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WHY WHEATBELT VALLEYS ARE VALUABLE AND VULNERABLE:
THE ECOLOGY OF WHEATBELT VALLEYS AND THREATS TO THEIR SURVIVAL

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ABSTRACT

Five sections are presented: a brief background on the biodiversity survey of the Agricultural Zone, general results of the survey, the impact of rising groundwaters on biodiversity generally, and finally in wheatbelt valleys in particular. Questions are posed about what we can do to ameliorate and live with this changed landscape.

The survey has shown that the agricultural zone of Western Australia is more biodiverse in all groups surveyed than previously recognised.

Areas affected by secondary salinisation show major declines in vascular plant and animal biodiversity. Rich complex communities are replaced by a few succulents and weeds. Similarly major declines in diversity occur in animal communities where specialists are lost and/or replaced by generalist species.

Salinisation will cause further fragmentation, significant loss of plant communities that typify the Wheatbelt, and a major rise in the extinction rate of native plants, unless efforts are undertaken by the whole community to reverse current threats.

INTRODUCTION

This paper is developed in five sections: a brief background on the biodiversity survey of the Agricultural Zone of Western Australia (hereafter referred to as the Wheatbelt); general results of the survey; impact of rising groundwaters on biodiversity generally; wheatbelt valleys in particular and finally what can we do to ameliorate and/or live with this changed landscape.

At this stage it is important to note that this paper is based on the information collected over four years of survey in the Wheatbelt and other related published and unpublished reports. Over the next year (2002) the survey information will be collated and analysed and further reports prepared. As a consequence the information and interpretation presented in this paper is preliminary.

BACKGROUND TO BIODIVERSITY SURVEY

The Wheatbelt is central to temperate south-western Australia which is recognised internationally as a mega diverse area for flowering plants. Significant parts of six of the eight biogeographic zones recognised in south-western Australia (Thackway & Creswell 1995) are found in the Wheatbelt. These are the Geraldton Sandplains, Swan Coastal Plain, Avon-Wheatbelt, Jarrah Forest, Mallee and Esperance Sandplains zones.

The Western Australian Museum had surveyed the vegetation and vertebrate animals of 23 nature reserves of the Northern and Central Wheatbelt during the 1970s (reports are in Biological Survey of the Western Australian Wheatbelt, Records of the Western Australian Museum supplements 1–13). While these will form an essential baseline for those reserves, the Wheatbelt has had no previous comprehensive systematic survey of the distribution and diversity of the plants and animals of the region. Under the State Salinity Strategy, a four year field survey (1997–2000) was undertaken by the CALMScience Biological Survey Group with Greg Keighery as Project Leader.

The survey was structured under a series of themes. A large number of knowledgeable and experienced specialists in each of these areas, from a variety of institutions, are participating. This participation has allowed the survey to address the diversity of a wide variety of organisms at the species level. The themes and key participants are listed below:

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Terrestrial Communities

Flora:
Greg Keighery, Neil Gibson and Andrew Webb.

Fauna:
Vertebrates - Norm McKenzie, Allan Burbidge, Jim Rolfe and Bill Muir;
Invertebrates (CALM) - Paul Van Heurck, Nadine Guthrie, Lisa King and Bradley Durrant;
Invertebrates (WA Museum) - Julianne Waldock, Barabara York Main and Mark Harvey;
Frogs (UWA) - Dale Roberts.

Soils:
Trevor Stoneman

Wetland Communities

Flora:
Mike Lyons

Fauna:
Stuart Halse, Adrian Pinder, Jane McRae and Melita Pennifold (supported by many interstate and overseas specialists).

Detailed Wetland Monitoring

Jim Lane, Stuart Halse, Neil Gibson, Dave Cale, consultants from Edith Cowan University and Geohydro.

The biodiversity survey provides an overview of the distribution and conservation needs of the terrestrial and wetland biota of the Wheatbelt. Almost 2,000 sites have been established and scored, including over 300 terrestrial and over 200 wetland fauna/flora inventory sites that will be able to be used as monitoring sites into the future.

RESULTS OF THE BIODIVERSITY SURVEY

The general outcomes of the survey, up to this stage, are considered under each theme.

Terrestrial Communities

Flora

The Wheatbelt has an estimated vascular plant flora of circa 4,000 species, of which over 60% are confined (endemic) to the area. The region is the centre of species diversity for many of the species-rich groups (*Acacia, Dryandra, Eucalyptus, Grevillea* and *Verticordia*) that characterise the south-west of Western Australia.

