QUESTION 3

Roadmap

What are the impacts and costs of dryland salinity?

- **Why is this question important?**
- **What did we know in 1998?**
  - NDSP Phase I (1993–1998)
    - Assessing the causes, impacts, costs and management of dryland salinity (Page 52)
    - Understanding dryland salinity (Page 52)
- **What advances have we made since?**
  - NLWRA (1997–2002)
    - Identifying the broad-scale impacts (Page 53)
    - Appraising infrastructure assets under threat (Page 53)
  - Current & future costs
    - Costing the impacts of dryland salinity (Page 54)
    - Communicating information on impacts and costs (Page 59)
    - Evaluating cropping regions of Australia (Page 60)
  - Ecosystem responses
    - Assessing aquatic biodiversity loss (Page 61)
    - Rising water table impacts on remnant vegetation (Page 61)
    - Investigating vegetation recruitment impacts (Page 62)
  - Cost sharing
    - Distributing the costs (Page 62)
    - Accounting for ecosystem services (Page 63)
- **Where to from here?**

What are the current and predicted impacts and costs of dryland salinity?

WHY IS THIS QUESTION IMPORTANT?

Dryland salinity has ecological, economic, social and cultural impacts and costs. Understanding the breadth of these impacts and costs, and how they may change through time, is needed to inform investment priorities and on-ground actions. Information on the ecological, economic, social and cultural dimensions of dryland salinity impacts and costs is needed at different scales to inform decision-making at different levels — National, State, regional, catchment, sub-catchment and property.

Foregone agricultural production was thought to be the main impact and cost of dryland salinity throughout the 1980s, together with declining river health from rising salt concentrations. The extent to which salinity impacted on in-stream, wetland and riparian health and on terrestrial ecosystems, particularly remnant vegetation stands, was not fully appreciated.

A realisation that the off-farm impacts on and costs to individuals, rural communities and the nation exceeded on-farm lost agricultural production emerged in the mid-1990s. These impacts include damage to rural and regional assets such as roads, railways, bridges and culverts, and damage to urban assets such as street paving and guttering, parks and gardens, and domestic and commercial buildings.

Quantitative and qualitative data on the impacts and their associated costs is important for informing the community and policy-makers about the scope of dryland salinity issues. The information can be used to encourage more strategic investment in salinity management, taking into account their salinity-related impact costs. It could also be expected to improve collaboration between farming and urban communities in working together to address salinity; and bring authorities with an interest in infrastructure and environment together to more holistically address the dryland salinity problem.

WHAT DID WE KNOW IN 1998?

Understanding dryland salinity [1] explains that in 1994 a long-term project was initiated to develop a method to estimate the full range of dryland salinity impact costs across the Murray–Darling Basin. In particular, the method needed to enable comparison of salinity impact costs on agriculture with off-farm costs on rural and regional infrastructure, urban infrastructure, and cultural heritage and the environment.

Chapter 4 of *Assessing the causes, impacts, costs and management of dryland salinity* [2] — 'What are the costs of dryland salinity in my catchment and who bears them?' — reported on the progress of this work and described the research activities to follow. While the case study information on the Loddon-Campaspe (Victoria)[3] and Upper South-East (South Australia)[4] catchments presented remains relevant, much of this chapter has been superseded by more recent work. Descriptions of the types of impacts and costs are valid, however reports discussed here provide more up-to-date information. This is especially so for the costs figures stated, with the national cost of dryland salinity of $270 million (including environmental costs) calculated in 1998 now estimated at $305 million for the Murray–Darling Basin alone (excluding environmental and cultural heritage costs).

WHAT ADVANCES HAVE WE MADE SINCE?

3.1 National Land & Water Resources Audit (1997–2002)

3.1.1 Identifying the broad-scale impacts

Assessments of dryland salinity and its impacts were undertaken through the Dryland Salinity Theme of the National Land & Water Resources Audit, published in 2001[5]. It was estimated that about 5.7 million hectares of Australia's agricultural and pastoral zones had high potential for developing dryland salinity through shallow water tables.

Predictions based on groundwater trends, field surveys and landscape characteristics indicate that unless effective solutions are implemented, the area could increase to 17 million hectares by 2050. Serious impacts have been identified for agricultural land, important wetlands and other habitats, flora and fauna, quality of water resources, and farm and community infrastructure.

The largest areas of concern are in the Western Australian agricultural zone, water resources of the Murray–Darling Basin (MDB) — especially for South Australia, wetlands of the MDB and south-western Victoria. Queensland assessments highlight potential impacts within 3.1 million hectares considered to have high salinity hazard.

The NLWRA showed that the economic impacts of salinity on dryland agriculture are relatively small when viewed in the context of total agricultural profits. The present value of agricultural profits is estimated to decline by 1.5 per cent over the next 20 years due to salinity, without allowing for farmers' adaptive behaviour.

The project provided a frame of reference (in time and space), a spatial basis to assess impact costs at catchment and continental scales; context for assessing structural adjustment implications for salinity management (discussed in Chapter 4 section 4.2.3); and was influential in the decision to implement a National Action Plan (NAP) for Salinity and Water Quality.

ACTION #3.1

Identify the resources in your catchment that may be adversely affected by the current extent of dryland salinity and its risk of spread and list these assets in order of priority for action.

3.1.2 Appraising infrastructure assets under threat

The *Infrastructure Assets*[6] project aimed to answer the question 'What is the cost of land and water degradation, including salinity to the economy?' It focused on cash flow impacts, rather than non-market impacts such as biodiversity. The project used data produced by the National Land & Water Resources Audit.

