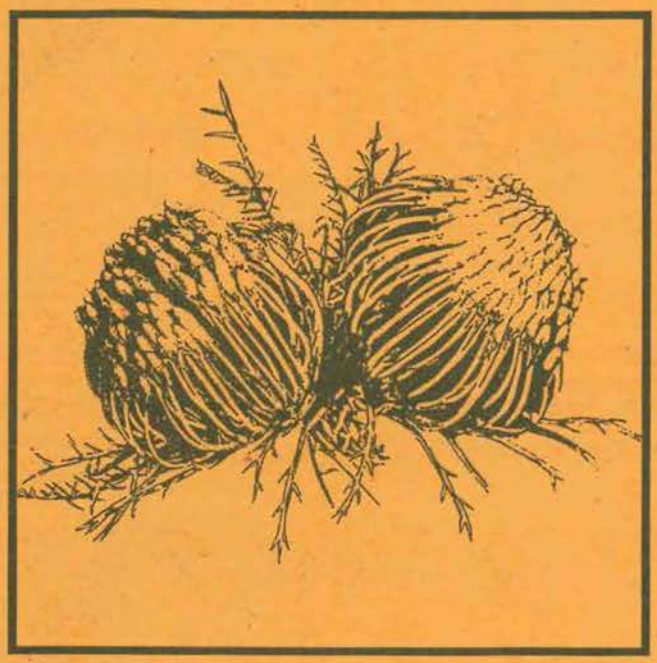
REMNANT NATIVE VEGETATION
TEN YEARS ON

A DECADE OF RESEARCH
AND MANAGEMENT



PROCEEDINGS OF THE
DRYANDRA WORKSHOP
SEPTEMBER 1993

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

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Seminar Convenor

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Introduction

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BACKGROUND TO SEMINAR

During the early 1980s, there were a number of changes that had important implications for nature conservation in agricultural areas of Western Australia. The most significant were:

- Sufficient rural land managers recognised the seriousness of land degradation to become interested in taking action, and the landcare movement was born in Western Australia. As rural communities began to understand that clearing of natural vegetation was a major cause of land degradation, many also began to accept that bushland is of value to agriculture. No longer was it considered merely a harbour for "vermin" and "noxious" species — useless, unproductive wasteland. Other factors also helped to change attitudes. For example, recent generations of farmers were not, or were minimally, involved in clearing bushland to create farmland. Their experience was not the same as that of older generations who worked hard to convert bushland, the "enemy". Barbara York Main (1993) discusses other factors that contributed to new, more positive attitudes towards bushland.

- The Department of Fisheries and Wildlife established the first rural-based management group for nature conservation, at Pingelly in 1978. This was followed by a management team based in the Katanning District in 1984. These two groups, now part of the Department of Conservation and Land Management (CALM), provided a core of rural-based land managers whose primary concern was nature conservation.

- The CSIRO Division of Wildlife and Ecology began an intensive research program on nature conservation in the Wheatbelt in 1984. The conjunction of this work with research by the Department of Agriculture, Water Authority of Western Australia, and CALM generated a large amount of information useful for management. Aside from work on nature conservation issues, research documenting hydrological changes in the landscape, and their relationship to bushland and revegetation, was vital in showing that solutions and theoretical concepts must be developed at landscape and regional scales.

- The seriousness and scale of landcare and nature conservation issues led to greater recognition of the need to manage across land ownership and tenure boundaries. (Interestingly, the promotion of this concept in relation to nature conservation, by Ian Crook, in about 1980 was probably too early for acceptance within the social and cultural environment of the time.)

Together, these changes stimulated a range of important research and management actions. Research actions, in particular, are summarised in a series of excellent workshops and conferences. For nature conservation, these are best exemplified by the "Nature Conservation" series and related workshops that began with "Nature Conservation: The Role of Remnants of Native Vegetation", held at Busselton in 1985.

Although land managers and planners, as well as researchers, were involved in these conferences, the primary focus was on research activities. While recognising the value of past research, Wheatbelt land managers within CALM, by the early 1990s, were beginning to ask: "What are the actual implications of this research for our day to day management?" Consequently, there were moves to convene a meeting of Wheatbelt managers and researchers to describe in detail the operational implications of the previous decade of research work.

About the same time, during a multi-disciplinary meeting at the CSIRO's office, Helena Valley, on integration of research in the Wheatbelt, the desire to hold a meeting to discuss research in agricultural areas was expressed.

Together, these two goals provided the impetus for a seminar at Dryandra in September 1993, aimed at discussing research and management in relation to remnants of native vegetation. Work from the previous decade was to be a particular focus.

Specific objectives for the seminar were:

- to list significant research results for remnant management;
- to assess whether conclusions from research had been implemented;
- to develop a list of actions to improve both the relevance of research and the implementation of its results.

SEMINAR PROCESS

To achieve these objectives, it was decided to hold a residential seminar at which a series of presentations by researchers and managers would be followed by workshops and plenary sessions. Those invited to the workshop represented a cross-section of land managers (including farmers), researchers and administrators working with remnants of native vegetation in the Wheatbelt. Thus, all those with a direct interest in the operational management of remnant vegetation were represented.

Throughout the seminar, participants were asked to keep in mind the following questions:

- Over the last decade, what research results, including reviews and theoretical work, have important implications for the management of remnant vegetation in south-western Australia?
- What do managers want from researchers?
- How well have managers implemented significant research findings?
- How well have researchers and managers liaised?
- How may research and management best be integrated?

Apart from review presentations for research (Denis Saunders) and management (Ken Wallace), and a special presentation by Bert Main, presenters were allowed only 10 minutes. Researchers were asked to spend about five minutes listing the management implications of their research, and five minutes on whether their research findings have been implemented. Conclusions were to include a listing of the three or four major issues which require resolution in order to improve the management of remnant vegetation. Researchers were asked not to present research data — that is, the seminar was intended to address the implications for management of past research, and was not an opportunity to present new data.

Managers were asked to spend five minutes discussing research results they have used in managing remnant vegetation, and a further five minutes discussing why these actions did or did not work. Conclusions were to include a list of major issues which require resolution in order to improve the management of remnant vegetation.

These constraints on presenters resulted in brief and pithy papers. They are not, nor were they intended to be, detailed, formal papers.

Following the presentations, a plenary session was held at which issues and workshop topics were developed. Participants then separated into workshop groups and discussed these topics. The workshop and plenary sessions are dealt with in detail on pages 69—88.

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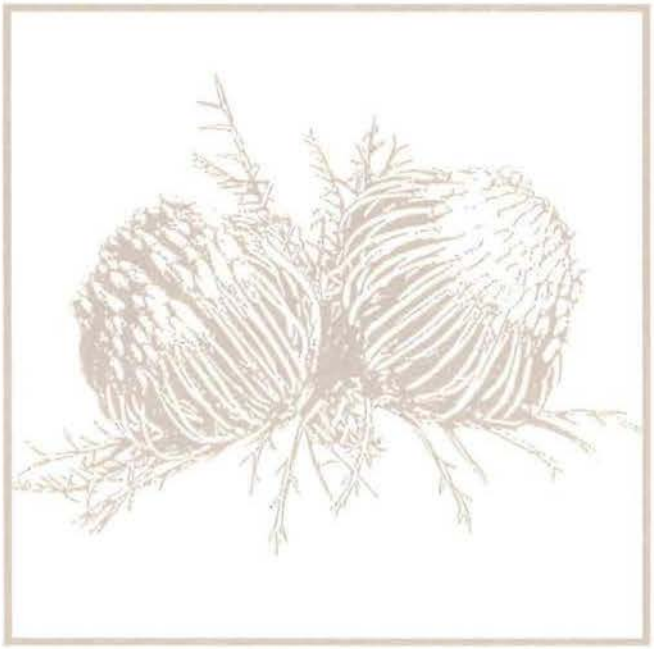
RESEARCHERS' PERSPECTIVES



Setting the Scene–Research on Remnants during the Past Decade

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INTRODUCTION

Although I have been asked by Ken Wallace to review the significant changes in research into remnants of native vegetation over the past decade, it is worth putting these changes into context by examining briefly the changes in attitudes towards remnants over the past three or four decades. Early attitudes were usually hostile, because remnants were seen as harbours for noxious weeds and vermin, particularly poison native plants, rabbits, and macropods (not necessarily in that order), or were regarded as wasteland covered with unsightly scrub. One only has to fly over the Wheatbelt and see how many remnants of native vegetation have gravel pits and rubbish dumps on them to gauge early attitudes towards remnants. These attitudes were reinforced by the feeling of many people that the landscape was alien and did not resemble the sorts of landscapes with which they felt most at home.