This huge number of species, and the diverse range of plant communities in which they grow, were systematically sampled on public lands across the landscape in over 750 standard area plots of 10x10 metres (100 m^2). A series of these are associated with the 303 biodiversity sites (see Fauna below) while others were located independently of these sites. Approximately 200 sites have also been established on private and local government lands by members of the Wildflower Society of WA (Inc.) as part of the Bushland Plant Survey programme (Keighery 1994) and results are being incorporated into the overall study.

The biodiversity of the Wheatbelt is much higher than previously estimated. For example:

- Detailed surveys of the Lake Muir/Unicup reserves (Gibson & Keighery 2000) have documented a vascular flora of almost 1,000 species (considerably higher than Mount Lesueur, a larger area on the northern sandplain considered exceptionally diverse).

- The small areas of bushland in and around the Quairading townsite (part surveyed with community volunteers) has a vascular flora of over 500 species, including two completely new species and the largest populations of two critically endangered taxa (Keighery *et al.* 2001 and survey data).

- Plant species richness of equal area plots (100 m^2) ranges between 20 and over 90 species, equal to most areas of the northern and southern heathlands. The winter wet and summer dry (ephemeral) wetlands and heathlands plots are often equally species rich. Heaths are species rich in shrubs, whereas the other communities are species rich in perennial and annual herbs. While it is often assumed that heaths and granite rocks are 'the species rich communities', as found here and previously on the Swan Coastal Plain by Gibson *et al.* (1994) ephemeral wetlands have very high species richness. This is because they contain several groups of species that grow, flower, seed and die or become dormant during the year, i.e. one in autumn as the rains are filling the wetland, a winter group when the wetlands are full, another as the wetlands begin to dry in spring and a final group when the wetland is dry in early summer

- Three presumed extinct plants, and at least seven other previously unknown species have been collected and documented.

Naturally saline areas have major biodiversity values with a variety of plant communities and species confined to these specialised habitats. These areas, occupying the base of the broad valleys and representing the paleodrainage lines, are widespread and of considerable age in the Wheatbelt. One indication of this specialised habitat is that at least 64 threatened and priority taxa are restricted to these areas. Several new taxa have been discovered during the survey. The plants and the communities they occur in are at major risk from rising water tables, altering the hydrological regime of these areas.

One of the outcomes of the plant survey is to identify native species of potential for revegetation. A database of species in naturally saline areas of the Wheatbelt (from plot and herbarium records) is being compiled.

The Wildflower Society of WA (Inc.) studies have already established that areas of privately owned bushland in good condition frequently contain communities and species of plants of regional significance, some of which are not represented in the conservation network (Gunness et *al.* 2000a & b; Gunness & Campbell 1998; Keighery et *al.* 2001)

Fauna

The sampling sites (3 x 50 metre long pit lines with 10 spider traps) are positioned on a minimally disturbed example of each of the 11 principal geomorphic units in the landscape, as well as on a salt-affected example of two of the units. Sites with natural vegetation have been chosen on typical examples of each unit, preferably within a conservation reserve. At the conclusion of the survey 303 terrestrial biodiversity (fauna and flora) sites have been selected and sampled for ground-dwelling arachnids (spiders and scorpions), some other invertebrates (carabid beetles, centipedes and millipedes) and small vertebrates (mammals, reptiles and frogs).

The study has dramatically increased available data on the distribution, status and habitats of small wheatbelt vertebrates and ground dwelling invertebrates. For example:

- The survey has collected over 50,000 ground dwelling invertebrates, making this the most comprehensive study of these organisms in Australia.
- In the first two years of sampling, 113 species of small ground-dwelling vertebrates (reptiles, mammals and frogs) were recorded, compared with previous Museum records of 130 species for the whole agricultural region. The sampling recorded an average of 9 species of vertebrate per quadrat. This is despite the known historical loss of 16 mammal species from the Wheatbelt.
- The first year's survey (less than a third of the study area) recorded 33 scorpions (previously 13 recorded for the entire Wheatbelt), 24 centipedes (previously 23 recorded) and 329 spiders (previously 128 recorded). Spiders have been sorted into 1,699 morpho-species for the Wheatbelt, suggesting a final tally of over 700 spider species. The sampling recorded 20-50 (average of 34) arachnid species per site.
- Although all vertebrates encountered can be assigned to described species, 60-70% of the arachnids were undescribed. At least 40% (210 of 500+ species) of the region's arachnids, and 25% (31 of 125 species) of its small ground-dwelling vertebrates, have distributions centred on the agricultural region or are endemic to it. Strong biogeographic patterns are apparent across the region in these faunas, and different communities of species occur on the different soil-types within survey areas (sands, clays, loams, saline floors etc).
- Biodiversity of terrestrial invertebrates is much higher than previously supposed for the Wheatbelt.