The results indicated that a best-bet estimate of future 'off-site' damage costs to local infrastructure was around $89 million per year in Australia in the year 2000, potentially rising by $62 million or 70 per cent over the next 20 years. This included damage to general urban infrastructure, roads, railways, bridges and so on.

The net present value of the increases in damage costs up to the year 2020 was estimated to be $561 million for salinity; $786 million for turbidity; and $86 million for erosion/sedimentation. This was conservatively based on an across-the-board five per cent increase in levels of salinity, turbidity and sedimentation in rivers across Australia, and assume a five per cent discount rate.

Estimation of the current and future size of the cost to the environment was not undertaken in this analysis. Significant impacts on the environment due to salinity will continue to be among the key off-site impacts of land and water degradation. At a national scale, off-site and down-stream damage costs caused by salinity are probably more important than on-farm yield losses.

ACTION #3.2

Use the Audit data to make a preliminary calculation of what dryland salinity is costing your regional economy, and the relative importance of off-farm versus on-farm costs, except where your catchment was part of the 'Costs' project (see Action #3.3).

Figure 3.1 shows an estimation of the relative size of future costs imposed by salinity on agriculture, local and downstream infrastructure over the next 20 years.

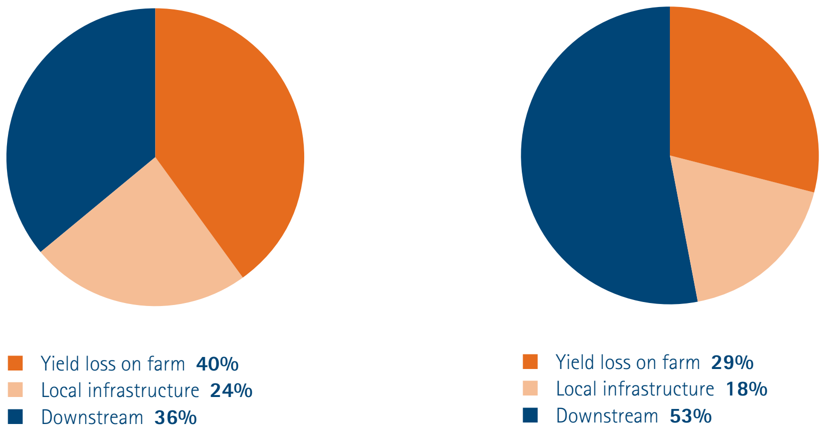
About two-thirds of the total increase in damage costs is anticipated to be off-farm with a five per cent increase in salinity, turbidity and sedimentation, excluding environmental damage. If water salinity levels were to increase by 20 per cent, then off-farm costs are calculated at more than 81 per cent.

Figure 3.1

Comparison of national salinity cost increases from 2000 to 2020 (net present values of increase at five per cent discount rate).

(Source: Young M., 2001, *Appraisal of infrastructure assets under threat*, National Land and Water Resources Audit, Commonwealth of Australia, Canberra ACT.)

10% increase in water salinity



3.2 Current & future costs

3.2.1 Costing the impacts of dryland salinity

In 1994, a project to estimate dryland salinity impact costs was initiated. The method is documented in the 'Costs Guidelines',[7] and was applied across the Murray–Darling Basin from 1999 to 2002 under the 'Costs'[8] project. The methods described can apply across Australia, and have been tested outside the Murray–Darling Basin in the Mt Pleasant catchment (SA)[9] and Lower Fitzroy catchment (Qld),[10] and in a separate project in the Glenelg-Hopkins[11] catchments (Victoria).

The 'Costs' final report details the causes of dryland and urban salinity, identifies types of salinity impacts, and estimates the current impact costs being incurred by stakeholders for each major catchment of the Murray–Darling Basin. The 'Costs Guidelines' provide methods for estimating marginal costs and predicting future costs, although only current costs were estimated in this research project. The Glenelg-Hopkins Catchment Management Authority in Victoria has used the 'Costs Guidelines' to predict costs over the next 30 years.

Dryland salinity impacts fall into two categories: impacts from saline water; and impacts from high saline water tables. Saline water can affect urban domestic, municipal and commercial users. High saline water tables can affect urban and rural assets. Some urban areas, as well as the natural environment, can be affected by both saline water supplies and high saline water tables.

The 'Costs' project estimated total impact costs incurred by: urban households and businesses; municipal councils; State Governments and public utilities; and dryland farmers (see Figures 3.2 and 3.3). Key findings were:

- Impact costs across the Murray–Darling Basin total about $305 million per annum. This figure is much higher than the previous 1993 estimate of $22 million per annum for seven case study areas. The true cost is much larger because the figure excludes salinity impacts on irrigated agriculture, cultural heritage, the natural environment and the city of Adelaide, South Australia
- Estimates of total impact costs are expected to rise as levels of awareness about the types of salinity impacts increase, as ways of measuring impact costs improve, and as the negative effects of salinity continue to outweigh the positive effects of amelioration activities
- At least 220 towns and rural centres in the Murray–Darling Basin are affected by urban salinity. This number contrasts with the NLWRA report *Australian Dryland Salinity Assessment 2000*[12] which estimated that only 68 towns across Australia were affected in 2000 and that 219 towns could be affected by 2050
- The cost of dryland salinity identified in the context of this report totalled $305 million dollars per year, split between commerce, industry and households (46 per cent), dryland agricultural producers (33 per cent) and Local and State Government agencies and utilities (21 per cent)
- A number of cultural heritage sites, heritage-listed buildings and some environmentally significant terrestrial and wetland areas are at risk.

