seeding when conditions are optimal, i.e.

~ when temperatures are sufficient for germination,
~ when moisture conditions are sufficient for germination,
~ when competition for light and moisture are minimal,
~ when there is a reasonable growing period ahead of summer or winter dormancy.

Past experience with direct seeding in the Boorowa Catchment suggests that the optimal window for seeding is from Early September to Late October. The above conditions should be taken into consideration before deciding when to sow.

Post Seeding Maintenance
It is important that the young seedlings be maintained in an environment free of weed and grass competition allowing them to make maximum use of available moisture and light. Grasses and weeds adjacent to tree lines can be controlled by use of a shielded herbicide spray, or herbicide wick wiper. If grasses and weeds look like becoming a problem take early action, ideally within 3-4 months of germination of the tree seeds. When trees/shrubs are well established, weed control becomes less important.

Spring - Year 1: Strip spray future tree lines to remove existing pasture competing, treat for red legged earth mite.
Autumn – Year 2: Respray tree lines with non residual herbicide to remove weed and pasture regrowth and conserve maximum winter rainfall.
Spring – Year 2: Final spray of tree lines ahead of seeding, treat for red legged earth mite.
Summer – Year 2: Check for weeds and apply shielded herbicide spray if necessary, check for earth mites and grasshoppers.

For further information

Greenotes, Greening Australia ACT & SE NSW PO Box 538, Jamison Centre, ACT 2614 ph (02) 6253 3035 fax (02) 6253 3145 email gaact@netinfo.com.au

- Greenotes #5 Collecting Australian Native Tree Seed
- Greenotes #6 Propagating Australian Native Trees

Who can help ?

Greening Australia ACT & SE phone (02) 6253 3035
DIPNR, Yass phone (02) 6226 1433
The Southern Tablelands Farm Forestry Network, 0412 195 499

FACT SHEET

RECOMMENDED SPECIES FOR UNDERSTOREY REVEGETATION (RED GUM / YELLOW BOX WOODLANDS)

The following species are readily available and are reliable for direct seeding

Scientific Name	Common Name	Preferred Habitat	Description*	Flowering
Acacia buxifolia	Box-leaf Wattle	acid, skeletal, rocky outcrops	**S**, shrub 1-2m	Aug-Oct
Acacia brownii	Juniper Wattle	poorly drained sandy soils	prickly shrub 0.5-2m	Mar-Sept
Acacia cultriformis				
Acacia dealbata	Silver Wattle	dry, acid skeletal soils	**S**, tree 2-7m	July-Oct
Acacia decora	Western Silver Wattle	dry rocky outcrops, red loams	rounded, spreading shrub 1-4m	Aug-Sept
Acacia genistifolia	Spreading Wattle	dry, shallow soils	**S**, shrub 1-2m	May-Oct
Acacia implexa	Lightwood	sandy, shallow, dry	**S**, small tree 5-15m	Dec-Mar
Acacia lanigera	Woolly Wattle	shallow, rocky/quartz slopes	shrub 1-2m	Winter to Spring
Acacia melanoxylon	Blackwood	prefers deeper soils	**S**, small-large tree 6-30m	Aug-Oct
Acacia paradoxa	Hedge Wattle	dry, shallow soils	**S**, small, spreading shrub 2-4m	Aug-Nov
Acacia rubida	Red Stem Wattle	dry soils	**S**, shrub-small tree 2-10m	Aug-Oct
Acacia verniciflua	Varnish Watltle	sandy, shallow, rocky soils	**S**, shrub 1-4m	July-Nov
Acacia vestita	Hairy Wattle	dry hillsides	spreading shrub 1-4m	Aug-Oct
Bursaria lasiophylla	Bursaria	dry	**S**, shrub to small tree1-8m	Nov-Feb
Bothriochloa macra			**S**,	
Bursaria spinosa	Bursaria	dry sites, gullies	**S**, shrub	Nov-Feb
Cassinia aculeata	Common Cassinia (Dogwood)	sandy, clay	**SC**, shrub 2-3m	Nov-Feb
Chionocloa pallida	Redanther Wallaby Grass		**DS**,	
Dodonaea viscosa subsp. viscosa	Giant Hop-bush	clay, sandy	**S**, tall shrub 1-6m	Sept-Mar
Eucalyptus blakelyi	Blakely's Red Gum	dry, well drained	**S**, tree 10-24m	Aug-Sept
Eucalyptus bridgesiana	Apple Box	clay	**S**, tree 8-25m	Jan-Mar
Scientific Name	**Common Name**	**Preferred Habitat**	**Description***	**Flowering**

Eucalyptus melliodora	Yellow Box	wet/poorly drained	**S**, tree 12-30m	Sept-Feb
Gompholobium hueglii	Giant Wedge Pea	poor sandstone soils	**S**, shrub 1-3m	Aug-Nov
Hakea sericea	Bushy Needlewood	hill country, within scrub	shrub 2-5m	May-Sept
Hardenbergia violacea			**S**,	
Hovea heterophylla			**S**,	
Hovea lineraris			**S**,	
Indigofera australis	Austral Indigo	poor shallow soils	**S**, shrub 0.5-2m	Aug-Sept
Juncus species	Rush		**SD**,	
Kunzea ericoides	Burgan	clay, sandy, wet/poor drained	**S**,	Nov-Feb
Kunzea parvifolia	Violet Kunzea	rocky slopes	**S**, shrub 0.5-2.5m	Oct-Dec
Leptospermum juniperum	Prickly Tea-Tree	poorly drained soil	prickly shrub 1-4m	Oct-Mar
Leptospermum lanigerum	Woolly Tea-Tree	along streams, swampy flats	shrub to small tree 2-6m	Sept-Dec
Leptospermum multicaule	Silver Tea-tree	dry hills	**SC**, shrub 0.5-2m	Spring
Melaleuca ericifolia	Melaleuca	poorly drained, swamps stream flats	shrub-small tree 2-9m	Oct-Nov
Melichrus urceolatus				
Microlaena stipoides	Weeping Grass	tolerant of low soil pH	S, small-med. perennial	Nov-Feb
Vittadinia spp.			**S**,	

Developed with the assistance of Rainer Rehwinkel (NPWS) and John Weatherstone

** Method of Propagation: **S** - seed, **C** - cutting, **D** - Division*

SUPPLEMENTARY LIST for UNDERSTOREY REVEGETATION

The following species are suitable for understorey revegetation, but may be more difficult to obtain

Scientific Name	Common Name	Preferred Habitat	Description*	Flowering
Acacia gunii	Ploughshare Wattle		**S**, small shrub	Late Winter
Aristrida ramosa	Purple Wiregrass	sandy	**S**,med.-large tussock grass	Dec-Feb
Brachyloma daphnoides	Daphne Heath	poor, dry, rocky or sandy hills	small, heathy shrub, to 1m	Aug-Sept
Bracteantha viscosa	Sticky Everlasting		**S**, perennial forb 80cm	
Bulbine bulbosa	Bulbine Lily	rocky sites	**S**, perinnial 40cm	Oct-Dec
Calytrix tetragona	Common Fringe-myrtle	rocky, sandy or gravelly sites	**S**, heathy shrub 1-2m+	Sept-Dec