Soils

Bulked surface soil samples from each site are collected for chemical analysis and the soil profile is described and sampled for chemical analysis. At each of the 303 sites a description, sampling and chemical analysis of soil profiles was made. This will allow use of Agriculture WAs soil profile database (10,000 profiles across the Wheatbelt) to interpolate the biodiversity-pattern models CALM expects to derive from the biological survey during 2002 (see McKenzie et *al.* 2000 for an example). In conjunction with ANUCLIM data (McMahon et *al.* 1995), these will allow modelling of species' "environmental envelopes", including their salinity responses. This will enable predictions of what are the tolerances of a wide range of plants and animals to changes in soil chemistry due to salinity.

Wetland Communities

Two hundred and thirty two wetlands were chosen to cover the full range of wetland types within the study area (water quality, geographic spread, primary and secondary saline sites and wetland morphology).

Flora

Within the 232 wetlands sampled for aquatic invertebrates, about 750 sites (100 m^2 or less) were established to document the floristics of these wetlands. Preliminary results have uncovered numerous new records and major range extensions of rare and priority flora. Several new taxa of Samphires (*Halosarcia* species) and *Frankenia* species have been discovered.

The study is confirming the high floral values of naturally saline areas and regional floristic differences in the salt lake chains.

Fauna

Survey work to date in wheatbelt wetlands has collected about 1,000 invertebrate species, distributed in 139 families and 270 genera. About 50% appear to be described species and approximately 15% are only known from the Wheatbelt.

Provisional data suggests numerous species are restricted to naturally saline wetlands, mostly *Parartemia* (Brine Shrimps), *Coxiella* (snails), Ostracods and Copepods (Crustaceans). These form a significant endemic component in south-western Australia.

Aquatic invertebrates from fresh water habitats in the Wheatbelt have significantly higher salinity thresholds than members of the same groups in Eastern Australia (Halse *et al.* 2000). This suggests that these organisms have local adaptations to wetting and drying cycles (the pools become more saline as they dry) of the more seasonal wetlands of the Wheatbelt. As a consequence these species can tolerate higher salinity thresholds before they are lost from our wetlands.

South-western Australia has a highly rich and endemic aquatic fauna of microinvertebrates, especially Crustacea. This diversity may be of equal significance to the flowering plants on a world scale.

Of particular note, for wetland conservation, is that most freshwater wetlands in the Wheatbelt are on private lands.

Detailed Wetland Monitoring

This project was designed to analyse and report trends in salinity and depth in wetlands that have been monitored since 1978. Recordings of salinity, depth and nutrient status are made in a broad range of wetlands. In addition changes in floristic composition, tree health, waterbirds and aquatic invertebrates in 25 wetlands are monitored.

Vegetation transects (2-5 per wetland, 80 in total) have been established at all 25 wetlands. Reference photos have been taken on each transect. Aerial photos showing position of transects and biophysical boundaries have been captured on Geographical Information Systems and are also available on CD ROM with the reports. Over 6,000 trees have been tagged on the transects and vegetation profiles constructed for each transect. Three major reports on these transects have been prepared and are lodged in the CALM Library at Woodvale in Western Australia. Monitoring bores have been established adjacent to these transects at 20 wetlands. Waterbirds and invertebrates (macro- and micro-invertebrates) have been sampled at 23 wetlands to prepare baseline data and five have been resampled.

Monitoring of wetlands has shown that wetlands often have different values for waterbirds, invertebrates and vegetation. Biodiversity is comprised of many groups that respond differently to the environment. A single biotic indicator cannot be used to summarise the overall biodiversity value of a wetland.

Summary

The biological survey of the Wheatbelt has revealed that:

- The agricultural zone of Western Australia is more biodiverse in all groups surveyed than previously recognised.

- Despite widespread and intensive clearing there have been only minor losses at the species level (except for mammals). However, there has been extensive depletion of communities and genetic variation. This loss will increase to the species level over the next 100 years if current trends continue. Even with intensive management and intervention there will be further decline in most areas. We must carefully plan to minimise this impact and to maximise biodiversity values of these affected landscapes.

SALINITY IMPACTS ON BIODIVERSITY

Terrestrial Communities

Flora

Of the 4,000 species present in the Wheatbelt, over 1,500 occur low in the landscape, in riverine valleys, freshwater or primarily saline lands. Of these taxa an estimated 450 are endemic to the Wheatbelt. These taxa are in danger of extinction over the next 100 years as a consequence of rising saline groundwaters. Several hundred other species found only in lowland woodland, Mallee and *Melaleuca* shrubland sites, will be under threat in the longer term. Another 400-500 lowland taxa are centred on the Wheatbelt although not confined to it. These taxa are also under immediate threat of major genetic erosion from salinisation and hydrological changes.