Barbara York Main (1993) discussed the effects of settlement by Europeans in the central Wheatbelt and pointed out the degrading consequences of this settlement on the landscape and on remnants of native vegetation. One simple and overlooked example was the role of domestic poultry in changing native vegetation. Main wrote that "Farm fowls (as well as turkeys and other poultry) have undoubtedly contributed to the destruction of the biological cohesiveness of the remnants associated with farmhouses".

Main also discussed the attitude at this period towards the land and its biota. This attitude is summarised in the praise by Sutton (1952, in Main 1993) of the settlers who conquered "forest wilderness" and turned "virgin lands" into "well-ordered farms and gardens". As Main pointed out, by the 1960s the only ungrazed remnants of native vegetation were the reserves set aside for public use, such as water reserves, townsites, and other utilities, or a number on private property.

Then, in the 1970s, attitudes towards native biota changed. Land degradation, the realisation that too much had been cleared in some areas, the strong interest in native plants, the loss of native species, the strong push for conservation through reserves, and a developing sense of "belonging to the landscape" all played a part in changing hostile attitudes towards native biota in general and remnants of native vegetation in particular. These changes were instrumental in a major push in the 1970s, by the WA Department of Fisheries and Wildlife, to have set aside, for the conservation of flora and fauna, as many of the significant Crown reserves in the Wheatbelt as possible. This meant that many of the larger remnants became flora and fauna reserves, or had conservation of flora and fauna added to their original gazetted purpose.

As part of this process in the early 1970s, the Department of Fisheries and Wildlife contracted the WA Museum to carry out a series of flora and vertebrate fauna surveys on 23 remnants of native vegetation the Department had recently acquired as conservation reserves. The aim of those surveys was to assess the conservation importance of the remnants in the extensively cleared Wheatbelt of Western Australia. The results of the surveys were published in a series of papers in *Biological Conservation, Australian Wildlife Research* and *Records of the Western Australian Museum*. The findings are interesting from both scientific and management points of view. The data they provided are still one of the best sets available on species–area relationships in fragmented landscapes, and have been widely quoted in the international scientific literature during the debates on the theory of island biogeography, a theory which has given little of practical importance to managers of conservation areas (Saunders *et al.* 1991). While it does provide an idea of how many species of selected taxa one can expect to occupy an area over time, it does not identify the species involved, which is of much greater importance and relevance to managers of conservation reserves.

The results of the surveys by the Museum gave some reasons for managers to be optimistic about the importance of the scattered conservation system in the Wheatbelt for the conservation of much of the remaining vertebrate biota. For example, Darryl Kitchener *et al.* (1980a, b) noted that remnants as small as 30 ha have value as sanctuaries for lizards (although varanids were not found on reserves under 272 ha) and specific mammal species, and are valuable conservation areas for plants. They noted (1980a) that "although the haphazardly spaced wheatbelt reserves are inadequate to preserve entire communities of large mammals and

apparently also of birds and snakes, we conclude that the reserve system is probably adequate to preserve representative lizard communities". They added (1980b) "that with careful management of the wheatbelt reserve system most of the native animal species still extant in this region should persist for periods within the time framework considered by contemporary conservationists ... (1 000 to 10 000 years)".

They also pointed out (1980b) that regardless of the size of the remnant, mammal species lost from particular remnants would almost certainly not re-establish themselves by natural processes, because the isolation of remnants had disrupted movements which would foster recolonisation in the event of local extirpation. Kitchener *et al.* (1982) noted that the long-term persistence of much of the avifauna of the Wheatbelt depended on the 500 randomly scattered nature reserves, occupying 2.4% of the area of the Wheatbelt. They were unable to indicate any loss of bird species from reserves during the period of land clearing in the Wheatbelt (the 70 years prior to their surveys), which they took to imply that loss of species of birds from reserves will be a slow process. They also pointed out that small nature reserves in the Wheatbelt are of value in the conservation of birds. They cited the example of East Yorkrakine Nature Reserve (north of Kellerberrin), which is 81 ha and during their surveys contained four species of passerines of vulnerable status, despite being isolated from other native vegetation for at least 50 years. They (1980b) did not believe that feral cats and foxes would have as severe an impact on native mammals in Wheatbelt remnants as cats have had on offshore islands.

While research over the next decade was to change some of these concepts dramatically, this early work by the WA Museum provided the vital foundation of information and ideas upon which new research developed the next generation of theories. Also, ideas developed by the Museum concerning issues such as the relationships between vegetation types and fauna, and the separation of the bird fauna into various categories depending on their tolerance of disturbance, were of real value to land managers.

This early work had one other important value. During the late 1970s and early 1980s, many people, including some land managers and academics, questioned the value of smaller remnants of vegetation. While predictions in the Museum papers concerning viability of remnants proved optimistic, their work did confirm the nature conservation values of small remnants and provided a counter to those who argued that small areas had no value.

RESEARCH OVER THE PAST DECADE

What has changed since the pioneering work of Darryl Kitchener and his colleagues, and what is the significance of the changes from a management point of view? In the first instance, remnants of native vegetation have had their profile lifted markedly, with a great deal of interest in them from research organisations, management agencies, agricultural advisers, funding agencies, and, most importantly, rural communities, including farmers and landcare groups (see Saunders *et al.* 1987, 1993; Saunders and Hobbs 1991; Hussey and Wallace 1993).

Research into remnants of native vegetation and their ecological role in the landscape over the past decade has indicated that we do not have any cause for optimism. Several irrefutable facts of relevance to management that have come out of research in the recent past are that remnants of native vegetation are degrading at rates that are measurable, and that species are still being lost. Without active management applied over the entire landscape, remnants will continue to degrade until this relaxation phase results in species-poorer animal and plant communities. Without major changes in management, there is no way that the collection of remnants in our conservation system will conserve the remaining native biota of the Wheatbelt over the next 100 years, let alone the 1 000 to 10 000 year timeframe that Kitchener and his colleagues suggested. We cannot afford to treat remnants as islands. If we take that approach, we will ignore the major degrading processes, most of which originate in the surrounding agricultural matrix.

Current State of Remnants

One of the most worrying research reports I have read recently is one written by Robert Lambeck and Jeremy Wallace (1993) on the assessment of the conservation value of remnants of native vegetation in the central Wheatbelt, using Landsat Thematic Mapper (TM) imagery. Their research showed that 70% of remaining native vegetation in the study area is not typical of the

unmodified vegetation types that characterised the central Wheatbelt prior to settlement by Europeans. In many of the remnants they examined, particularly the smaller ones, all of the vegetation within the remnant was spectrally unlike any of the flora regarded as indicative of that found before settlement last century. They concluded that the conservation value of many of the remnants has been seriously jeopardised, and they attributed the degradation to impacts of domestic livestock, clearing, invasion by weeds, harvesting of timber, mining of gravel and the dumping of rubbish (see also Arnold and Weeldenburg 1991). In their summary, they stated that only 3% of the original pre-clearing landscape remains in what could be regarded as good condition. They added the important rider that "The probability of such a small component of the landscape continuing to support the essential ecosystem processes that underpin regional biodiversity [is] extremely remote": I would have said it is impossible.