Awareness of these findings is expected to influence consideration of the rural and urban dimensions of salinity during development and implementation of regional resource management plans and government salinity management programs.

ACTION #3.3

Use the Costs Guideline *to estimate current, marginal or future predicted costs for any region in Australia, but start by reading the 'Costs' final report to see what work has already been done and what sort of results you can expect.*

Figure 3.2

Breakdown of current dryland and urban salinity costs across the Murray–Darling Basin by major stakeholder group

(Source: Wilson S.M., 2004, *Determining the full costs of dryland salinity across the Murray–Darling Basin: Final project report*, Report to the Murray–Darling Basin Commission and National Dryland Salinity Program, Murray–Darling Basin Commission, Canberra ACT.)

Total dryland and urban salinity impact costs ($/yr)

- Commerce and industry **21%**
- Households **25%**
- Local Government **10%**
- State Government agencies and utilities **11%**
- Dryland agricultural producers **33%**

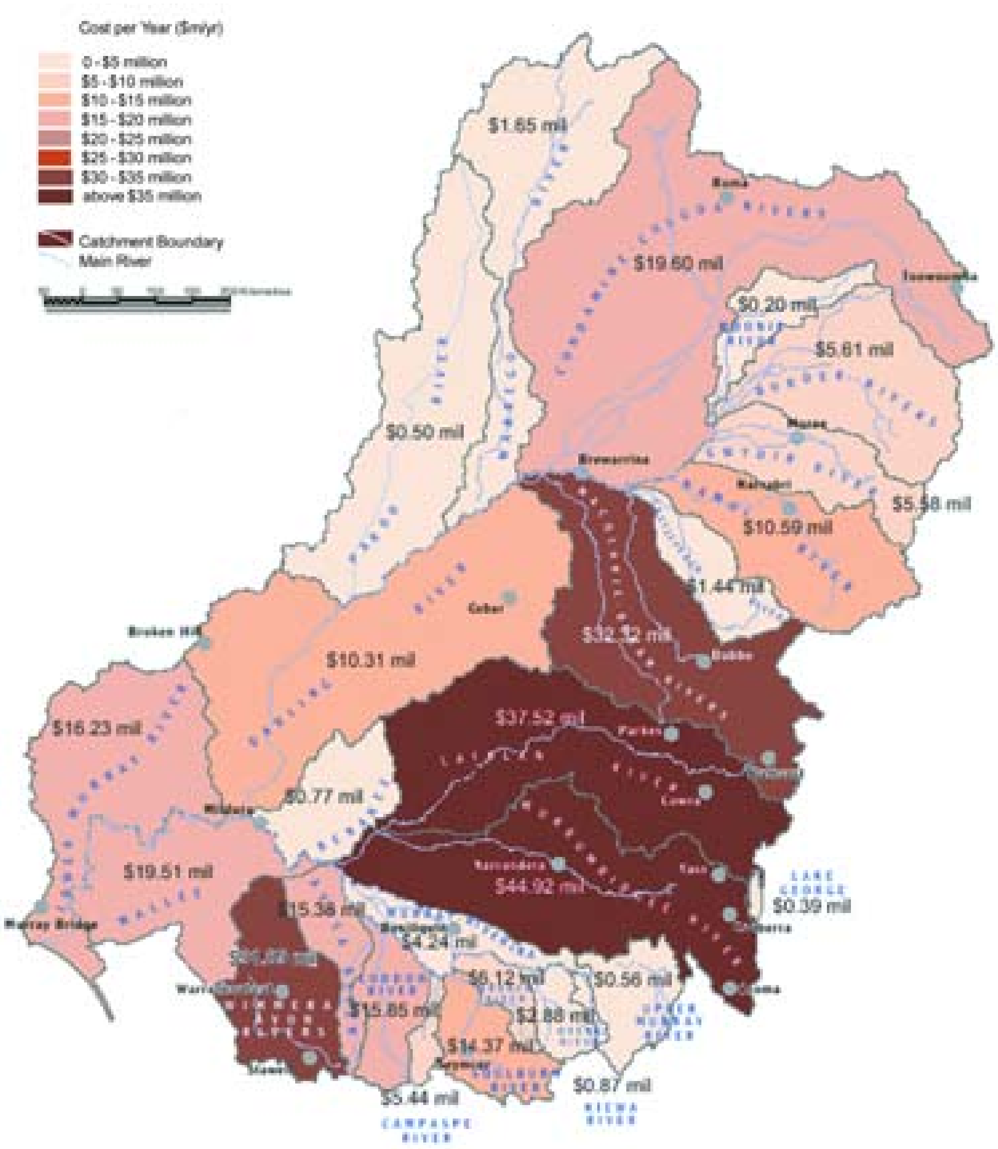
Environment & cultural heritage not valued

Total: $305 million per year
(excludes environmental and cultural heritage costs)

Figure 3.3

Total current annual cost of dryland and urban salinity to key stakeholders across the Murray–Darling Basin ($mil/yr)

(Source: Wilson S.M., 2004, *Determining the full costs of dryland salinity across the Murray–Darling Basin: Final project report*, Report to the Murray–Darling Basin Commission and National Dryland Salinity Program, Murray–Darling Basin Commission, Canberra ACT.)



Notes: Figures include all estimated current impact costs to urban and rural households, commerce and industry, Local Governments, State Government agencies and utilities and dryland agricultural producers, but exclude all costs of salinity to agricultural producers in irrigation areas, and to the natural environment and cultural heritage. Estimates also exclude any costs of salinity to Adelaide (which sources much of its water from the Murray River), as this city is located outside the Murray–Darling Basin.