Scientific Name	Common Name	Preferred Habitat	Description*	Flowering
Carex appressa	Tall Sedge	wet sites, above creeks	**D**, perinnial, 40-120cm	
Cassinia longifolia	Shiny Cassinia (Cauliflower Bush)	dry, shallow	**SC**, shrub 1-3.5m	Dec-Mar
Cassinia quinquefaria	Cassinia		**SC**, shrub 1-3m	Jan-Mar
Cheiranthera linearis	Finger Flower		shrub to 30cm	
Chrysoccephalum apiculatem	Common Everlasting (Yellow Buttons)		**SDC**, upright/creeping perinnial 7-60cm	Late Winter-Spring
Cryptandra amara	Bitter Cryptandra		heathy shrub -35cm	
Cymbopogon refractus	Barbed Wire Grass		**S**,	
Danthonia spp.			**S**,	
Daviesia species	Pea	dry rocky or sandy sites	**S**, shrubs 0.5-2m	Aug-Dec
Dianella spp.	Flax Lily		**SD**, tufted perinnial -80cm	Nov -Feb
Dichantheum sericeum	QLD Bluegrass		**S**,	
Dillwynia sericea			**S**,	
Epacris spp.	Heaths	near swamps, streams	small heath 0.5-2m	various
Exocarpus cupressiformis	Cherry Ballart	shallow soils	small tree 3-8m	Dec-May
Exocarpus strictus	Pale-fruit Ballart		shrub 1-2.5m	Aug-Nov
Glycine clandestina	Twining Glycine		**S**, creeping pereinnial	
Gonocarpus tetragynus	Common Raspwort		**S**, perennial -35cm	Sept - Feb
Grevillea alpina	Cat's Claw	stoney, sandy ground	shrub to 2.5m	July-Sept
Grevillea juniperina	Prickly Grevillea	sand or rock near rivers	**SC**, prickly shrub 1-2.5m	Oct-Jan
Grevillea lanigera	Woolly Grevillea	sandy, rocky sites	**SC**, shrub 1-2m	Aug-Dec
Haloragis heteophylla	Swamp Raspwort	wet, drainage lines	**C**, sparse perennial 20cm	Summer
Helichrysum thyrsoideum	Sticky Everlasting	rocky highland sites	shrub 1-2m	Nov-Feb
Hibbertia obtusifolia	Grey Guinea Flower		**SC**,	
Isotoma fluviatilis	Swamp Isotome	wet, drainage lines	**CD**	Nov-Feb
Leucochrysum albicans	Hoary Sunray		**S**,	Sept-Feb

Scientific Name	Common Name	Preferred Habitat	Description*	Flowering
Lissanthe strigosa	Peach Heath	rocky ground	**S**, shrub -1m	
Melaleuca armillaris	Giant Honey-myrtle	sands, granite outcrops	large shrub-tree 2-14m	Nov-Feb
Poa species	Poa		**D**	
Pomaderris angustifolia	Pomaderris	near streams	dense shrub 1-3m	Oct
Pomaderris betulina	Birch Pomaderris	near streams	shrub 1-3m	Oct
Pultenaea foliosa, procumbens or subspicata	Bush Peas	dry	**SC**, low shrub -2m	Spring
Sorghum leiocladum	Wild Sorghum		**S**,	Dec-Feb
Stipa species	Grass		**SD**,	

Developed with the assistance of Rainer Rehwinkel (NPWS) and John Weatherstone

** Method of Propagation: **S** - seed, **C** - cutting, **D** - Division*

NATIVE SEED COLLECTION

Why should you collect native seed?

The cost of seed is a major part of the cost of revegetation projects. Collecting your own seed keeps costs down, and also ensures the best source of seed from local species suited to local conditions.

How do you collect seed?

- Seeds of native plants are usually found in a pod, woody capsule or cone. The seed is ready to be collected as the seed matures (usually December-January).

  For eg wattles and the pea flower family in our region produce pods that open as they mature and can be picked when they are brown and just starting to open.

- Collect the seeds in calico bags, pillowslips or cardboard boxes.

- Dry them in a warm dry place on a sheet or newspaper until seed has been shed. This may take anywhere between a few days to several weeks.

  Banksia cones and Hakea fruits may need to be put in a very slow over for an hour or more to encourage them to open up and release their seed.

- Store the dried seed in jars in a cool place away from sunlight.

REMEMBER!

! Only collect seed from healthy trees and shrubs that have minimal insect damage and healthy leaves and foliage.

! Choose seed from a site that has several healthy specimens of the desired species.

! Never collect seed from a single remnant tree.

! Collect seed from different parent trees of the same species within a distance of 100 metres apart. This will ensure a good genetic diversity.

! Take the smallest branches possible to reduce parent tree damage.

Who can help?
DIPNR Yass, (02) 6226 1433
John Weatherstone, "Lyndfield Park Nursery" (02) 4845 1282

FACT SHEET

NATIVE PLANT PROPAGATION

How do I treat the seed before sowing?

- Wattle seed: Boil 6 times the volume of water relative to the volume of seed. Add seed to boiling water after turning off heat (but while still boiling).
- Allow standing for at least 3-4 hours, or overnight.
- Use the seed immediately or after drying (dry seed is easier to handle than wet seed).

  If drying, lay out seed on hessian, shade cloth etc until dry.

What type of soil mix should I use?

The basic soil mix includes coarse river sand, loam and peat, used in equal proportions. A small amount of slow release pelleted fertiliser with a low phosphorus content can be mixed in with the soil.

How should I sow the seedlings?

- Ensure the soil mix is moist (not wet).
- Make a small depression in soil and drop in seeds (4-6 seeds each for small seeds such as eucalyptus, 2-4 seeds for acacias and other large seeds).
- Large seeds should be covered with 3-5 mm layer of the soils mix and watered gently.
- Smaller seeds should be covered with a thin layer of coarse, washed river sand and gently sprayed with water. Try not to move the seeds and sand when watering.

How do I take care of the seedlings?

- Keep the seedlings moist, but not wet.
- Keep them in open sun or part shade with good air circulation to prevent fungal disease.
- Leave all seedlings to grow until they develop their second set of leaves. Then select the healthiest - one per tube - and cut the rest off at soil level.
- To 'harden off' seedlings, place them in full sun and water less frequently 3-4 weeks before planting. These seedlings can be planted when 10 cm tall. Otherwise, wait until they are about 25-30 cm tall, and then plant.

Who can help?
Yass Landcare Office C/- DIPNR Yass, (02) 6226 1433
John Weatherstone, “Lyndfield Park Nursery” (02) 4845 1282

FACT SHEET

GRAZING MANAGEMENT IN NATIVE VEGETATION

Why should I manage grazing in areas of native vegetation?

Unmanaged grazing in areas of native vegetation does not allow regeneration of native plants. It can also result in high levels of damage to plants, introduction of weeds, and soil compaction. However, grazing does not have to be completely stopped.

How do I manage grazing?

These strategies will depend on the condition of the native vegetation.

FENCES
To control grazing access, native vegetation needs to be fenced.

TIMING
Avoid grazing during flowering and seeding of native plants, usually between September and January. Avoid stocking during significant regeneration events, such as rainfall during seeding.

DURATION
Control the length of time stock are left to graze. For highly degraded areas, crash-grazing (high stock rate over a short period) is effective in reducing weed cover to allow natural seed regeneration.

STOCKING RATE
The best method is varying stocking rates.

Who can help?
NSW Department of Primary Industries, Yass Office (02) 6226 2199

REVEGETATING AREAS AFFECTED BY DIEBACK IN BLAKELY'S REDGUM

What is dieback?