Representation of Remnants

Typically, remnants are small, and none are large enough to be driven by internal processes. All are now driven mainly by the ecological processes generated by the surrounding agricultural matrix. Remnants do not represent the pre-clearing range of animal and plant associations. The process of selection of land for agriculture and the process of fragmentation were not random. Plant communities were linked strongly to soil types, and because certain soil types were more suitable for agriculture than others, those soil types are poorly represented on remnants in agricultural areas. The Wheatbelt is no exception, and Graham Arnold and John Weeldenburg's (1991) study on the distribution and characteristics of native vegetation in the central Wheatbelt illustrates this point. For example, they found that the Merredin and Belka landforms, which formerly were dominated by salmon gum woodlands, occupied about 16% and 5%, respectively, of the landscape, yet they occupied only 6% and 1% of remnants. On the other hand, rock outcrops occupied only 4% of the area but represented 28% of the remnants. In addition, they found that 77% of remnant vegetation was privately owned. The implications of these results for management are serious and far-reaching. The soils regarded as indicative of good agricultural land, and any associated uncleared biota are poorly represented on conservation reserves. Woodlands are in this category, and if conservation of woodlands is an aim of management, then private land must be managed with that aim in mind. Private land now contains much of what must be regarded as our conservation estate. One of our challenges is to come up with ways to ensure that part of the conservation estate is managed with conservation as the primary function.

Native Vegetation Is Resistant

Research has shown that native vegetation is resistant to invasion by exotic vegetation, provided that the remnant vegetation is not disturbed or enriched with nutrients (Hobbs and Atkins 1988). Unfortunately, the agricultural matrix surrounding most remnant vegetation results in a wide range of disturbances and considerable nutrient enrichment. Ignoring the obvious and major disturbance of grazing by domestic livestock, and enrichment by fertiliser drift, how many times do we see dead sheep disposed of by throwing the carcases into the bush? As the carcases decompose, nutrients are released and scavenging animals scraping around the carcases disturb the area. Any seeds of weed species caught in the wool have an ideal bed on which to establish themselves. Similarly, the vegetation scraped from the edges of roads or firebreaks is usually piled in the bush and left. These piles, like the rotting carcases, are major foci of weed invasion along road verges and through many other remnants of native vegetation.

Remnants Are Influenced by the Surrounding Matrix and Have an Effect on the Surrounding Matrix

It is well known that the extensive clearing of native vegetation in the Wheatbelt has resulted in major changes in the hydrological balance, leading to widespread salination of susceptible areas. Nearly 20% of all cleared agricultural land may be useless for cereal cropping within the next 30 years because of increases in salt levels in the soil (Nulsen 1993). Ecological processes do not stop at legal boundaries, and remnants of native vegetation are being affected by increasing soil salinity. Position in the landscape does not necessarily guarantee immunity from degradation. For example, Durokoppin Nature Reserve is 1 100 ha and located in the highest point of the landscape at the top of two catchments. Because of the higher water use by remnant vegetation than by agricultural vegetation, watertables are up to 7 m lower under the reserve than under nearby agricultural land (McFarlane *et al.* 1993). Nonetheless, watertables are rising under the reserve as

water flows into the "hydrological shadow" and, if this continues, will probably reach the root level of the salmon gum woodland in the lower part of the reserve, with further loss of an already severely restricted vegetation type. At present, we do not know how many other remnants are threatened in this way. However, George and McFarlane (this volume) believe that a significant area of our conservation estate is under threat.

Remnants Are Still Degrading and Losing Species

The losses of native mammals from the Wheatbelt are well known (Burbidge and McKenzie 1989) and still continuing (Hobbs. *et al.* 1993a). Birds are demonstrating the same trends as the mammals. For example, of 192 species of birds recorded from the Wheatbelt since 1900, 96 species (50%) have decreased in range and/or abundance, and only nine (5%) have increased (Saunders 1993). Species are still being lost from the region, from districts and individual remnants (Saunders 1989). Kitchener *et al.* (1982) cited East Yorkrakine Nature Reserve as an example of the conservation value of small remnants for species dependent on native vegetation. In the period between these researchers' surveys in 1974 and the surveys by the CSIRO in 1988, three of the four species the former noted the reserve was of value for became extinct. In the Wheatbelt, a number of species dependent on native vegetation are located on remnants of native vegetation in populations which are too small to be viable. In addition, those populations are isolated from other such populations, and they are gradually becoming extinct because of a range of stochastic events. In this situation, the effects of the fox and cat on these isolated populations are much more severe than Kitchener and his colleagues predicted. The work of Jack Kinnear *et al.* (1988) and Tony Friend (1990) on relict populations of endangered marsupials are good examples of what we stand to lose if we fail to control foxes and cats throughout the Wheatbelt.

Remnants Must Be Managed in a Total Landscape Context

The take-home message regarding the management of remnants of native vegetation in the Wheatbelt must be that they cannot be managed in isolation. Any management which concentrates only on individual remnants, particularly those designated as conservation reserves, and ignores the surrounding agricultural matrix is doomed to failure and will continue the degrading processes which are leading to the loss of our unique biota. We need to get away from the single species–single remnant approach to management and concentrate on developing an integrated landscape approach which involves all of the people and groups engaged in management of elements of the Wheatbelt landscape (Hobbs and Saunders 1991, 1993; Hobbs *et al.*1993b). We need to work with all of these individuals and groups, to integrate our knowledge and use it to construct management models which aim to protect our remaining biological heritage within production-oriented agricultural landscapes. The aim of this workshop should be to come up with ways to assist us achieve that goal.

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Impact of Fire on Fauna in Remnant Vegetation–Research Findings and their Implications for Management

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INTRODUCTION

The following is a summary of the major findings from ongoing projects to research the impacts of experimental fires on small vertebrates and invertebrates inhabiting remnant shrubland and woodland vegetation in the Wheatbelt and South Coast regions of Western Australia. These studies have focused on Tutanning, Durokoppin and East Yorkrakine Nature Reserves in the Wheatbelt over the past seven years (1987–1993), and on the Stirling Range National Park between 1989 and 1992. For further detail on these areas, study design, and results, the reader is referred to Friend *et al.* (1989), Friend (1993), Friend and Williams (1993), Little and Friend (1993), and Strehlow (1993).

In addressing the primary aims put forward for the remnant vegetation workshop at Dryandra from the perspective of a research worker involved in this area, I have adopted a quite specific approach which refers to the first major objective: "To list, based on work in the South West over the last decade, significant research results and their implications for remnant management".

RESEARCH FINDINGS

Ten major research findings and their implications are listed in point form below, followed by their implications for management.

1. *Research finding:* The small vertebrate and invertebrate fauna inhabiting semi-arid woodlands and shrublands in Western Australia appears to be relatively resilient to single fire events of small scale and low to moderate intensity (but see point 7). The impact of repeated fires, however, is unknown.

   Management implications: Single fires may not be a great threat to fauna provided they are infrequent and of small scale relative to remnant size. It is essential that whole reserves are not burnt in one event, especially by a high intensity fire.

2. *Research finding:* Resilience may be greater in the seasonally dry shrublands and woodlands than in the more mesic but less seasonal habitats (for example, South West forests). Adaptations for seasonal aridity may impart considerable resilience to fire. However, despite this, fauna populations may change greatly under a regime of frequent fires. There are fire-sensitive species and habitats within the regions studied (for example, *Phascogale calura*, *Allocasuarina*, mygalomorph spiders) that require special consideration.