In Western Australia the impact of salinity on agricultural land, infrastructure, biodiversity and water resources has been undertaken as part of the Salinity Investment Framework[13]. For agriculture, the Framework shows that investment in salinity management is estimated to eventually generate a stream of additional profits (and losses avoided) for farmers that, in present value terms, equates to $716 million. The analysis can be used to speculate that the annual cost to farmers of forgone profit is around $300 million (that is, if farm operations are completely and permanently unconstrained by salinity) and the present value of those annual impacts (losses) is around $4 billion. In terms of infrastructure, assessments based on salinity impacts on highway and local road maintenance (costs of $19,840 and $6614 per kilometre), indicated a total combined recurrent costs of $21 million. However, when the length of roads at risk are considered this increases to a combined cost of $175.5 million. Importantly, the costs are likely to accrue to Local Government. The present value of future repairs to highways, main and local roads are estimated to be $1355 million. An assessment of the current annual and potential costs to railways ranges from $0.5 m to $7.0 million per year. The present value of in-perpetuity costs was estimated to be $176 million.

The Rural Towns Program (RTP)[14] (http://agspsrv34.agric.wa.gov.au/environment/townsite_salinity/index.htm) was an initiative of the 1996 WA Salinity Action Plan and developed in response to the recognition that salinity has a significant impact on rural infrastructure and communities. Approximately 38 communities are now involved in this program (see Figure 4.8 in Question 4), 15 of which are considered a high priority for future action. Detailed hydrological studies are conducted in all participating towns, involving drilling, aquifer tests and modelling to determine the impact of applicable management tools. From these studies a salinity management plan is prepared and, in some cases, implementation has commenced.

In six of the rural towns where implementation plans were established (Brookton, Corrigin, Cranbrook, Katanning, Merredin, Morawa) detailed economic analyses were conducted[15] (see Table 3.1), with separate reports published for each town. The reports show that, typically, roads were the infrastructure item most affected by the impact of rising water tables and salinity, representing about two thirds of the total cost in each town. Housing represented about 20 per cent of the total cost, with public buildings, commercial buildings and other infrastructure, such as recreation areas, representing the remaining 15 per cent. However, economic modelling revealed that the benefit–cost ratio of investing in these towns was relatively low. The low benefits were the result of the relatively low value of the asset base, the long time to impact (which devalues the need to invest now) in some cases and the relatively high cost of treating and disposing groundwaters. An electronic decision support tool called *Urban Salinity Economic Analysis Package* (USEAP) and an associated operating manual were also produced.

Current work is aimed at reducing the cost of water management strategies and value adding the saline water generated from pumping systems established or proposed in the towns. In addition, detailed hydrologic assessment tools are being developed to improve the efficiency of locating pumping bores. Desalination and related water management systems are being developed in conjunction with the *Healthy Country*[16] project.

Table 3.1

Damage and control costs for six towns participating in the Rural Towns Program, in Western Australia

(Source: Department of Environment, 2003, *Salinity Investment Framework Interim Report – Phase 1*, Salinity and Land Use Impacts Report No. 32, Resource Science Division, Perth WA.)

Town (timescale of estimates)	Damage costs (7%)	Timing of onset of major costs (years)	Total cost of potential options to control rising groundwater (7%)	Cost of abandoning land and infrastructure (7%)
Brookton (60 yrs)	$0.618m	4	$0.275m[1]	$0.678m
Corrigin (60 yrs)	$0.210m	2	–$0.105m[2]	$0.09m
Cranbrook (60 yrs)	$0.611m	22	$5.742m evap $1.554m ($2.251m[3])	$0.889m
Katanning (30 yrs)	$6.865m	1	$7.609m evap $3.422m	$13.8m
Merredin (60 yrs)	$0.384m	26	$4.565m evap $0.922m ($1.827m[4])	$0.698m
Morawa (30 yrs)	$0.248m	1	$0.900m	N/A

1. assumes reduced need to purchase scheme water.
2. shown as a negative cost because of benefit due to reduced need to purchase scheme water.
3. if pumping and drainage implemented in Year 16.
4. if pumping and drainage implemented in Year 20.

The report *Financial costs to Local Government of dryland salinity*[17] provides a method for Local Government to assess the cost of salinity and develop appropriate responses to these financial implications. The method includes a financial model, which is described in *Salinity impact model: Impact of salinity on rate revenue and land values – Urban fringe and provincial centre fringe*[18]. The model was applied to five municipalities to estimate the increase in infrastructure expenditure costs due to salinity and the affect of these increased costs on rate income. It also takes the existing rate income by different land use types and shows the impact that reduced land values due to salinity will have on the rate base over time. The work found that dryland salinity will financially affect Local Government through the infrastructure that it maintains and renewal costs on behalf of its community, and through its property value based rating system. The case studies investigated included:

- A rural municipality with limited urban areas and a low value infrastructure base
- A rural municipality with a number of small towns and urban areas with a diverse but not high value infrastructure
- A provincial centre, primarily urban municipality with a diverse and moderately high value infrastructure base
- A metropolitan fringe municipality with a high value infrastructure base but low infrastructure maintenance budget
- A municipality on the fringe of a large provincial centre with a low value infrastructure base but a relatively high infrastructure maintenance budget.