Areas affected by secondary salinisation show significant declines in vascular plant biodiversity and loss of structural diversity. Rich complex communities are replaced by a few succulent shrubs and weeds.

Outside of the Wheatbelt hydrological changes threaten the diverse floras of naturally saline landscapes and areas of species rich heathland and ephemeral wetlands of the northern sandplains and Swan Coastal Plain. The karst communities, both subterranean and surface heaths, of the northern Swan Coastal Plain are threatened by flooding and perhaps increased impact of diseases from *Phytophthora* species.

Fauna

Approximately 25% (31 of 125 species) of its small ground-dwelling vertebrates (mammals, reptiles and frogs) have distributions centred on the Wheatbelt or are endemic to it. At least 40% (210 of 500+ species) of the region's terrestrial invertebrates have distributions centred on the Wheatbelt or are endemic to it.

A significant decline in the biodiversity of terrestrial invertebrates is apparent at secondarily saline quadrats (even partially affected), which have an average of 30% fewer species than their non-salinised counterparts. This loss is actually higher as localised specialists are replaced by "weedy" generalist species.

Wetland Communities

Flora

The impacts are greatest low in the landscape in and around all wetland types. However as the terrestrial and wetland plant communities intergrade specific comment is made under Flora in the section above.

Fauna

Birds

Of the 61 more common waterbird species in the south-west, only 16 prefer strongly saline (more than 20,000 mg/L) or hypersaline (more than 50,000 mg/L) conditions. Data from a 1981-85 survey of the south-west showed that an average of five waterbird species used hypersaline wetlands, compared with 20 in saline wetlands and 40 in fresh wetlands containing live trees and shrubs. Death of shrubs and trees in many wheatbelt wetlands due to salinity has caused a 50% decrease in the number of waterbird species using them. If the trend of increasing salinity continues, only 16 species, plus three or four species that use freshwater dams, will persist in the Wheatbelt out of an original waterbird fauna of more than 60 species.

Invertebrates

In a preliminary analysis of the first 700 species recorded, 253 species (45%) were restricted to fresh water with salinity less than 3,000 mg/L. However, 35 of the species occur on granite rock outcrops where salinity is unlikely to occur, leaving 218 species (39% of the fauna) that are vulnerable to increasing salinity. If all wetlands in the Wheatbelt became saline (more than 10,000 mg/L), most of these 218 species will disappear from the Wheatbelt, despite the fauna being more saline tolerant than in eastern Australia.

Species richness declines with salinity and the average number of invertebrate species present in fresh wetlands is about 50, in wetlands with salinity 20,000 mg/L about 25, in wetlands with salinity 50,000 mg/L about 12 and in wetlands with salinity greater than 100,000 mg/L about four. As a rule of thumb, doubling salinity halves the number of aquatic invertebrate species.

Caveats that must be attached to the above statements at this stage of the work are that probably not all wetlands will become saline, some species will persist in dams, and many

species have ranges that extend outside the Wheatbelt.

Summary

The areas most immediately threatened by salinisation are the valley floors of the Wheatbelt. These areas affected by secondary salination show major declines in vascular plant and animal biodiversity. Rich complex communities are replaced by a few succulents and weeds. Similarly, major declines in diversity occur in animal communities where specialists are lost and/or replaced by generalist species.

Although dryland salinity is an Australian wide problem, information about the impact of hydrological change on biodiversity in Western Australia is more substantial than that of eastern Australia. For example, the Murray Darling Commission report on Salinity (Murray-Darling Basin Ministerial Council 1999) noted:

"No assessment has been made of the impact of dryland salinity on the biodiversity of the Murray-Darling Basin."

The challenge is what are we going to do with this new information? How to integrate these data into managing this changing landscape.

SALINITY IMPACTS ON WHEATBELT VALLEYS

We have already seen that the valley systems of the Wheatbelt contain a large component of the communities and species of the region threatened by salinisation. Since these areas are low in the landscape this is not surprising. In the final section on impacts we will consider the plant communities under threat from salinisation. These communities are the most readily understood and visible "management unit." They are the units for which all managers of lands can observe the visible signs of salinisation and can undertake intervention activities to maintain and monitor the results.