   Management implications: Management prescriptions developed for mesic areas (for example, jarrah forest, etc.) do not necessarily apply to semi-arid ecosystems. Some details of life history and habitat preferences are needed for all species, in order to decide appropriate management prescriptions (see also point 5).

3. *Research finding:* Frequency and scale of burns are probably the two most important factors to consider in fire management. There is no evidence from our studies (for example, in Stirling Range National Park, where both spring and autumn experimental burns have been conducted) that season of burn is of major significance, at least to invertebrates.

   Management implications: Burning should not be carried out too often, or on too large a scale (see also points 6 and 10).

4. *Research finding:* Post-fire response patterns of most small vertebrate groups are closely tied to (and may be predicted from) their shelter, food and breeding requirements (life history parameters).

   These patterns are as follows:
   - ❖ mammal responses are reasonably predictable;
   - ❖ reptiles somewhat less;
   - ❖ amphibia show little relationship.

   These patterns are derived from large-scale wildfires throughout temperate Australia. Data from our smaller scale and lower intensity mallee-heath fires, however, have not shown such clear trends for small mammals and reptiles.

   Management implications: A model to predict the broad impact of fire on small vertebrates is thus

possible, and indeed has been developed. A database of species' life history characteristics and probable post-fire response patterns can be linked to such a model. This needs further input of data and needs to be made accessible to managers.

5. *Research finding:* Given the above, fauna can be considered and grouped in terms of life history categories based on shelter and food requirements. Thus we do not have to worry about every species (for example, the 50 plus species in our Wheatbelt studies reduce to 16 life history categories).

   Management implications: The use of life history categories greatly simplifies the amount of information that managers need to consider when developing fire management plans.

6. *Research finding:* Results from space-for-time studies of potentially sensitive species in the Stirling Range National Park (for example, honey possum, *Tarsipes rostratus)* indicate clear trends with post-fire age of vegetation.

   Management implications: These data suggest a minimum time between burns in the Stirling Range National Park of 15–20 years (allowing some leeway). In the lower rainfall areas of the Wheatbelt region, where vegetative growth is slower, the minimum is likely to be 20–25 years.

7. *Research finding:* For invertebrates, the level of taxonomic resolution (that is, orders versus species level identifications) influences the results of studies on fire impact.

   Management implications: One cannot assume that all is well if looking at broad-scale taxonomic groupings, because responses are species-specific. Individual species may be markedly affected by fire (both increases and decreases), but at the order level of identification these trends will tend to cancel out and thus not be apparent.

8. *Research finding:* Particular groups of invertebrates which are long-lived and have special habitat requirements seem especially sensitive to fire. Such "indicator" species or groups (for example, mygalomorph spiders) set the limits for fire regimes.

   Management implications: Invertebrates may prove better indicators of seral status and appropriate fire regimes than higher organisms. Invertebrates should be included in fire ecology studies and, indeed, in biological surveys in general.

9. *Research finding:* Invertebrate abundance and composition do not correlate well with floristics or vegetation structure. Patterns which may exist are at a fine level of resolution.

   Management implications: Categorising and protecting areas on the basis of plant and vertebrate species richness does not necessarily ensure adequate conservation of invertebrates.

10. *Research finding:* With respect to animal abundance and composition, the synergistic effects of season, locality and year-to-year variability in climate, and stochastic events like droughts and locust plagues generally outweigh any changes attributable to fire alone. An excellent example of such synergistic impacts is the post-fire locust plague which eliminated *Allocasuarina* from an area burnt at Tutanning. This may lead to long-term impacts on stand structure and faunal abundance and composition, simply because these two events happened in tandem.

    Management implications: Fire managers need to take account of pre-fire conditions (for example, is drought in force or imminent?) before burning, but many post-fire events and outcomes are beyond the managers' control.

CONCLUSION

Given the importance of season, climate and stochastic events in determining species abundance and distribution patterns, the need for and use of fire as a routine management tool to maintain or increase faunal diversity needs to be carefully evaluated. At this stage in the development of our knowledge base, it is clearly better to err on the side of conservatism in formulating any fire regime for remnant shrubland and woodland habitats. As a general rule, larger scale block burning should not be carried out except in special

circumstances — for example, for specific regeneration purposes, experimental research or where it contributes to a well-considered strategic fire management objective. Protection of areas from large-scale, high-intensity wildfires through a system of internal and external low fuel zones should remain a high priority for managers of remnant vegetation.

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The Effect of Changing Hydrological Processes on Remnant Vegetation and Wetlands

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INTRODUCTION

Remnant vegetation and wetlands on both private and public land are rapidly being degraded by dryland salinity, inundation, silting, nutrient enrichment and weed invasion. Remnants in the lower parts of catchments are most affected. Many cannot be saved without expensive and integrated programs to reduce the degradation of agricultural catchments in which they are located. There is an urgent need to identify those remnants which have the highest values and for which cost-effective recovery plans can be developed. In most cases, it is not possible to manage these remnants in isolation from the surrounding catchment, and society will need to contribute to the cost of catchment management if the nature conservation values of these remnants are to be retained. Innovative methods need to be developed which maintain the nature conservation value of the remnants at the same time as increasing the soil conservation and farm production benefits that they provide for farmers. It is only when the on-farm remnants are seen as being important for land-holders that they will be properly managed.

This review concentrates on the hydrologic benefits afforded by remnants and the threat posed by hydrological forms of degradation. We have opted to use the case study approach to highlight the major issues affecting remnants in the Wheatbelt. Our case studies are mainly from our current and past research activities. A more detailed account of our research is presented elsewhere (George *et al.* in press).

HYDROLOGICAL PROCESSES IN REMNANT VEGETATION

Surface Hydrology

Mallees have been shown to harvest water with their vase-like branches, directing stem flow to their bases, where it infiltrates deeply beside roots (Nulsen *et al.* 1986). This practice reduces soil evaporation and provides the plants with water during the dry summer and autumn period. Salmon gums (*Eucalyptus salmonophloia*) and gimlets (*E. salubris*) also appear to harvest water, although no measurements have been made.

Water harvesting also appears to be occurring differentially in open areas between trees in the Wheatbelt. Nulsen *et al.* (1986) recorded up to 7.7 mm of overland flow coming from 4 m^2 plots in a bush catchment during a 30.9 mm storm. However, there was almost no runoff recorded from the catchment further downstream. Local redistribution of water among the vegetation accounted for the lack of stream flow. In contrast, organic crusts were suspected of causing low infiltration and sorptivity in four Wheatbelt soils within bushland in comparison with adjacent soils within cleared catchments (McFarlane *et al.* 1992a). Gravelly soils were also more water repellent before clearing. Soils in undisturbed remnants have low levels of the radioactive fallout product caesium-137, further indicating that there is considerable local redistribution of water in Wheatbelt remnants (McFarlane *et al.* 1992b). Infiltration must be concentrated at selected points, as little runoff is observed leaving remnant vegetation.

The fate of macropores formed by tree roots after clearing is poorly known. However, anecdotal evidence suggests that they become clogged or sealed, resulting in increased waterlogging of surface soils. Some remain open, as evidenced by the rapid responses by some watertables to rainfall (Engel *et al.* 1989; George *et al.* 1991).

Native C4 grasses have different water use patterns from introduced (predominantly annual) C3 plants. Prior to agricultural development, soils were wetter in spring and drier in autumn (Johnston 1993). Advantages of the native grasses include deeper rooting, greater water use, lower nutrient requirements and better distribution of feed throughout the year.