3.2.2 Communicating information on impacts and costs

The *Salinity Management Handbook*[19] and the Western Australian program *Rapid Catchment Appraisal* described earlier in sections 1.2.2 and 2.2.2 are significant sources of information on dryland salinity, together with resources from the Tools[20] project. The overarching *Salinity Information Package*[21] (described in the Introduction) considers both dryland salinity impacts and costs, and the ten detailed *Regional Information Packages*[22] for major catchments of the Murray–Darling Basin include the specific impacts and costs findings from the 'Costs' project described above.

The *Local Government*[23] project raised awareness of the risk of dryland salinity among 450 Local Governments within rural Australia via the dissemination of an information kit on CD-ROM[24] and focus group discussions. It was supported by financial modelling case studies, providing councils with an easy-to-use tool to determine the financial implications of salinity on infrastructure. Case studies of successes and failures by local government in Australia including urban councils are documented and analysed. The report outlines the economic rationale for Local Government getting involved and investing in dryland salinity control.

Under the NSW Salinity Strategy[25], the Urban Salt Action Team works with Local Government to provide training, education and technical support on urban salinity issues. As part of the Local Government Salinity Initiative a series of booklets are being produced. At present these include:

- *An Introduction to Urban Salinity*[26] — an overview of the processes, impacts and management options for urban salinity
- *Indicators of Urban Salinity*[27] — contains information on a range of salinity indicators and explains the causes of salinity
- *Broad Scale Resources for Urban Salinity*[28] — discusses some of the resources available to determine the nature of salinity issues in a particular region
- *Site Investigations for Urban Salinity*[29] — provides a framework for assessing the impact of salinity on a proposed development and the impact of a development on salt and water processes
- *Roads and Salinity*[30] — describes how salt and water processes can affect road structure as well as strategies to prevent road damage and minimise the role roads play in salinity problems
- *Building in a Saline Environment*[31] — explains how salt damages buildings and how to build structures that are less susceptible to salt damage
- *Waterwise Parks and Gardens*[32] — contains information on creating and managing sustainable, water-efficient landscapes.

Ten workshops/training sessions based on the contents of these booklets have been held in regional New South Wales. The Local Government Salinity Initiative (LGSI) is supported by the Local Government and Shires Associations of NSW. A Western Sydney *Salinity Code of Practice* has been developed that uses the level of salinity hazard, riskiness of the land use and size of the development to determine whether a level 1, 2 or 3 investigation and management response is appropriate. The Code of Practice was supported by training sessions and an information resource kit, which includes the LGSI booklets. At least one staff member from 22 per cent of councils in New South Wales attended training sessions in urban salinity between October 2002 and July 2003.

ACTION #3.4

Refer to the Tools Regional Information Packages *for summary information on the findings of the 'Costs' project in your region, and consult the* Salinity Information Package *for more general information on salinity costs.*

ACTION #3.5

Refer to the 'Local government' project information kit on CD-ROM and the series of booklets on urban salinity to guide salinity identification and management for urban areas in your region.

3.2.3 *Evaluating cropping regions of Australia*

The *Economic Evaluation of Salinity Management Options in Cropping Regions of Australia*[33] project was inspired by the findings of the National Land & Water Resources Audit, which estimated 2.6 million hectares of GRDC's agro-ecological zones (see Figure 3.4) to be salt-affected, with an additional 1.1 million hectares predicted to be affected by 2020.

The five agro-ecological zones facing large salinity increases are the WA Sandplain, SA Vic Bordertown Wimmera, NSW Vic Slopes, WA Central and Vic High Rainfall. Over 60 per cent of the additional salt-affected area will be in the Western Region, in particular the WA Sandplain and WA Central zones. Some zones, such as the WA Sandplain and WA Central, are already major grain growing regions so their forecasted large increases in salt-affected areas toward 2020 will impact on national crop production.

Across all the zones, if half the forecast additional area to become salt-affected is normally sown to crops, this represents, at worst, a potential loss around half a million hectares of crop land.

The five agro-ecological zones forecast to experience large salinity problems over the next 20 years are, with the exception of the Vic High Rainfall zone, also the major consistent sources of Australian farm profit. Declines in farm profit due to salinity within these zones could have damaging consequences for overall grain industry profits and for regional economies. The impact of salinity, measured as the present value of the decline in farm profit from 2000 to 2020 due to worsening salinity, is around $238 million. Including impacts beyond 2020 increases this cost to $387 million. This equates to an annual cost of around $29 million in foregone farm profit.

ACTION #3.6

Consider the estimates for current and predicted impact costs on farm profits for GRDC's agro-ecological zones for individual grain growers and the grains industry in your management response to dryland salinity.