Dieback refers to the thinning of a tree's crown or canopy. In Red Gum, this is due to the removal of foliage by intense insect attack. It ultimately results in the death of the tree due to a lack of enough leaf area to photosynthesise.

Extensive dieback can affect;

- soil structure
- watertable levels
- salinity
- loss of shelter
- flora & fauna biodiversity
- landscape

Dieback in Red Gum is primarily caused by psyllid (lerp) attack. Research suggests the main causes of lerp infestations are loss of predators, a reduction in the number of trees in the landscape through clearing, and a weakening of the vigour of the tree due to stress.

Lerps !

Psyllids (lerps) are 1-2mm long, feed on sap and can fly long distances. They shelter beneath a white, fan shaped covering or cocoon called a "lerp" attached to leaves. They feed by injecting toxin into the leaf causing the leaf to die. They breed three to four times a year with eggs hatching after one to two weeks. The newly-hatched psyllids immediately commence feeding.

Reducing the impact of dieback

Revegetation is the most effective way to reduce the impact of dieback caused by insect attack. Revegetation will reduce stress on the tress and attract natural predators of the insects.

Things you can do

- fence trees (mature trees in clumps of 5 - 10) from stock to encourage revegetation
- encourage a diverse understorey including indigenous grasses, wildflowers, shrubs and trees which provide shelter for predatory fauna.
- choose plants with a range of flowering times
- choose a range of plant shapes & sizes to attract diversity of birds & insects
- monitor the revegetation areas for evidence of a range of birds & insects, their preferred plants and changes in the conditions of trees.

Who can help?

NSW Department of Infrastructure, Planning and Natural Resources, Yass Office (02) 6226 1433

6.3 SOIL MANAGEMENT ACTION PLAN

Why Do Anything?

Our soil is the most valuable asset a landholder can own. It underpins almost every enterprise a landholder may be involved with. Improving and maintaining good soil health will increase the efficiency and future sustainability of agricultural enterprises, whilst reducing the extent of land degradation, thus improving the health of the Catchment.

What Can We Do?

Adopt improved management practices, improve our knowledge of the soil types, structure and health of our soils, monitor changes in soil health.

How Will We Do It?

Below is an action plan to help identify the actions required to improve soils in the Boorowa Catchment. The Lachlan Catchment Management Authorities Blue Print also lists soil health as one of the Lachlans key issues. The codes you see in italics, in brackets, beside the actions, relate to where the LCMAs Soils Management Actions parallel our actions.

Identify the problem

1. Continued Investigation into soil acidity and sodicity in our catchment *(SS07, SS20) SS06).*
2. Identify Perennial Pasture Species suited to our soil types and climate. *(SS01).*
3. Identify Landholders using conventional farming techniques or farming country above Land Capability Designation.

Plan a strategic Approach to Implement Management Action

4. Plan an approach which address the above problems. Include in this plan possible sources of funding etc.

Implement management actions

5. Raise awareness through a newsletter and Newspaper Column.
6. Assist Landholders in the purchase/acquisition of soil test kits. These could be part of a Landcare Members "Start-up kit". Ensure adequate training in kit use is available.
7. Promote the use of soil ameliorants as a "Quick Fix" for soil chemistry imbalances. The main emphasis should be on changed management approaches to maintain soil health. *(SS08).*
8. Encourage liming of soils with pH below 4.8 $CaCl_2$
9. Encourage increased perenniality in pastures, managed to maintain soil health (see best management practices below). *(SS03)*
10. Encourage the acceptance and use of native perennial grasses which are well adapted to low pH, and climatic conditions *(SS06)*
11. Encourage, through field days, demonstrations and presentations, the uptake of Reduced Till and No Till techniques, including Stubble Management. This should include machinery conversion techniques as well as management changes required for implementation of these systems, tailored to the soil type, landscape and enterprise. *(SS17, SS15, SS13, SS26).*
12. Utilize the Landcare Network to create an environment where Landholders discuss issues,

problems and solutions, and encourage innovation.

13. Provide support through advice and information on how to manage acidic and/or sodic soils. *(SS21).*

Promote and educate

14. Engage educators capable of teaching landholders about their soil, subsidise attendance costs for landholders.
15. Promote the uptake of Best Management Practices for soil management outcomes (See below). This should include training landholders who are moving towards No Till systems in the management actions/techniques that are required within such systems. (eg: chemical weed/pest control cycles)
16. Advertise, using the network, funding opportunities which help in any aspect of this action plan.
17. Promote soil testing prior to addition of ameliorants, and ensure, through training, that Landholders understand results and management implications.

Monitor

18. Continued monitoring of soil parameters by landholders, to track changes in soil health. Make results available to other landholders. Use good and bad examples in future promotions.

6.3a SOIL MANAGEMENT BEST MANAGEMENT PRACTICES

The approaches you take in order to maintain good soil health will depend greatly on your soil type/types on your property. It is this factor that should determine what enterprise(s) you can undertake.

Education.
It is very important to understand the soil types, where they change, and what capabilities each soil has on your property. Equip yourself with the knowledge and tools required to monitor your soils physical, biological and chemical state.

Utilise professional soil testing, but use your understanding of the figures to analyse the results.

Fencing.
It can be very useful to fence your property according to changes in soil type. This will allow you to manage each soil type to best suite its health.

Grazing.
Manage your grazing enterprise to encourage an increase in perennial ground cover. The more species (whether introduced or native the better) Aim for 80-100% groundcover at all times with a legume content of no more than 30%.

Use ameliorants such as lime if your pH is below 4.8. and gypsum to improve poorly structured (sodic) soils. Base your rates on professionally analysed soil test results.

Use minimal till or no till techniques to replace degraded pastures. Implement a grazing system which enables long term (10+ year) maintenance of these pastures. This may involve High intensity, short duration grazing with long rest periods.

Cropping.
Reduce tillage of soils to a minimum. This may require the purchase of new, or conversion of existing equipment to minimal or no till.

Retain stubble to reduce wind and water erosion, and to retain biological matter. There is equipment available that can assist in knocking down stubble to aid in assimilation. As your soil health improves, stubble will break down faster, adding valuable carbon to the system.

Understand the use of chemical weed and pest control used within these systems. Keep burning to a minimum. Avoid mechanical weed control (ie: ploughing or scalping).

Reduce the area affected by compaction under wheeled equipment by employing tramline, or GPS technology, use “light-footed” equipment where possible.

Understand the varying crop moisture and nutrient needs, within paddocks, to reduce fertiliser waste, which contributes to pH imbalance through leaching. This may require close crop inspection or technology such as that used in Precision Farming techniques.

6.4 WATER MANAGEMENT ACTION PLAN

Why Do Anything?

The large-scale landscape changes mentioned to this point will take a long time implement. To minimise the impact of current landscape condition, on our water resources, we need to implement "quick fix" solutions to protect our waterways. We need to prevent loss of productive farmland. We need to minimise sediment, salt and chemical content in our waterways. We need to maintain flows and water quality in our creek and river systems to benefit riparian and aquatic habitat functionality, as well as considering downstream users.

What Can We Do?

We can manage the drainage lines, creeks and rivers on our properties, to reduce the risk of soil eroding into our waterways. We can manage areas higher in the landscape to reduce the contribution of salt, sediment and pollutants entering our waterways. We can address the issue of bed lowering and bank destabilisation through our management actions.