Groundwater Hydrology

There are numerous examples of groundwater levels rising after clearing of native vegetation in the Wheatbelt. Generally, water levels are rising by between 0.2 and 0.5 m per year in the above 500 mm rainfall zone, and by between 0.05 and 0.2 m per year in the below 500 mm rainfall zone (George 1992). In some higher rainfall areas, watertables have risen over 25 m since land clearing which occurred less than 80 years ago.

Recharge occurs throughout most of the landscape (George *et al.* 1991). Processes may differ depending on the soil type, and include:

- matrix recharge in soils with low water-holding capacities (for example, deep sands and gravels);
- matrix recharge in arkosic sands below granite outcrops;
- preferred pathway recharge in duplex soils on hillsides, and below sandplain seep discharges;
- preferred pathway and matrix recharge in inundated valleys after storms.

The proportion and total contribution of each form of recharge depend on the distribution of soils and landforms in each catchment. No study has accurately determined the relative contributions. From a management viewpoint, it makes most sense to reduce the recharge in that component which is most cost-effective or which offers other benefits (for example, drying out sandplain seeps, revegetating low-productivity rock outcrops, and draining duplex soils prone to waterlogging).

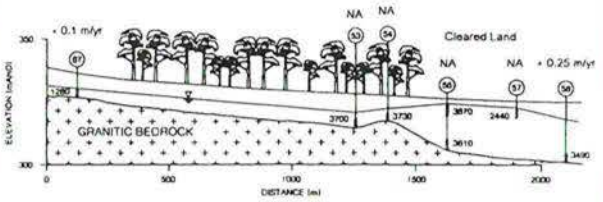
EFFECTS OF REMNANT VEGETATION ON LAND DEGRADATION

Salinity

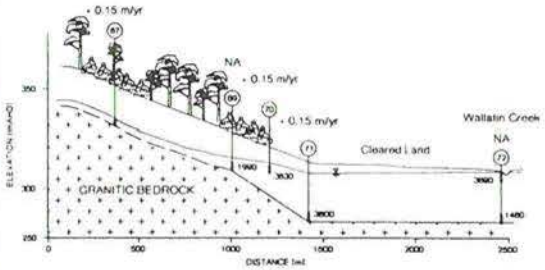
Transects of boreholes were drilled into Durokoppin and Kodj Kodjin Nature Reserves, to study the impact of native vegetation on dryland salinity in the adjoining catchments (McFarlane *et al.* 1992c). The watertables in both reserves are up to 7 m lower than in equivalent landscape positions in the adjoining cleared areas (Figure 1). Salinity affected only 0.1% of the farmland in the agricultural catchment that contains the reserves. In contrast, over 2.8% of the farmland in an extensively cleared adjoining catchment was salt-affected. Recent monitoring within the reserves indicates that watertables are rising at about 0.15 m per year, suggesting that groundwater is moving into the reserves from surrounding land. High groundwater levels under cleared areas next to the Durokoppin Nature Reserve are beginning to affect the south-western and south-eastern parts of the reserve. However, both Durokoppin and Kodj Kodjin Nature

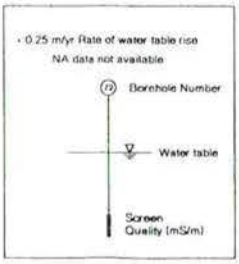
Figure 1. Lower groundwater levels under native vegetation in nature reserves from George *et al.* in press.

A. Durokoppin Nature Reserve



B. Kodj Kodjin Nature Reserve





Reserves appear to be safe from major salinisation, as the reserves occupy most of their catchments.

Eutrophication

Dense native vegetation around streamlines is seen as one of the most effective means whereby phosphate attached to suspended sediment can be removed from runoff before it enters estuaries (David Weaver pers. comm.). Weaver (1991) noted that up to 60% of the total phosphate washed into the Kalgan River in 1991 was attached to mobile sediment.

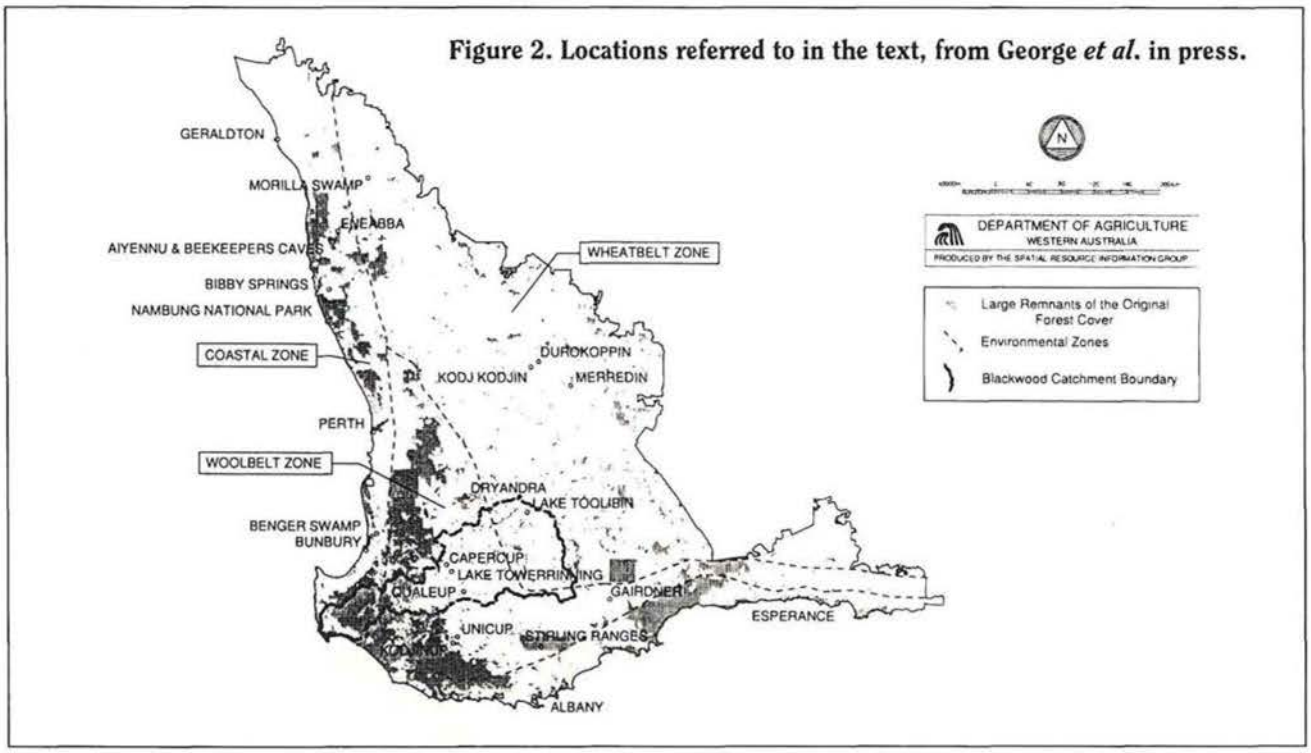


Figure 2. Locations referred to in the text, from George *et al.* in press.

LAND DEGRADATION AND REMNANT VEGETATION

Salinity — Public Land

Olsen and Skitmore (1991) reviewed the effect of salinity, erosion, sedimentation, eutrophication and weed invasion on the state of the rivers in Western Australia. Some of these rivers form corridors of public land through farmland (for example, Kalgan River), whereas others are privately owned. Few rivers are fenced to protect them from stock, although there are projects under way to fence some riverine vegetation — for example, parts of the Denmark, Avon and Kalgan rivers.

The effects of high groundwater levels under cleared areas next to the Durokoppin Nature Reserve are described in the previous section. This case study is an example of the hydrological relationships that may be expected for remnants high in the landscape, at least in the eastern Wheatbelt. Effects lower in the landscape have been, and will continue to be, more dramatic.