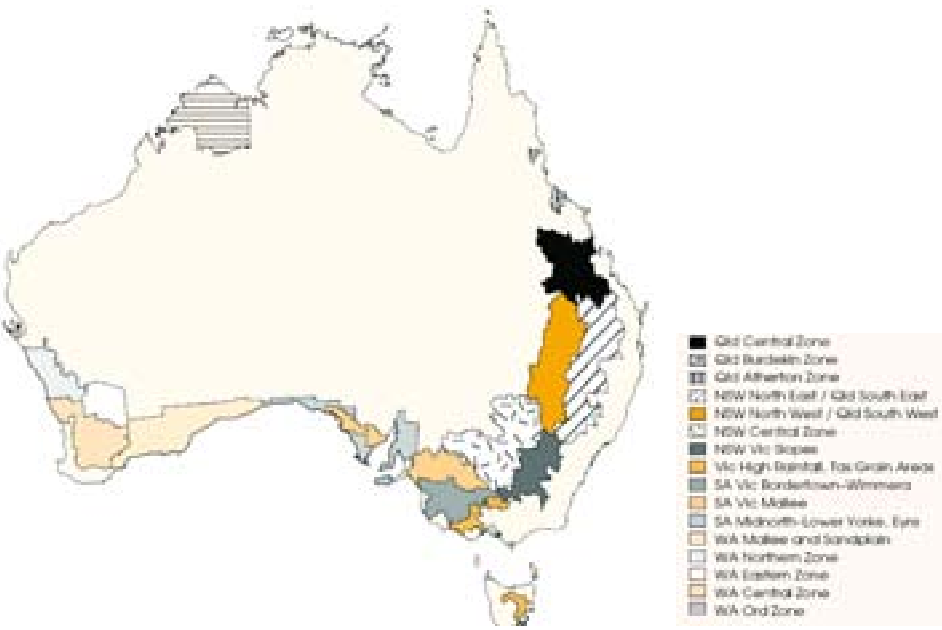
ACTION #3.7

Ascertain whether an assessment of the current and predicted impact costs on farm profits for beef, sheep meat, wool or other industries is needed to inform your management response to dryland salinity.

Figure 3.4

GRDC agro-ecological zones

Source: ABARE (1999), Australian Grains Industry Performance by GRDC Agro-ecological Zone, April 1999. Page 19.



3.3 Ecosystem responses

3.3.1 Assessing aquatic biodiversity loss

The *In-stream health*[34,35] project undertaken in the Barwon River catchment (south-west Victoria) set out to trial the development of a system that will predict the loss of aquatic biota caused by a rise in salinity. Methods were developed to rapidly test the relative salinity tolerance of a large number of species (57).

In order to construct a predictive system the frequency distribution of the relative salinity tolerances of the species tested was assessed — this distribution approximated log-normal and can therefore be used as the basis of a predictive system. A log-normal distribution means that most species are slightly tolerant, while some are very sensitive and some are very tolerant. This suggests that initial salinity increases will affect only a minority of aquatic macro-invertebrate species. However, further salinity rises will affect many species, and progressive increases will affect the few more tolerant species remaining.

Short-term or acute lethal tolerance was used as an indicator of the macro-invertebrates' relative tolerance. The relative salinity tolerance of specific macro-invertebrate taxa was also assessed and found that mayflies and non-arthropods (snails and worms) were the most salt-sensitive and macro-crustaceans were the most tolerant. Rare species tended on average to be more tolerant than common species. To assess the tolerance of a wide range of species and taxa that comprise natural communities there is a need for testing of both common and rare species. However, rare species are difficult to test because it is hard to collect them in large numbers.

This research has shown that it is feasible to develop a system to predict the loss of aquatic biota caused by rises in salinity and that acute lethal tolerances do relate to field occurrences. It has identified which specific taxa are sensitive/tolerant and that there is a need to consider rare species. The project has given an indication of spatial variation in salinity tolerance and provided preliminary information on sub-lethal and critical life-stages.

ACTION #3.8

Estimate the loss of aquatic biota from a rise in salinity in your catchment using the preliminary methods developed by the 'In-stream health project' project to rapidly test the relative salinity tolerance of a large number of macro-invertebrate species.

3.3.2 Rising water table impacts on remnant vegetation

The *Restoring Remnant Vegetation*[36] project developed a decision-tree approach to predict likely ecosystem response to changes in hydrologic balance. The research was conducted in the upper and middle Blackwood Basin in Western Australia.

At landscape scale, hydrological modelling of the future groundwater surface was linked with the distribution of plant community types in vegetation remnants. This identified those remnants most at risk from rising groundwater.

The work demonstrated that broad-scale estimates of losses from salinisation may over-estimate the actual impact, as fine-scale variation in micro-topography mediates the broad-scale risk from water table rise, such that some locations escape impacts, at least in the short-term.

The hydrological information derived for the upper Blackwood is being incorporated into a regional predictive analysis of salinity impacts for the major rivers of the WA wheatbelt (including the Blackwood) under the WA Engineering Evaluation Initiative.

ACTION #3.9

Test the decision-tree approach developed by the 'Restoring Remnant Vegetation' project in your catchment to predict likely ecosystem responses to changes in hydrologic balance.

ACTION #3.10

Use waterlogging and elevation as an initial indicator of the capacity of primary saline ecosystems to persist in a secondary saline environment.

3.3.3 Investigating vegetation recruitment impacts

The *Recruitment Biology*[37] project investigated the recruitment biology of vegetation communities, in the south-west of Western Australia near Jerramungup. The Gairdner River is naturally saline and the woodland of yate (*Eucalyptus occidentalis*) trees, melaleuca shrubs and sedges observed, grows in shallow soils above a hypersaline water table, in many places twice as salty as the ocean.

The research found that the current structure, species abundance and diversity along primary saline rivers did not persist in secondary saline environments. Waterlogging and elevation are useful initial predictors of a site's fate, particularly in the lower parts of the landscape. Waterlogging duration, soil chloride and soil type increase the predictive power higher in the landscape.

Information on the impact of salinity and waterlogging on yate woodland will ensure that management strategies can be developed that consider specific soil and water thresholds necessary to maintain functioning ecosystems.

3.4 Cost sharing

3.4.1 Distributing the costs

The report *Robust separation – A search for a generic framework to simplify registration and trading of interests in natural resources*[38] considers how to establish a robust, economically efficient and equitable system of defining, allocating and managing use of natural resources. Such a system defines interests, rights and use obligations that sit within an economically efficient trading system. The report does not consider pricing, charging or how to convert from existing systems (these are proposed for reports to follow).