How Will We Do It?

We will maintain and manage all existing riparian vegetation. We will target areas at high risk of erosion. We will manage them according to the best management practices listed.

(codes in *brackets* indicate Matching Blueprint Actions)

Identify the problem

1. Use mapped extent of Gully Erosion, combined with local knowledge, to target areas of high priority. (*WA06 - 08*)
2. Seek expert advice on the severity of the problem and possible local causes. (*WA14*)
3. Explore options including Engineering solutions, Vegetation Management and Water Sharing to address identified priority areas. (*WA09*)
4. Utilise existing modelling and ground truthing experiments to establish water use efficiency regimes of different land uses to help assess impacts on flow regimes. (*WA01, 02*)

Plan a strategic approach to applying Management Actions

5. Plan management actions on a sub-catchment-scale to ensure continuity of management action application, and to maximise natural resource outcomes.
6. Plan on-ground works to implement management actions at the Property Plan Scale.
7. Develop best management practices for the establishment and management of buffer zones near stream banks. *(WA10)*

Implement management practices

8. Manage stock access to protect areas of identified stream bank erosion, eg: large mobs grazing for short periods to maximise ground cover and plant health. *(WA22)*
9. Change practices to include buffer zones near stream banks.
10. Utilise well managed perennial pasture to maintain cover in buffer zones. *(WA11)*
11. Encourage zoning of appropriate stream bank areas for public use, access and environmental benefit. (*WA27, 28, 29*)
12. Use 'environmentally-friendly' chemicals near waterways, and ensure other chemicals do not enter the stream bank zone.
13. Utilise erosion control works and establish areas of native vegetation in severely eroding riparian zones. *(WA09)*

On-ground works

14. Where the need arises, fence off sections of stream bank that have potential for, or are showing signs of erosion due to stock movement. Exclude stock until stability is achieved. Careful use of stock as buffer management tool. It may be necessary to provide alternative watering points for stock. (*WA15*)
15. Remove weeds such as Cumbungi, Crack willows or Black willows from streambeds if they are diverting flow into the banks, creating erosion. Departmental approval is required for such activities (see who can help)
16. Improve stream bank vegetation cover and biodiversity. (*WA15*)
17. Undertake structural earthworks on severely eroding banks. (WA07).
18. Control Vermin.
19. Control carp populations through participation in regional actions.

Promote and educate

19. Develop information kit/guidelines for landholders.
20. Utilise Water Watch to encourage Junior Landcare participation and learning.
21. Utilise demonstration sites.
22. Encourage voluntary agreements such as land retirement, management agreements and covenants for stream bank areas.

Monitor

23. Establish regular assessment and mapping of stream bank conditions (building on existing GIS data).
24. Monitor riparian and aquatic ecosystems to ascertain health and ecological functionality. Develop Macroinvertebrate monitoring program (utilise Junior Landcare) to monitor change and the impacts of management practices.
25. Utilise Rapid Bio-assessment Techniques for Aquatic Habitat/Ecology Monitoring
26. Monitor downstream sediment loads to test impact of actions taken.

6.4a Water Management Best Management Practices

What is Gully Erosion ?

Gully erosion is the loss of soil along water channels caused by water and/or wind. It is caused by continuous cropping, overstocking or clearing leading to vegetation decline along water channels and erosion.

Why do we need to fix it ?

Sediment transported by gullies causes problems in watercourses, farm dams and water storages. It also causes management problems on-farm such as access across or around the gully, danger to livestock and a decrease in farm water quality.

What can you do?

- Improve grazing/cropping management practices to control erosion
- Reduce grazing pressure to allow for regeneration
- Fence off pockets of remnant native vegetation near gullies to use as seed producers
- Divert water from the gullies to allow stabilisation (structural earthworks)
- Revegetate gullies using native species appropriate for the local area.
- Reduce siltation and sediment build up in streams
- Arrest active gully erosion
  (headward advancement or deepening)

What is the stream bank zone ?

The stream bank zone is the area adjoining a waterway including the vegetation on both the banks up to 30 metres from the waterway channel.

Why do we need to manage it ?

- to maintain good water quality
- to prevent erosion
- to maintain aquatic habitat
- to provide a wildlife corridor

What can I do ?

There are a number of things you can do to improve the sustainability and health of the stream bank. As a first step, the stream bank zone should be managed to allow controlled access of stock and to assist regeneration and weed control.

- willow control
- weed control
- revegetation, and

- structural works.

Facts sheets on each of these activities are attached.

Some general principles :

- don't build structures on, or close to a stream bank, leave a buffer zone
- don't remove trees, shrubs or grasses from the stream bank (unless noxious weeds)
- only allow stock watering points on gently sloping banks, and ensure erosion control measures are in place, eg paved ramp etc.
- don't allow excessive build-up of debris in the stream which can divert the stream flow
- access ramps to the stream should only be built on the inside of bends
- never excavate a stream without getting advice and permission !

!!! Remember: any works undertaken on a stream, creek or river may require a permit or permission from one or more agencies - ask for advice!!!
Call The Lachlan CMA 63411600

REPAIRING GULLY EROSION

Before you begin repair works, consider the characteristics of each gully. What is its size (length, depth, width), soil type, the size of the catchment, and the amount of runoff. These will dictate which option you might undertake to repair the gully. The following options are suitable for small to large gullies

Fencing - In most cases fencing out the gully will assist in stabilisation of the gully sides and allow vegetation to establish. It is also important to keep stock from the gully, particularly if it is eroding.

Gully diversion and shape - Water is diverted away from gully head to a safe disposal area via a diversion bank on low grade. The gully below the bank can then be shaped and revegetated. This is a good option for small to medium gullies. It allows gullies to become productive providing topsoil is stockpiled and spread back over the site after the gully is reshaped.

Rock Flume – provides a more stable base. Rock should be placed on filter fabric so that water flows over it and not around the sides. This is a cheap alternative to concrete, however, they should not be designed for large or prolonged volumes of runoff.

Concrete Flume – forms a long life stable structure for highly active gullies where there are high volumes of water. These need to be properly designed and constructed. Contact DLWC for advice.

Dam -This can be built above the gully to stop the water flowing over the gully head or can be built in the gully with top water level drowning the active head. Storm water can be diverted away from the gully, or contained in the dam and released into the gully slowly over time through a trickle pipe.

Low Cost Wire Weirs - For gullies where earthworks are impractical or uneconomic, such as large gullies, or where the gully head is off the property, other measures can be taken. Gully bed and gully wall stabilization can be undertaken with low cost wire weirs. These are built from a combination of steel posts, reinforcing mesh, wire netting, concrete blocks, etc. They catch sediment, reducing the grade on the gully floor. This slows water down decreasing its erosive force.

Revegetation - Trees, shrubs and grasses assist in gully control in several ways. They; hold soil together with roots, dry out wet areas, protect the soil surface, and act as silt and debris traps.

Future Management - The fill area and water entry points to the creek/stream should be fenced out (at least temporarily) and de-stocked for a minimum of 12 months to allow establishment of ground cover. After this time the site may be brought back into production to a limited extent. Grazing should be undertaken on a rotational or crash grazing basis with the emphasis being on maintaining at least 70% ground cover, and not grazing grasses lower than 4.5 cm in height.