Toolibin Lake is located in the middle of a broad valley in a catchment which is 92% cleared of native vegetation. Saline runoff and rising groundwaters threaten the lake and its reserves (Stokes and Sheridan 1985; McFarlane *et al.* 1989). Increased frequency of inundation is thought to be contributing to the death of fringing species (Mattiske 1982). Active intervention is being undertaken, and both a technical advisory group and a recovery team have been appointed to begin the task of protecting the lake and its flora and fauna (Toolibin Lake Recovery Team and Toolibin Lake Technical Advisory Group 1994). Works to by-pass highly saline surface flows around the Lake have been completed in conjunction with catchment and reserve drainage schemes. Groundwater pumping and other actions are planned. It is likely that the only way to preserve the Toolibin environment will be to isolate it from the catchment in order to prevent saline waters from entering it on all but very wet years. Issues raised by work at Toolibin are as follows:

- Toolibin and its reserves will become badly degraded unless protected from saline groundwaters and saline runoff.
- The ecological value of the lakes needs to be clearly enunciated by both the local communities and the managing agency.
- Protection carries large implementation and running costs.

- ❖ Restoration of the pre-clearing environment may never be possible. Moreover, the preservation of remnant ecosystems appears impossible in Wheatbelt landscapes. Conservation of selected components may be all that is practical.

There are many other examples of threatened nature reserves. Capercup Nature Reserve is a wandoo (*E. wandoo*) woodland located 5 km west of Duranillin. Recent drilling has shown that the reserve has very saline groundwaters (2 000– 6 000 mS/m) within 2 m of the surface on its western side. The groundwater is as close, but much fresher (300 mS/m), on its eastern side. Most of the adjoining catchment has been cleared in the last 15 to 30 years, and groundwater levels are believed to be rising by between 0.3 and 0.5 m per year. It is likely that the western side will begin dying in the next few years, and about 50% of the reserve will be affected within the next decade.

Kulikup Lake, another nature reserve, is located 15 km east of Boyup Brook. It is covered by reeds and fringed with paperbarks, wandoo and flooded gums. At present, the lake appears to be safe from salinity for about 20 years, as the watertable is over 9 m below the surface and has a moderate salinity (450 mS/m). The Department of Conservation and Land Management (CALM) has monitored the surface water in the lake for over a decade. We believe groundwater monitoring is essential in all nature reserves.

The Qualeup lakes and associated nature reserves are located 25 km west of Kojonup, and range in cover from reed beds and paperback swamps, to wandoo and flooded gum (*E. rudis*) woodlands. In some cases, the lakes already have saline springs emerging within them (Wardles Bush Lake — not a reserve); in others, the watertable is still 4–11 m below the lake's floor (Wardles Grassy Lake, catchment 60% cleared). At Qualeup Lake itself, the watertable is near the surface on the western side and about 4 m below on its eastern side. The waters are saline (500–2 000 mS/m). Qualeup Lake will begin to deteriorate in the next five years.

Groundwaters responsible for salinisation in the Capercup, Kulikup and Qualeup reserves are difficult to manage, as they are often contained in fault zones or small artesian fluvio-lacustrine deposits. The lakes and wetlands contain some species of native, perennial shrubs and grasses that may have agricultural value.

Issues that this section has raised are as follows:

- ❖ CALM and associated agencies must begin a program of risk evaluation for the reserves they manage.

- ❖ Drilling observation wells in threatened reserves should be a major target for the next five years.

- ❖ The reality is that many reserves may die before management plans are implemented. This should be noted from the risk evaluation program.

- ❖ Programs to preserve the genetic diversity of threatened reserves should be commenced (for example, seed collection schemes).

Salinity — Remnants on Private Land

Saline groundwaters are rising around the Pallinup River as a result of land clearing. Saline seeps around the river are affecting native vegetation on both private and public land. Natural drainage in the Wellstead area is into yate (*E. occidentalis*) swamps that were perched above the regional groundwater system. Rates of groundwater rise of about 0.3 m per year have been reported from the western south coast over the last 19 years (McFarlane 1992), and many lakes are now becoming salt-affected.

Yate swamps throughout the south coast are under similar threat.

In some places, the yate swamps are the major form of remnant vegetation. Their loss would greatly reduce the habitat for fauna in the region. Unfortunately, it will be difficult to prevent groundwaters from rising in these areas without major changes to farming systems. Crops and pastures are affected by waterlogging, and the main outlets for drainage of this land are the swamps. There have been no definitive studies of the long-term costs and benefits of drainage practices.

Valleys containing wandoo remnants north-west and south-west of the Qualeup lakes are beginning to become saline, and swampy areas have begun to die. Hillside seeps have developed above lakes on many properties, and saline water is collecting in them.

Gibbs Swamp is a small lake on private land about 15 km west of Boyup Brook. The lake is covered by flooded gum and paperbark communities. The local catchment group (Boree Gully) has successfully established local vegetation near the swamp. Drilling has shown that both the deep and shallow aquifers are highly saline (1 200–2 000 mS/m) and that the shallow watertable may already be adversely affecting the swamp. Monitoring has been started, to evaluate whether the revegetation will be successful.

Drilling under wandoo vegetation on the Boyup Brook Golf Course located very saline groundwaters (7 000 mS/m) which are discharging from a clayey regolith. It is sobering to note that the golf course design, essentially based on 'alleys', with 30–40% of the lower catchment under woody perennial vegetation, is inadequate to prevent salinisation and death of the wandoo trees.

On properties near Duranillin, large areas of valley remnants of wandoo and associated species have been fenced from stock. However, rising watertables threaten many of these remnants.

Many lakes and wetlands in the Unicup area are also beginning to degrade as a result of clearing in the 1970s and 1980s. Saline waters flowing from the Unicup lakes and surrounding farmland threaten Kodjinup Lake and its reserve, and the Buranganup Plain wetlands. On some farms, lakes are beginning to fill with groundwater, and overflow, their highly saline waters (2 000–6 000 mS/m) causing pollution. This is also happening in saline lakes within some reserves (for example, Pindicup Lake). Both these lakes overflow into adjoining reserves.

The points that these investigations have raised are as follows:

- Farmers who have fenced and protected valley remnants may not gain much value from their investment. In particular, wandoo woodlands and yate swamps that occur in valleys are under threat.

- Drainage may be essential to maintain the productivity of farmland and to preserve the lakes and wetlands.

- In the Unicup area, lakes on both farmland and reserves are filling, and saline water is beginning to affect other reserves downstream. Active drainage systems are required urgently.

RECOMMENDED ACTIONS

- The beneficial and detrimental effects of agricultural drainage on the long-term viability of remnants in representative areas of the South West need to be established. Studies which concentrate on the short-term effects of drainage on the remnant and ignore what is happening in the rest of the catchment are likely to be misleading.

- There is an urgent need to identify those remnants that have the highest values and for which cost-effective recovery plans can be developed. Groundwater monitoring is needed, to identify areas that are at risk and may be helped by early intervention.

- Understanding the water relations of native vegetation may be essential for its management and rehabilitation, particularly if water harvesting is as important as it appears in undisturbed remnants. Understanding how native plants manage water may also enable agricultural systems to be developed which result in less degradation. For example, understanding how moort (*E. platypus*) grows so well in sodic grey clays may help the management of these problem soils.

- Forest and woodland ecologists should become much more involved in the development of productive agricultural systems that will reduce the negative impacts of the current systems on remnants.

CONCLUSIONS

Developing economic products from our remnant stands of native vegetation must become a prime role for the new generation of researchers. There is little or no practical use in studying plants and animals that are threatened if a similar amount of time is not put into developing solutions to eradicate the factors leading to their demise. If we fail in this task, within our lifetime we will probably lose over 80% of remnant ecosystems on private land and as much as 50% within public reserves.