Non Saline Valley Floor Communities

A considerable diversity of tall woodlands of Wandoo (*E. wandoo*), Inland Wandoo (*E. capillosa*), Salmon Gum (*E. salmonophloia*), Red Morrell (*E. longicornis*), Black Morrell (*E. melanoxylon*) and Gimlet (*E. salubris*) once dominated the better drained heavy soils of the valley floors and slopes throughout the Wheatbelt. These woodlands generally extend into the adjacent pastoral regions. However, we know that the woodland understory varies across their range with rainfall and soil. These woodlands are now greatly fragmented but remain evocative of the area and are of considerable significance to our local and national heritage. The Wheatbelt will lose much of its local landscape character if they are lost.

In the south-east Wheatbelt there are woodlands of different composition, especially by dominant species (for example, *Eucalyptus ovularis*, *E. myriadena* and *E. flocktoniae*). In this area variable Mallee communities (*Eucalyptus platypus*, *E. celastroides*, *E. calycogona*, *E. cooperana*, *E. forrestiana* and *E. kessellii*) largely replace these woodlands on clays and calcareous clays and are being impacted by rising saline groundwaters.

There are also a number of possibly naturally rare woodlands, such as Lowland Brown Mallet (*E. astringens*) and Black Wandoo (*E. melanophitra*) that are also at risk.

Freshwater wetlands: (Creeks, Rivers, Lakes, Ephemeral wetlands)

Rivers in the incised western Wheatbelt are fringed by Flooded Gum (*Eucalyptus rudis*) communities and these are already greatly impacted by salinisation. Inland of these rivers, Flat Topped Yate woodlands (*E. occidentalis*) and its related Mallee form (*E. sporadica*) are dominant around small freshwater swamps and are also being impacted by salinisation and more frequent flooding.

The communities of lakes and ephemeral wetlands of the Wheatbelt contain an enormous diversity of plant communities depending on soil type and inundation, ranging from woodlands of *Melaleuca* species, through shrublands, heaths and sedgelands to aquatic herblands and are all under great threat. As an example Gibson and Keighery (2000) documented over 25 distinct wetland plant communities in the Muir – Unicup Recovery Catchment.

Rising groundwaters and drought are also causing stress of several of the major trees species of the western Wheatbelt such as Flooded Gum, Yate and Wandoo leading to increased insect and fungal attack.

Naturally Saline Habitats

These areas contain a diversity of Mallet (*Eucalyptus spathulata*), Mallee (including the oil Mallees, *E. suggrandis* and *E. vergrandis*), Woodland (*Casuarina obesa*, *Eucalyptus salicola*, *E. sargentii* and

E. kondinensis), shrubland, heath and herb communities that are at major risk from rising water tables. These areas probably contain the genetic biodiversity needed to find economic plants to revegetate the Wheatbelt for salinity control (e.g. the oil mallees, Broomebush (*Melaleuca uncinata*), saline adapted shrubs and bunch grasses).

The naturally saline areas of the Central/Western Wheatbelt are a priority for conservation because the threat of hydrological changes is more rapid and advanced in these areas. Although it could be argued that these areas are more resilient to change, the buffering effects are near exhaustion.

Summary

Salinity will impact on biodiversity of the Wheatbelt valleys at all levels of biodiversity - community, species and population in a wide variety of the organisms studied.

WHERE TO?

This section will briefly focus on how the biodiversity survey will aid aspects of tackling salinisation to protect biodiversity. The survey of the Wheatbelt will provide an overview of the patterning of many organisms across the region. It will enable the description and delineation of the areas with the most threatened communities and high levels of biodiversity. This will enable the selection of a further series of Biodiversity Recovery Catchments, in addition to the existing 6 recovery catchments, as outlined in the State Salinity Strategy.

The delineation of threatened species and communities will also be undertaken. A report on the conservation status of the vascular plants of the Wheatbelt is currently being prepared. Actions coordinated by CALMs Threatened Species and Communities Unit will target the most critically threatened communities and species for recovery actions.

The nature and degree of the impact on biodiversity at a site depends on a complex series of related hydrological factors. Crucially the time for impacts to develop fast in higher rainfall areas is a major determinant of options to protect remnant vegetation. How pervasive are the impacts in the valleys, depending on the effect of microtopographic relief? This still leads to increased fragmentation of remnants caused by salinity and these effects are still poorly understood. These areas of operational research need to be addressed in the future.

Clearly salinity is only one of the problems faced by biodiversity in the Wheatbelt. Broadscale clearing has led to fragmentation of remnants with all the attendant problems of edge effects, loss of genetic diversity, weeds, feral animals, losses of connectivity, disruption of ecological processes and unnatural disturbance regimes. Obviously to keep our marvellous and unique Wheatbelt plants and animals everyone needs to respect, value, appreciate and understand their local biodiversity. Hopefully the major outcome of the survey will be a major contribution to this process.

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