Once works are complete they need to be looked after to increase their life span. Overgrazing and stock tracks can erode the works, reducing their effectiveness.

Who can help?

Department of Land and Water Conservation, Yass (02) 6226 1433

FACT SHEET

SUITABLE SPECIES FOR REVEGETATING GULLIES

Good vegetation coverage is very effective in providing long-term gully stability. The combined root systems of trees, shrubs and grasses bind together cobbles, gravel, sand and soil.

TOE

The area where the gully floor and side walls meet (the toe), is the most susceptible part of a gully to erosion. Stabilisation requires the establishment of a good cover of vegetation. Some good species to use include;

COMMON NAME	SCIENTIFIC NAME	REVEGETATION INFORMATION
Alpine Bottlebrush	***Callistemon pityoides***	Prefers periodically wet ground near swamps and watercourses
Broad-leaf Cumbungi	***Typha orientalis***	
Common Reed*	***Phragmites australis***	Likes damp to saturated soil and will also grow in deep brackish water. Is commonly seen growing along stream banks in the region, very useful at stabilising stream banks and undercuts, and can tolerate deep shade
Common Rush	***Juncus usitatus***	Will grow in shallow water as well as the bank because it likes damp to well saturated soil
Cumbungi*	***Typha spp.***	Grows on damp or saturated soils, usually in stationary or slow flowering water up to two metres deep, has the potential to blanket areas of slow moving water
Purple Loosestrife	***Lythrum salicaria***	damp mud or wet sand, perennial herb to 1.5m, dies back in winter, re-shoots from crown
Red Stem Wattle*	***Acacia rubida***	dry, alluvial soils, including steep well drained banks
Rice Sedge	***Cyperus difformis***	poorly drained soils, grass-like perennial tussock, to 2m
River Clubrush	***Schoenoplectus validus***	damp or saturated soils, perennial to 3m, survives periodic wet, prevents erosion
River Tea Tree	***Leptospernum obovatum***	sandy, gravelly sites and rock outcrops, excellent for protecting stream banks,
Rushes	***Juncus spp.***	damp or saturated soils, perennial to 1m, survives periodic wet conditions
Silver Wattle	***Acacia dealbata***	dry sites, frost and drought hardy, vigorous spreading and anchoring root system, regenerates easily by seed and suckering
Spiny Headed Mat Rush	***Lomandra longifolia***	height to 80cm, dense, fibrous root system
Tussock Sedge **Tassle Sedge** **Tufted Sedge**	***Carex appressa*** ***Carex fascicularis*** ***Carex gaudichaudiana***	Sedges: generally grow in poorly drained soils along streams and wetlands, copes with periodic wet and dry conditions. Tassle and Tufted Sedge: perennial tussocks, helps prevent erosion

BANK FACE

Shrubs and grasses are generally best for revegetation of banks. Many of the following species can also be planted as River Corridor Species.

COMMON NAME	SCIENTIFIC NAME	REVEGETATION INFORMATION
Australian Anchor Plant	***Discaria pubescens***	near streams, shrub 1-2m
Bertya	***Bertya rosmarinifolia***	prefers near streams, height 1-2m
Blackthorn	***Bursaria lasiophylla***	thorny shrub, grows readily along river, creeks and gullies, wide spreading root system that binds the soil effectively, 2-4m
Box Micranteum	***Micrantheum hexandrum***	rocky sites near streams, shrub 2-4m
Burgan	***Kunzea ericoides***	near streams, shrub 2-4m, may invade cleared country
Cauliflower Bush	***Cassinia longifolia***	shallow soils, shrub 1-3.5m
Common Cassinia	***Cassinia aculeata***	shrub 1.3-5m
Common Fringe-myrtle	***Calytrix tetragona***	rocky, gravelly soils and sand, shrub 1-2m
Crimson Bottlebrush	***Callistemon citrinus***	damp, sandy flats and near swamps, shrub 1-3m
Dagger Wattle	***Acacia siculiformis***	prefers sandy or rocky soils, very hardy
Giant Hop-Bush	***Dodonaea viscoasa* subsp. *spatulata***	rocky outcrops, dry sandy soils, shrub to 6m
Hemp Bush	***Gynatrix pulchella***	near streams, shrub 2-4m,
Long-leaf Lomatia	***Lomatia myricoides***	Will grow on poorer soils, along creeks and gullies, shrub 2-5m, intolerant of high phosphorus alluvial sites
Narrow-leaf Bitter Pea	***Daviesia mimosoides***	various soils, shrub to 2m, hardy, useful for poor open sites, regenerates quickly after fire
Narrow-leaf Hopbush	***Dodonea viscosa* subsp. *angustissima***	rocky outcrops, dry sandy soils, shrub 1-4m
Ovens Wattle	***Acacia pravissima***	common near streams and on damp sheltered sites, shrub to small tree 3-8m
Prickly Grevillea	***Grevillea juniperina***	sand or rock near rivers, creeks, shrub 1-2.5m, suitable for low phosphorus soils
Poa Tussocks* (Tussock Grass)	***Poa sieveriana, Poa labillarbiera***	perennial, prefers dry, alluvial soils on stream banks and low-lying sites, unpalatable for stock
Pomaderris species	***Pomaderris andromedifolia, angustifolia, subcapita, aspera, eriocephala, betulina***	in scrub, usually near streams, shrub 1-4m
River She-Oak	***Casuarina cunninghamiana***	along streams, roots bind banks
River Tea-Tree	***Leptospermum obovatum***	sandy, alluvial soils and rocky outcrops, periodically wet sites along watercourses, shrub 2-3m, excellent for streambank protection, thinning may be

		in riverbed
Slender Tea-Tree	***Leptospermum brevipes***	near streams, damp or rocky sites, shrub 2-4m
Small-fruited Hakea	***Hakea microcarpa***	rocky soils, next to watercourses and swamps, shrub to 2m, not tolerant of phosphorus, therefore no suited to rich, alluvial soils
Swamp Paperbark	***Melaleuca ericifolia***	poorly drained soils, swamps and stream flats
Swamp Tea-Tree	***Leptospermum myrtifolium***	periodically wet soils, near streams, swamps and soaks, shrub 1-2.5m, may invade cleared, wet areas
Tussock Grass	***Poa labillardieri***	grows readily along stream banks, unpalatable for stock
Woolly Grevillea	***Grevillea lanigera***	Small shrub, grows readily in lighter soils along watercourses, well draining sandy or rocky soils with clay subsoil, will regenerate naturally during good seasons, soil with low phosphorus content
Woolly Tea-Tree	***Leptospermum lanigerum***	wet, sandy or alluvial soils and rocky sites, shrub 2-6m

Who can help?

Lachlan Catchment Management Authority (02) 63411600

FURTHER REFERENCES

Rizvi, S.A and Crouch R.J. *Gully Stabilisation: 20 Promising Native Species*. CaLM Technical Paper 2, Department of Conservation and Land Management, Sydney, 1993.

IMPORTANT THINGS TO KNOW ABOUT REPAIRING GULLIES

❖ Active gullies take priority.

While filling a stable gully is possible, it is a low priority as there is no environmental benefit compared to treating an actively eroding gully.

❖ Design and Construct Earthworks.

Have all earthworks designed and construction to Council/DIPNR standards. In the site plan allowance should be made for vehicular access so that heavy trucks do not create an erosion problem.

❖ Catchment Size >25 ha.