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Research into Remnant Management Issues: Nuts and Bolts and the Big Picture

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INTRODUCTION

Plant ecological research at the Kellerberrin study site over the past nine years can be separated into four main areas:

- survey and collection;
- basic research on ecological processes;
- review and synthesis;
- "advancement of theory".

Here I outline the major components of each of these, indicate relevance to management where applicable, and discuss the ease with which results from each can be utilised by managers. I suggest that only results from the review and synthesis phase can be transferred effectively to management.

SURVEY AND COLLECTION

An important and ongoing component of the research has been documentation of the flora and vegetation of the region. This has consisted of intensive specimen collection and identification, intensive vegetation surveys of particular areas, and more extensive surveys of the study area and beyond. In addition, the use of remote sensing as a rapid assessment technique was explored (Hobbs *et al.* 1989). None of this work has any direct management application, apart from the provision of information on new localities for rare and endangered flora. Nevertheless, the work has formed the background to much of the research conducted in the area. The taxonomic knowledge and information on plant distributions have also been utilised extensively by others, and provided a basis for the development of a revegetation guide (see section on "Review and Synthesis").

BASIC RESEARCH ON ECOLOGICAL PROCESSES

This work has focused on factors which impact on native vegetation in remnants. In particular, fire, weed invasion, grazing, and interactions between these have been investigated, and the relevance of these factors to rehabilitation of degraded areas has been assessed.

Much of the work on fire is still in progress, but the experimental fire program at Kellerberrin has indicated that patch burns within remnant areas are possible, and can be conducted with little risk to surrounding areas. Initial results indicate that post-fire vegetation recovery is good and that fire stimulates regeneration of a wide suite of species. The studies lack generality, however, and yield little useful information on the effects of variation in fire regimes.

Studies on weed invasion and control have highlighted the importance of disturbance and nutrient additions to the facilitation of invasion (Hobbs and Atkins 1988; Hobbs 1989, 1991a). We have shown that fire need not enhance weed invasion, but that roadside vegetation is an important exception to this (Hobbs and Atkins 1991; Hester and Hobbs 1992). Weed control may enhance regeneration of some tree species, but is expensive and time-consuming (Hobbs *et al.* 1993a). Grazing studies have highlighted the role of sheep grazing in promoting weeds (Scougall *et al.* 1993). Indeed, the effects of grazing are extensive and pervasive, and affect not just the vegetation but also soil characteristics. All these factors have important implications for rehabilitation. In particular, in many cases fencing is not enough to encourage regeneration, and more intensive management is required (Hobbs 1991b).

REVIEW AND SYNTHESIS

In conjunction with others, we have made several attempts to synthesise results to date and to mesh these with other relevant work. The outcome of workshops on corridors and landscape reconstruction has been a synthesis of existing information on these areas, and a heightened awareness of the issues involved on the part of the wider community (Saunders and Hobbs 1991; Saunders *et al.* 1993). The effectiveness of this has been increased by these publications being used for material by magazines such as *Ecos* and *Rural Research*, and by other media exposure.

The most important synthesis work was, to my mind, the Rottnest workshop, which resulted in the production of the Springer-Verlag book *Reintegrating Fragmented Landscapes* (Hobbs and Saunders 1993) and the *Revegetation Guide to the Central Wheatbelt* (Lefroy *et al.* 1991). The first of these collected available information, from numerous disciplines, on the history of development in the central Wheatbelt, its current

problems and its potential solutions. It represents an attempt to provide an integrated approach to the region's problems, and has been used extensively, both on a local scale by catchment groups and universities teaching inland management courses, and more widely on a national and international scale.

The aim of the revegetation guide was to provide a "user-friendly" version of information gathered in the Springer-Verlag book. It was developed in consultation with managers and was aimed directly at them. It was well received when published, and a subsequent survey has indicated that it has had a reasonable rate of use. Of 100 households contacted one year after the publication of the guide, 50 remembered receiving it, 25 had used it and six stated that it had changed their management methods. The guide has also been used as a model for similar guides in the northern and southern Wheatbelt and elsewhere in Australia.

"ADVANCEMENT OF THEORY"

An important part of our research serves not only the management community but also the broad scientific community. Advancement of theory in the sciences of conservation biology and landscape ecology is an important step in ensuring that research carried out by scientists may be integrated and useful in a management context (Hobbs 1992a, b; Hobbs and Huenneke 1992; Hobbs 1993a, b; Hobbs *et al.* 1993b). We have been emphasising that much conservation science has little to do with real world situations, and that there is little time to waste on research which does not address real world problems. We have had some success in doing this, and our Western Australian laboratory is recognised as a leading group in conservation biology and landscape ecology. This in itself is important in promoting the transfer of research findings: acceptance is more likely if the promulgators are recognised leaders in their field.

IMPORTANT ISSUES TO BE FLAGGED FROM THE RESEARCH

The research to date has highlighted the following areas which deserve attention:

- External influences on remnants, and the need for a landscape context are important (Saunders *et al.* 1991; Hobbs 1993b). Remnant management is (or should be) mostly concerned with problems arising outside the remnant, but this is not necessarily recognised.

- The research brings into question the extent to which rehabilitation of degraded remnants is practical. Rehabilitation is possible, but is not easy and may be expensive. Can we expect extensive rehabilitation programs to occur?

- What is the correct emphasis between revegetation and remnant management? Both are valuable, but, given a choice, which is better to pursue?

- The latter questions are predicated on the larger question of "what are the conservation and management priorities?". These are poorly defined except in broad "motherhood" terms, but are essential if research is to address the relevant questions.

CONCLUSIONS: NUTS AND BOLTS AND THE BIG PICTURE

Initially when writing this paper, I found it hard to place much of the research conducted over the past nine years in a useful management context. It then became apparent that, on their own, individual bits of research resulting in individual research papers were seldom of direct use. They are an essential part of the process of examining the "nuts and bolts" of the problems being addressed, but do not necessarily plug straight into a management problem, except in a very broad sense. It is only when a number of such individual pieces of research are linked together, either by the individual researcher, or in conjunction with other researchers and managers, that the relevance to management becomes more apparent. The assembly of a "big picture" enables all the individual bits of research to be placed in context and to be made more readily accessible to managers. This process of assembling the "big picture" entails stepping back from the field quadrat or mist net or whatever, and taking stock of what the information already gathered can tell us. This pursuit has, in the past, not been accorded the same scientific merit as going out and discovering really exciting new things. However, this is changing, which is just as well, since I conclude that the synthesis process is essential if the transfer of research findings to management is to succeed.

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Gondwanan Botany: A Perspective on Remnant Management in South-West Australia

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INTRODUCTION

Botanical research in vegetation remnants of south-western Australia has been increasing over several decades. This has led to a new Gondwanan perspective on the flora, which has significant implications for management. In this extended abstract, I aim to summarise some pertinent research results, highlight their management implementation, and conclude with recommendations for achieving better integration of research and management. Due to the required length of the paper, factual material is not referenced. For further information, interested readers should consult references in Hopper (1979, 1992), Hopper *et al.* (1990), and the popular reviews of Australia's fossil record by White (1986, 1990) and Rich and Rich (1993).

SIGNIFICANT RESEARCH RESULTS — THE GONDWANAN PERSPECTIVE

A new and deeper appreciation of the great antiquity and unique attributes of the south-western flora has emerged in recent years. The present-day flora sits on a landscape that has not been glaciated since the Permian (260 million years ago), and has remained above sea level, sometimes as an island, during all subsequent inundations of the Australian component of Gondwana.