The report *Cost-sharing for on-ground works*[39] considers the rationale for adopting cost sharing, including the role of government. It explains the principles of cost-sharing and how these may be applied to action planning at the regional level. Four examples of cost-sharing frameworks are described. *Investment programs and institutional arrangements for effective natural resource management*[40] reports on the application of the 'Cost-sharing for on-ground works' approach in the Liverpool Plains (NSW).

ACTION #3.11

Investigate opportunities for cost-sharing arrangements to inform the development and support the implementation of your regional dryland salinity plan.

The following four economic reports on conserving native vegetation are summarised in the publication *Managing the bush*[41]:

- *Motivating people – using management agreements to conserve remnant vegetation*[42]
- *Beyond roads, rates & rubbish – opportunities for Local Government to conserve native vegetation*[43]
- *Opportunity denied – review of the legislative ability of Local Governments to conserve native vegetation*[44]
- *Talking to the taxman about nature conservation – proposals for the introduction of tax incentives for the protection of high conservation value native vegetation.*[45]

Policy options for how to encourage sustainable land use are described in a discussion paper[46] that outlines 18 suggestions. The options come under five major categories – Make plans (e.g. Define property holders' rights and responsibilities); Find resources (e.g. Offer tax incentives); Gain knowledge and skills (e.g. Extend landholders' skills); Encourage change (e.g. Pay farmers for environmental services); and Monitor progress (e.g. Monitor for adaptive management).

3.4.2 Accounting for ecosystem services

The 'Ecosystem Services'[47] project studied the services people obtain from the natural environment, the economic and social value of these services, and the opportunities that can arise from considering them more fully in land management policies and decisions. Some examples of natural ecosystem services include provision of clean and pure water; maintenance of liveable climates and atmospheres; pollination of crops and native vegetation; fulfilment of cultural, spiritual and intellectual needs; and provision of unforseen options for the future.

The *Ecosystems Services* project investigated case studies in the Goulburn-Broken catchment (Victoria), the Atherton Tablelands (Qld), the Rangelands and Gwydir catchment (NSW), the Blackwood catchment (WA), the Onkaparinga catchment (SA), the Brigalow (Qld) and Brisbane (Qld). The analysis framework used in these studies and further discussion is provided in section 5.10. The research provides a better understanding of the benefits and beneficiaries of ecosystem services, and direction on more equitable sharing of the costs and benefits of natural resource management.

ACTION #3.12

Develop opportunities to market ecosystem services in your region to make sustainable land management more economically viable, and maintain a watching brief on the progress and relevance of programs and activities taking place elsewhere.

A report[48] on the contribution of mid to low rainfall forestry and agroforestry to greenhouse and natural resource management outcomes identifies opportunities to help deliver carbon sequestration and more sustainable natural resource management in conjunction with regional economic development and agricultural diversification benefits.

The key findings of this work are:

- Revegetation and land use change over large areas in mid to low rainfall regions of southern Australia using commercial forestry and agroforestry is vital to sustainable natural resource management. Carbon sequestration from these activities could make a significant contribution to meeting Australia's greenhouse goals.
- There are good opportunities to use tree crops to modify agricultural systems in the mid and low rainfall zone of southern Australia.
- Revegetation at the required scale is unlikely to occur with either public or private investment alone at present market values.
- The current market value of greenhouse and other ecosystem services is unlikely to be sufficient to fully fund revegetation at the scale required.
- Wherever possible, market signals should be used to guide investment in tree crops.

Two complementary studies on the opportunities for ecosystem services in Australia are outlined in the summary report *Making farm forestry pay – Selling the environmental services of farm forestry*[49]. The first study, *Making farm trees pay*[50], assesses why existing incentives for farm forestry are not adequate, and whether markets for environmental services could be developed to make farm forestry economically attractive. The second, *Emerging markets for environmental services*[51], reviewed several case studies of environmental markets in the USA and United Kingdom, focusing on elements that were critical for the success of the trading programs. These reports concluded that opportunities exist in Australia to develop markets for ecosystem services.

The NSW Government's Environmental Services Scheme[52] focuses on land use changes that will produce economic and ecological benefits for individual properties and the State as a whole. The scheme provides financial incentives for landholders to change to 'environmentally-friendly' land uses such as the establishment of deep-rooted perennial pastures on land currently used for cropping or annual pastures, commercial tree planting and establishment of saltbush pastures. Information from this scheme will eventually be used to develop markets through which a range of environmental services can be traded.

R & D TIP #3.1

Review the strategic plan for the National Land & Water Resources Audit Phase II (2002–07) and/or speak with Audit staff to ascertain the extent to which the planned program of activities will meet your particular needs.

WHERE TO FROM HERE?

National Land & Water Resources Audit

The NLWRA identified that information on the impacts of dryland salinity on biodiversity is scant and that detailed assessment of impacts will need to be undertaken as part of all regional planning. The priorities for further research highlighted were the assessment of the ecological impact of elevated salt loads in streams, and improved methods for the application and integration of social and economic data in the setting of salinity control targets.

Current and future costs

Some costs of salinity may be recoverable, such as using saltland agronomy,[53] while others are not. We need to particularly focus on preventing future damage to high value assets, using cost-effective treatments. Close attention will need to be paid to the cost-benefit of protecting private assets versus public assets (e.g. wetlands and heritage buildings), which may be more efficient than efforts to protect agricultural land. Cost-benefit analysis of the major dryland industries – wool, beef, sheep meat, grains – is needed to inform this decision-making. It will also be necessary to account for the value of saline land as an agricultural resource, increasingly highlighted through research of the Sustainable Grazing on Saline Lands (SGSL) Sub-Program.