Catchments above 25 ha can periodically yield large volumes of water, which is difficult to control. Any works would require a detailed design to cater for appropriate storm events (ie. 20 year return period).

❖ Catchment Size 15 – 25 ha.

Jobs should be designed and approved by Council and DIPNR.

❖ Catchment Size <15 ha.

Below 15 ha catchment, DIPNR minimum standards is recommended and no further design is usually necessary.

❖ Suitable Dam Site.

A site is suitable for a dam if the site is flat <5% and/or in a minor gully or flow line where there is suitable earth material for dam construction (ie. clay).

What is a

Diversion Bank? A bank constructed by a dozer or grader, which is designed to safely divert runoff water from one point to another.

Flume? A stable area which allows water to flow into the bottom of a gully without causing erosion.

Bank and Pipe? A diversion bank with a pipe (usually 150-mm poly pipe) to cater for flows from minor run-off events or from spring flows, which protects the outlet from eroding.

Who can help?
Yass Office C/- DIPNR (02) 6226 1433

7 REFERENCES

ANZECC & ARMCANZ (2000). *The Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy Paper No 4, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra (*http://www.ea.gov.au/water/quality/nwqms/index.html*)

ANZECC & ARMCANZ (2000b). *Australian guidelines for water quality monitoring and reportin*g. National Water Quality Management Strategy Paper No 7, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra. (*http://www.ea.gov.au/water/quality/nwqms/index.html*)

Arrow, M and Woodlands, K. (2000) *Preventing and Treating Soil Erosion - Lachlan Soil Management Guide*. NSW Agriculture, NSW Department of Land and Water Conservation & National Landcare Program.

Australian Heritage Commission (1999) *Protecting Local Heritage Places, A Guide for Communities.*

Baldwin B, Marsh D and Gilchrist K (undated) *Managing Dryland Salinity at Boorowa – A Landcare Case Study*. Orange Agricultural College, University of Sydney.

Beavis S. and Beavis F.C. (1996) *Hydrogeological report – Narrallen Creek Catchment*. A report to the Breakfast Creek Landcare Group. 35pp.

Boorowa Shire Council (2001) *Urban Stormwater Management Plan*. A report to NSW Environment Protection Authority.

Butler, B. (2000a) *The Central Lachlan Catchment, an Overview - Lachlan Soil Management Guide*. NSW Agriculture, NSW Department of Land and Water Conservation & National Landcare Program.

Butler, B. (2000b) *Managing Soil Structure - Lachlan Soil Management Guide*. NSW Agriculture, NSW Department of Land and Water Conservation & National Landcare Program.

Brown N. (1997) *Binalong Landcare Report*. NSW Department of Land and Water Conservation, 51 pp.

Clark R. (1995) Catchment Planning – the Boorowa experience. *Murray-Darling 1995 Workshop: Groundwater and the Community*. Australian Geological Survey Organisation Wagga Wagga, 70-73.

Coram J.E., Dyson P.R., and Evans W.R. (2001) An Evaluation Framework for Dryland Salinity. Report by Bureau of Rural Sciences for National Land and Water Resources Audit, Canberra. *(http://www.affa.gov.au/corporate_docs/publications/pdf/rural_science/Evalframeworkrep.pdf)*

Cosgrove N. and White J., (2002) *Yass Area Catchment Action Plan*. Yass Area Network of Landcare Groups, Yass.

Cox S. and Goldney D. (1997) *Boorowa Shire Koala Survey*, Environmental Studies Unit, Charles Sturt University, Bathurst.

Cramsie J.N., Pogson D.J. and Baker, C.J. (1978) Geology of the Yass 1:100,000 Sheet 8628. *Geological Survey of New South Wales, Sydney*, 85 pp.

Curlewis A. (1994) *Breakfast Creek Landcare Group Catchment Plan*. A report to the Breakfast Creek Landcare Group. 30pp.

Department of Land and Water Conservation (DLWC) (1999) *Stressed Rivers Assessment Report - Lachlan Catchment*, NSW Department of Land and Water Conservation

EcoGIS (2001) *Vegetation classification and modelling of pre-European and extant vegetation in the Boorowa Shire*. Prepared for the NSW National Parks & Wildlife Service Conservation and Planning Division, Southern Directorate. 11pp *(http://www.nationalparks.nsw.gov.au/PDFs/sbs_nss_scope_brwa_methods.pdf)*

Emery K.A. (undated) *Rural Land Capability Mapping*. Soil Conservation Service of NSW.

Evans W.R. (1994) Regional salt balances and implications for dryland salinity management. In *Proceedings of the Water Down Under 94, 25th Congress of IAH, Adelaide*. Institution of Engineers, Australia Conference Publication 94/10, 349-354.

Evans W.R. (1995a) Do we really know how dryland catchments work? In *Murray-Darling 1995 Workshop: Groundwater and the Community*. Environmental Geoscience and Groundwater Division, AGSO, Wagga Wagga, 93-96.

Evans W.R. (1995b) Begalia Catchment dryland salinity study. *NSW Department of Water Resources, Technical Services Division Report* TS.95.005, 50pp.

Evans W.R. (1998) What does Boorowa tell us? Salt stores and groundwater dynamics in a dryland salinity environment. In *Groundwater: sustainable solutions, Proceedings of the IAH International Groundwater Conference,* (Eds. T.R. Weaver and C.R. Lawrence) University of Melbourne, Melbourne, 8-13 February, 267-274.

Evans W.R. and Bradd J. (2001) *Dryland salinity hazard Boorowa River Catchment*. A report to the Boorowa River Catchment Committee, 29pp. NSW Department of Land and Water Conservation Hydrology Unit, Parramatta.

Eyles R.J. (1977) Changes in drainage networks since 1920, Southern Tablelands NSW. *Australian Geographer* 13, 377-386.

Franklin J. (1999) Dryland salinity – a land management issue not a disaster. In *Rising water tables and salinity in the Yass River Valley* (Ed J.O. Langtry) Murrumbidgee Landcare Association, Yass, 21 March, 31-56.

Freudenberger D. (2001) *Bush for the birds: biodiversity enhancement guidelines for the Saltshaker Project, Boorowa, NSW*. Consultancy report to Greening Australia ACT & SE NSW, Inc. CSIRO Sustainable Ecosystems, Canberra. 48 pp. (*http://www.cse.csiro.au/research/Program2/SAND/Resources/Saltshaker.pdf*)

Freudenberger D., Harvy J. and Drew A. (2003) *A assessment of the potential biodiversity benefits of the Saltshaker Project, Boorowa, NSW*. Consultancy report to Greening Australia ACT & SE NSW, Inc. CSIRO Sustainable Ecosystems, Canberra. 64 pp.

Gammie N. (1999) *Salinity strategy for the Lachlan River Catchment*. Report for the Lachlan Catchment Management Committee.

Gibbons P. and Boak M. (in press). *The role of paddock trees for regional conservation in the agricultural landscape.* Ecological Management and Restoration.

Hassall & Associates (1999) *Weddin Catchment Action Plan*. Weddin Landcare Steering Committee, Grenfell NSW.

Hassall & Associates (2003) *Standards and guidelines for sub-catchment and property plans*. Lachlan / Macquarie Landcare Executive Committee (LMLEC) and the Department of Land and Water Conservation (DLWC). February 2003.

Hayman G. (1996)a, *Implementation of the Boorowa River Salinity Catchment Plan. Final Report Project No. LA0022.93, December (1993) – June (1996)*. A report to the Boorowa Community Landcare Group Inc.

Hibberd J. and Taws N. (1993) The Long Paddock Revisited 15 Years on: A Comparative Study of the Condition and Use of Travelling Stock Reserves in the Southern Tablelands 1977-1993. Unpublished report for the Nature Conservation Council

Hill C. (1996) *Economic evaluation of tree planting and perennial pastures, Boorowa River Catchment area.* A report to the Boorowa Community Landcare Group Inc. 18pp. NSW Department of Land and Water Conservation, Economic Services, Parramatta.

Hird C. (1991) Soil landscapes of the Goulburn 1:250,000 Sheet. *Soil Conservation Service of NSW, Sydney.*

Hook R.A. (1992) Rapid appraisal techniques for dryland salinity. Pilot study: Upper Lachlan Catchment. *NSW Department of Conservation and Land Management*, 146 pp.

Hughes A.O. and Prosser I.P. (2003) Gully and Riverbank Erosion Mapping for the Murray-Darling Basin. *CSIRO Technical Report 3/03, CSIRO Land and Water, Canberra*. 20pp. *(http://www.clw.csiro.au/publications/technical2003/tr3-03.pdf)*

Ivey ATP and Wilson Land Mangement Services (2000) *Cost of land degradation in the Boorowa River Catchment and downstream*. A report to the Boorowa Regional Catchment Committee Inc. 96 pp.

Jackson-Nakano A. (2002) The Pajong and the Wallabalooa: a history from the records of Aboriginal farming families at Blakney and Pudman Creeks, 1820-1945, and historical overview 1945-2002. *Aboriginal History Monograph* 9, ANU Canberra, 214 pp.

Johnston A.J., Pogson D.J., Thomas O.D., Watkins J.J. and Glen R.A. (2001) Boorowa 1:100 000 Geological Sheet 8629, Provisional First Edition. *Geological Survey of New South Wales, Orange.*

Jenkins, J. (1997) *Implementation of the Boorowa River Salinity Catchment Plan – Stage 2. Final Report Project No. LA0144.94, June (1994) – June 1997*. A report to the Boorowa Community Landcare Group Inc.

Joyce A., McAuliffe T.F. (1993) Upper Lachlan Salinity Study- Stage 1 Report. *NSW Department of Water Resources, Lachlan Region Report No*. LR93/8.

Lachlan Catchment Management Board (2003) *Integrated Catchment Management Plan for the Lachlan Catchment 2002*. February 2003. *(http://www.dlwc.nsw.gov.au/care/cmb/blueprints/pdf/lachlan_blueprint.pdf)*

Langford P. Robert (2003) "*Boorowa Regional Catchment Committee GIS Metadata*".

Lloyd, H.V. (1990) *Boorowa: over 160 years of white settlement*.Toveloam Panania.

Lu H.,. Moran C.J, Prosser I.P., Raupach M.R., Olley J., and Petheram C., (2003) Sheet and Rill Erosion and Sediment Delivery to Streams: A Basin Wide Estimation at hillslope to Medium Catchment Scale. *CSIRO Technical Report 15/03, CSIRO Land and Water, Canberra*. 20pp. *(http://www.clw.csiro.au/publications/technical2003/tr15-03.pdf)*

Massey C. (1998) *An assessment of riverine corridor health in the Lachlan Catchment, New South Wales*. Lachlan Catchment Committee, July, 1998.

McGowen I. (personal communication) NSW Department of Agriculture – Orange.

Moore C. and Joyce A. (1998) *Upper Lachlan Salinity Study- Stage 2 Report.* Department of Land and Water Conservation, Central West Region, Forbes.

Moore C.L. (1998) Dryland salinity in the Frogmore area, NSW: geological control on buffering and migration of saline water. *Geological Society of Australia Abstracts* 49, 321.

Muller R. and Lennox G. (1999) Review of groundwater trends in the Lachlan Valley, upstream of Lake Cargelligo. *NSW Department of Land and Water Conservation*, CW GWS 99/1, 46 pp.

Murray-Darling Basin Ministerial Council (2001) *Integrated Catchment Management in the Murray-Darling Basin 2001-2010. Delivering a sustainable future*. Murray-Darling Basin Ministerial Council, Canberra.

Narayan K.A., Vink R and Henschke C.J. (1996) Groundwater modelling to predict the impact of management scenarios for two dryland salinity catchments, S.A. *CSIRO Division of Water Resources Report* 96/3.

Newham L.T.H. (1999) The use of remote sensing and geographic information systems in Landcare resource assessment and planning. BSc (Hons) thesis, Australian National University, Canberra.

Newham L. and Field J. (1999) *Boorowa land cover mapping project*. Final report to the Boorowa River Catchment Committee. ANU Department of Forestry. 59pp.

NHMRC/ARMCANZ (1996) *Australian Drinking Water Guidelines*. National Health and Medical Research Council / Agriculture and Resources Management Council of Australia and New Zealand, Canberra. *(http://www.health.gov.au/nhmrc/publications/pdf/eh19.pdf)*

Nichols C. and Scown J. (1993) Dryland salinity in the Yass River Catchment – processes and management. *NSW Department of Conservation and Land Management*.

Nicholson, A. and Woolridge, A. (2000) *Identifying and Treating Dryland Salinity- Lachlan Soil Management Guide*. NSW Agriculture, NSW Department of Land and Water Conservation & National Landcare Program.

NLWRA, (2001) Australian dryland salinity assessment (2000) *National Land and Water Resources Audit, National Heritage Trust, Canberra.* 129 pp.

NSW Agriculture (2000) *The Grazier's Guide to Pastures – Sowing and managing profitable pastures in the Central and Southern Tablelands, Monaro and Upper South West Slopes of New South Wales*. NSW Agriculture, Dubbo and Orange.

Packer I. (2002) *Save our soils and stop salinity.* Department of Land and Water Conservation, Cowra.

Parker P. (2000) *Identifying and Managing Soil Acidity - Lachlan Soil Management Guide*. NSW Agriculture, NSW Department of Land and Water Conservation & National Landcare Program.

Parsons W.T. and Cuthbertson E.G. (1992) *Noxious Weeds of Australia.* Inkata Press, Australia.

Priday S., Mulvaney M., Gellie N. and Hudson K. (2002) *The Native Vegetation of Boorowa Shire*. NSW National Parks & Wildlife Service, Hurstville NSW. *(http://www.nationalparks.nsw.gov.au/PDFs/sbs_nss_scope_boorowa.pdf)*

Powell J. (1992) *Dryland salinity control in the Boorowa River Catchment*. Results of a Salt Action project by the Boorowa Community Landcare Group and the Rye Park Landcare Group (December, 1992).

Ratchford A. and Leah Moore C. (2002) Regolith influence on surficial water chemistry at Hovells Creek, Central West NSW: Dryland salinity hazard mitigation in high-relief granitic landscapes. In *Regolith and Landforms in Eastern Australia* (Ed I.C. Roach) CRC LEME, 102-106.

Salas G. and Smithson A. (2002) Groundwater levels and trends in fractured rock areas of the Middle and Upper Macquarie Catchment, Central New South Wales, Australia. In *Balancing the Groundwater Budget, Proceedings of the IAH International Groundwater Conference*, Darwin, 12-17 May, Abstract.