Planning could be further supported by reinterpreting the current findings of the 'Costs' project within the *Groundwater Flow Systems Framework*[54] to establish the distribution of impact costs across groundwater flow system types. A high proportion of the impact costs in local groundwater flow systems compared to intermediate and regional systems would provide a broad indication of our capacity to remedy impact costs through vegetation-based versus engineering-based solutions in the shorter-term. This is especially important for managing impacts on important environmental and cultural heritage assets.

The results of the 'Costs' project could be improved by additional investigations to overcome data and information limitations with respect to the current area of salinised, urban impacts and their costs, damage to cultural heritage, and damage to wetlands.

More thorough knowledge of the existing area of salinised land, as well as a consistent measure of its severity, is required. This requires further work to record, in digital form, the location, area and severity of all salinity outbreaks. The report *Economic Evaluation of Salinity Management Options in Cropping Regions of Australia* identified the GRDC agro-ecological regions of WA Sandplain, SA Vic Bordertown Wimmera, NSW Vic Slopes, WA Central and Vic High Rainfall as priority areas for further investigation.

The 'Costs' project suggests that urban areas experience the greatest impact of the costs related to dryland salinity, at least within the scope of this study. It must be recognised that this work is not exhaustive of all towns and cities and does not include the costs related to river salinity, irrigated agriculture or the environment and cultural heritage. All estimates of urban salinity costs are therefore indicative only and require further refinement.

Notwithstanding general acceptance that dryland and urban salinity is having adverse effects on places, buildings, archaeological sites, gardens and trees with cultural and Aboriginal significance, there is limited documentation of these impacts. A systematic assessment is required. The *Salinity Investment Framework* and the *Rural Towns Program* in Western Australia provide leading examples.

There is an urgent need to improve monitoring of salinity levels of high-value wetlands at risk from salinity, and to improve understanding of salinity impacts on in-stream plants and animals, and on riparian vegetation.

A further advance in understanding impact costs would be achieved by using the 'Costs Guidelines' to predict future impact costs. This could be undertaken using the digitised datasets from the National Land and Water Resources Audit and *The Salinity Audit of the Murray–Darling Basin 1999*,[55] which show the likely extent of high water tables and salinity concentrations in rivers in 2020, 2050 and 2100. Where improved datasets are available, such as the Groundwater Status Report for the Murray–Darling Basin,[56] they should be used in this analysis.

In the longer term, the design of salinity programs and collaboration between stakeholders could be enhanced by assessing the costs of salinity at regular intervals, preferably under the direction of regional organisations preparing and implementing salinity plans. This has the potential to:

- Further increase community, industry and government awareness of the nature of salinity impact costs, and the level of costs being incurred by stakeholders
- Assist in attracting levels of investment in salinity management appropriate to the levels of costs being incurred or predicted
- Assist in strategic allocation of investment across urban, rural, environmental and cultural heritage issues
- Contribute to regular monitoring, reporting and evaluation processes introduced to facilitate the longer-term development of salinity management programs.

Ecosystem responses

Research on aquatic biodiversity loss indicated a need to extend studies to ascertain the degree to which the findings from the Barwon catchment (Victoria) apply to other locations. Further studies on sub-lethal effects, longer-term lethal effects and tolerances of critical life-stages (such as eggs and young) of a sub-set of species are necessary, as is knowledge of the relationship between these effects and field distributions. Consideration of whether other biological groups (e.g. micro-invertebrates, some life-stages of fresh water fish, etc.) are more sensitive than macro-invertebrates should also be considered.

The decision-tree approach to provide likely ecosystem response to changes in hydrologic balance and the recruitment biology investigations of yate communities were both undertaken in Western Australia. Further trials are needed to determine the extent to which these research findings are relevant elsewhere. The hydrological information from the Blackwood catchment is being applied in the WA wheatbelt under the Engineering Evaluation Initiative, and this will provide further testing of the methods and findings.

R & D TIP #3.2

Consider the on-going activities of the Salinity Investment Framework, Rural Towns Program *and the implementation of the* Basin Salinity Management Strategy *(www.mdbc.gov.au)*

R & D TIP #3.3

Consider the outcomes of research from the Sustainable Grazing on Saline Lands (SGSL) Sub-Program (www.lwa.gov.au) and PUR$L (www.ndsp.gov.au) on the changing value of saline land as an agricultural resource.

R & D TIP #3.4

Consider the research portfolio of the Land & Water Australia (www.lwa.gov.au), particularly the Contaminants Program, the CRC for Freshwater Ecology (www.environmentdirectory.com.au/research/crcfw.html) and the WA Engineering Evaluation Initiative (www.wrc.gwa.gov.au/protect/salinity) for further information.

R & D TIP #3.5

Follow the progress of investigations by CSIRO Land and Water (www.clw.csiro.au) on efficient trading systems and on ecosystem services under the NAP (www.napswq.gov.au).

Cost sharing

Investigations are required to more clearly define interests, rights and use obligations within an economically efficient trading system. Supporting research on pricing, charging and how to convert existing systems is in progress. This system must be supported by equitable cost-sharing arrangements to support on-ground works in natural resource management with a public good component. The provision of ecosystem services should be fully accounted for in any trading system and associated cost-sharing mechanisms.

Link back to Introduction

Link to Q.1 - Extent and Risk

Link to Q.2 - Causes and Processes

Link to Q.4 - What can we do?

Link to Q.5 - Integrate with other NRM issues

Link to a checklist of actions

Link to - Where to get help

Link to Glossary and References