Schumann B. (personal communication) NSW Department of Agriculture – Queanbeyan.

Scott D. (1991) Rapid appraisal techniques for dryland salinity, Upper Lachlan Catchment - Hydrogeology and surface water hydrology. *NSW Department of Water Resources, Technical Services Division Report* TS.91.040.

Semple W.S. and Williams B.G. (2002) Saline seepage scalds. *Natural Resource Management* 5, 13-21.

Simpson P. and Langford C. (1996) *Managing high rainfall native pastures on a whole farm basis*. NSW Agriculture.

Sly, R. (1998) *Cowra District Land and Water Action Plan*. A report for the Cowra District Landcare Steering Committee Inc. Cowra. Unpublished.

Sticpewich A. (2000) *Upper Lachlan Regional Action Plan*. A report for the Upper Lachlan Catchment Coordinating Committee.

Stirzaker R., Vertessy R. and Sarre A. (2002) *Trees, water and salt: an Australian guide to using trees for healthy catchments and productive farms*. Joint Venture Agroforestry Program and Rural Industries Research and Development Corporation

Thomas V., Gellie N. and Harrison T (2000) *Forest ecosystem classification and mapping for the Southern CRA region*. NSW National Parks and Wildlife Service Southern Directorate for the NSW CRA/RFA Steering Committee March 2000.

Tuckson M. (1993) Bore surveys, piezometers and monitoring. Determining the part played by groundwater in dryland salinity and waterlogging. *NSW Department of Water Resources Technical Report* 93/11, 3TR345, August 1993.

Vase J., Barnett P., Beale G., Dawes W., Evans R., Tuteja N.K., Murphy B., Geeves G. and Miller M (in press) Modeling the effects of landuse on water and salt delivery from a catchment affected by dryland salinity. *Hydrological Processes.*

Walden C. (1995) Results of a pH and salinity of some deep drill hole cores from the Boorowa and Rye Park districts, NSW. NSW Department of Water, Land & Conservation, Yass, unpublished report.

Walker G., Gilfedder M. and Williams J. (1999) Effectiveness of current farming systems in the control of dryland salinity. *CSIRO Land and Water, Canberra* 16 pp.

Wasson R.J., Mazari R.K., Starr B. & Clifton G. (1998) The recent history of erosion and sedimentation on the Southern Tablelands of south-eastern Australia: sediment flux dominated by channel incision. *Geomorphology*, 24 (4), 291-308.

Williamson, D.R., Gates. G.W.B., Robinson, G., Linke, G.K., Seker, M.P. and Evans, W.R. (1997) Salt Trends; Historic Trend in Salt Concentration and Saltload of Stream Flow in the Murray-Darling Drainage Division. *Murray Darling Basin Commission Dryland Technical Report 1, Canberra*

Wooldridge A.C. (1999) Dryland salinity – we are all in this together. In *Rising water tables and salinity in the Yass River Valley* (Ed J.O. Langtry) Murrumbidgee Landcare Association, Yass, 21 March, 31-56.

Wooldridge A.C. (personal communication) Salinity Investigations Officer, DLWC – Cowra.

Yates C.J. and Hobbs R. J. (1997) Temperate eucalypt woodlands: a review of their status, processes threatening their persistence and techniques for restoration. *Australian Journal of Botany*, 45, 949-973.

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APPENDIX 2 NOXIOUS WEEDS

Category	Action for Control (Under the Noxious Weeds Act 1993)
W1	*Weeds 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.*
W4g	*Shall not be sold, propagated or knowingly distributed*
W4f	*Shall not be sold, propagated or knowingly distributed. Any biological control or other control program directed by a local control authority must be implemented.*

SOURCE: Southern Slopes Noxious Plants Authority, 2003

Common Name	**Botanical Name**	**Category**
Alligator Weed	*Alternanthera philoxeroides*	W1
Black Knapweed	*Centaurea nigra*	W1
Hawkweed	*Hieracium spp.*	W1
Horsetail	*Equisetum spp.*	W1
Karoo Thorn	*Acacia karoo*	W1
Kochia	*Kochia scoparia*	W1
Lagarosiphon	*Lagarosiphon major*	W1
Miconia	*Miconia spp.*	W1
Parthenium weed	*Parthenium hysterophorus*	W1
Salvinia	*Salvinia molesta*	W1
Senegal Tea Plant	*Gymnocoronis spilanthoides*	W1
Siam Weed	*Chromolaena odorata*	W1
Spotted Knapweed	*Centaurea maculosa*	W1
Water Hyacinth	*Eichhornia crassipes*	W1
Water Lettuce	*Pistia stratiotes*	W1
African Boxthorn	*Lycium ferocissimum*	W2
African Love Grass	*Eragrostis curvula*	W2
Blackberry	*Rubus fruticosus (agg. spp.)*	W2
Buffalo Burr	*Solanum rostratum*	W2
Columbus Grass	*Sorghum x almum*	W2
Devil's Claw (Purple flower)	*Proboscidea louisianica*	W2
Devil's Claw (Yellow flower)	*Ibicella lutea*	W2
Dodder	*Cuscuta campestris*	W2
Fireweed	*Senecio madagascariensis*	W2
Galvanised Burr	*Sclerolaena birchii*	W2
Green Cestrum	*Cestrum parqui*	W2
Horehound	*Marrubium vulgare*	W2
Johnson Grass	*Sorghum halepense*	W2
Longstyle Feather Grass	*Pennisetum villosum*	W2
Nodding Thistle	*Carduus nutans*	W2
Opium Poppy	*Papaver sominiferum*	W2
Pampas Grass	*Cortaderia spp.*	W2

Common Name	Botanical Name	Category
Rhus Tree	*Toxicodendron succedanium*	W2
Scotch/English Broom	*Cytisus scoparius*	W2
Silverleaf Nightshade	*Solanum elaeagnifolium*	W2
Spiny Burrgrass	*Cenchrus incertus C. longispinus*	W2
Sweet Briar	*Rosa rubiginosa*	W2
Wild Raddish	*Raphanus raphanistrum*	W2
Bathurst, Noogoora, Californian & Cockle Burrs	*Xanthium spp.*	W3
Scotch/Illyrian/Stemless Thistle	*Onopordum spp.*	W3
Serrated Tussock	*Nassella trichotoma*	W3
St John's Wort	*Hypericum perforatum*	W3
Patterson's Curse, Vipers Bugloss	*Echium spp.*	W3
Sifton Bush	*Cassinia arcuata*	W3
Harrisia cactus	*Harrisia spp.*	W4f
Prickly Pears	*Opuntia spp.*	W4f
Cabomba spp.	*Cabomba*	W4g
Willows	*Salix spp.*	W4g

Noxious Weeds in the Boorowa Area Catchment (Southern Slopes Noxious Plants Authority)

MAPS.

These Maps were produced by Rob Langford and David Hilhorst
with data acquired from several sources as indicated on each map.
Our thanks to these organisations for enabling the creation of these planning/monitoring tools.

All themes/layers present on these maps are available in a digital form. As well as satellite images and many other themes/layers as represented in the "*Boorowa Regional Catchment Committee* GIS Metadata". (Robert P. Langford 2003). These layers/images can be viewed on the Landcare computer (65 Court Street Boorowa) or arrangements can be made through the Lachlan CMA Officer (63851018), to bring this tool to Landcare Group Planning meetings on a lap top/data projector.

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