The terrain of the South West, mountainous when Triassic-Cretaceous dinosaurs dominated the fauna, has been progressively eroded flat to the point where most soils are highly impoverished of nutrients, and drainage inland of the Meckering Line is largely uncoordinated and incapable of flushing salt from the system.

The flora has responded to this unique environmental history in ways quite different to those of the very recent, invasive, post-glacial floras of Europe and North America about which most botanical science and teaching are based. For example, the gathering and storing of nutrients from highly infertile soils has placed a selective premium on the evolution of novel root systems — for example, the fine mat of subsurface proteoid roots of banksias, or symbiotic partnerships with soil microorganisms such as mycorrhizal fungi. The diversity of such fungi has scarcely been documented, but Syme's discovery of more than 300 macrofungi in Two Peoples Bay Nature Reserve suggests a complexity equal to that of the better documented flowering plants.

The 50 million year old fossil banksias from the Kennedy Range inland from Carnarvon indicate the great antiquity of some extant south-western genera, and suggest that much of the diversity in wildflowers we see today originated when dinosaurs probably grazed the then mountainous terrain of the South West.

Superimposed on the great antiquity of components of the flora have been opportunities for explosive speciation among the relatively few genera that survived the onset of aridity and great extinction of the south-western rainforests that dominated our vegetation for much of the last 100 million years. The progressive aridity began some seven million years ago as Australia drifted northwards from Antarctica. A Mediterranean climate became established, and the South West then entered a period of climatic turbulence during the ice ages of the past two million years. This precipitated differential soil erosion, with the present-day Wheatbelt from Shark Bay to Israelite Bay experiencing greater climatic and erosional change than either the high-rainfall forests or the arid interior.

The flora responded dramatically, with rapid evolution yielding one of the world's richest wildflower regions. The South West has an estimated 8 000 species, 75% of which are to be found nowhere else, 30% are yet to be described by botanists, and possibly as much as 75% are yet to be grown in cultivation.

Plant biodiversity, consequently, is concentrated in complex patterns in Wheatbelt remnants, with rapid turnover across landscapes. Lateritic uplands, for example, as little as half a kilometre apart, may have less than 50% of their species in common. Distinctive floras are evident over short distances as one travels through the Wheatbelt. Burgman's (1988) studies between Ravensthorpe and Cape Arid National Park indicated that nature reserves need replication every 15 km in mallee, to capture most plant diversity.

Not surprisingly, threatened plants are concentrated in Wheatbelt remnants, and are less frequent in the forests to the south-west or in the arid zone inland.

Threatening processes, largely attributable to human activity, include land clearance, rising saline watertables, nutrient poisoning through fertiliser usage, grazing by exotic animals, inappropriate fire regimes, weed invasion, disease, harvest and eradication of economic wild species, and loss of native animals and the ecological processes they supported.

Moreover, it is evident that the recruitment biology of native plants is complex, and restoration of plant communities is very challenging. For example, Wheatbelt granite outcrops have exceptionally rich floras, with high numbers of fire-sensitive plants, whose management has yet to be investigated in any detail.

Despite the above challenges, conservation of intact remnants is very cost-effective, and remains the highest priority strategy from a biodiversity perspective.

MANAGEMENT IMPLEMENTATION

Remnant conservation programs on private and Crown lands should be managed in a way which recognises the high turnover of plant diversity in the landscape. In particular, a high degree of geographical replication is called for. However, a floristically complex vegetation and paucity of botanists have hampered the general inventory of remnants, and have led to difficulties in developing local district management priorities to maximise conservation of plant diversity.

Threatened plant distribution and abundance data have been effectively included in management considerations in some districts, but poorly in others (dependent on interest of local communities). More integrated efforts are required.

As would be expected, active management of remnants to maintain plant biodiversity is embryonic, as is research. Management has quite rightly focused on stemming the tide of direct human destruction and degradation of remnants. However, we have reached the point where active restoration management is needed. It is here that the Gondwanan perspective has much to contribute.

RECOMMENDED ACTIONS

Firstly, I firmly believe that botanical researchers need to focus more on communicating their findings in plain concise English to the media and public, and especially to managers. Botanists need to monitor public understanding and use of their results as much as how often papers are quoted in the scientific literature.

Secondly, integrated research approaches are essential. A combination of process research (necessarily confined to few sites) and descriptive research (wider geographical scope) is needed to yield cost-effective and efficient conservation of biodiversity.

Thirdly, it is vital that there be collaborative interaction of managers and researchers, combining the operational and investigative skills of each group — for example, in long-term monitoring and experimental management.

In terms of applicable prescriptions, in view of the floristic complexity to be found in remnants, conservative management and highly replicated conservation activities across the landscape are recommended, focused on intact remnants with the highest biodiversity (genetic, specific, community, landscape — for example, the Stirling Range, Fitzgerald River, and Lesueur national parks, remnants in the western central Wheatbelt, granite outcrops).

I would suggest that managers need to pay more consistent attention to ensuring biodiversity conservation in remnants — local activity must be integrated with regional and global goals. This will occur if clear objectives, integrated actions and performance-measured outcomes are required for both research and management of remnants.

Finally, we need to become Gondwanan botanists and managers. We are dealing with an incredibly diverse flora of great evolutionary antiquity. Many components are poisoned by conventional fertilising and watering regimes. They respond to disturbance in new and often unpredictable ways. Their recruitment is triggered by a range of cues whose significance is only just becoming apparent. Even the ubiquitous impact of fire on germination and flowering has remained enigmatic for large numbers of species, and has defied traditional research tools developed on northern hemisphere floras (although recent experiments with smoke-induced germination by Kings Park and Botanic Garden staff show significant promise). Few other regions of the

world demand such urgent and integrated collaboration of researchers and managers to meet conservation aims.

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The Exotic Predator Problem

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INTRODUCTION

Fifteen years ago, when I joined the Department of Fisheries and Wildlife, fire ecology was the dominant research topic of the day. Medium-sized marsupials were either rare or extinct over much of mainland Western Australia, and those populations that were previously locally abundant had crashed. It was speculated that their demise was possibly due to drought and a variety of other causes — for example, inappropriate burning regimes, fragmentation of habitats beset by a variety of man-made disturbances, diseases, and climatic changes, to list a few. Clearly, it was a situation that held little scope for optimism.

My own views were strongly biased towards a nutritional explanation. Having worked with high-density populations of island macropods which experience seasonal nutritional stress, the idea of drought-induced mortality coupled with a reduced reproductive rate seemed to be an eminently reasonable explanation, at least for the recent declines. The puzzling aspect was: why no recovery following the end of the drought?

I abandoned this nutritional hypothesis after two years of research on Wheatbelt rock-wallabies (*Petrogale lateralis*), because, contrary to expectations, the supporting evidence for nutritional stress was negative even during a declared drought year. Accordingly, we were confronted with this question: given a fit, healthy population producing young, why the low numbers and why no population growth?

These questions were answered by my research on rock-wallabies living on remnant vegetation in the central Wheatbelt. In this area, we found that fox (*Vulpes vulpes*) predation was the primary factor controlling population numbers. By reducing fox populations through baiting, we were able to reverse the parlous situation of the rock-wallaby.

Baiting programs, now operational on several Wheatbelt reserves, have produced comparable reversals for other species. Tammars (*Macropus eugenii*), brush-tail possums (*Trichosurus vulpecula*), woylies (*Bettongia penicillata*), and numbats (*Myrmecobius fasciatus*) have increased appreciably and can be sighted on most occasions, with little effort, where baiting programs have been implemented. Elsewhere, chuditch (*Dasyurus geoffroii*) and ring-tail possums (*Pseudocheirus peregrinus*) have increased in response to baiting regimes. Bandicoots (*Isoodon obesulus*) have been successfully translocated to the Tutanning Nature Reserve, from where they had disappeared (Friend, pers. comm.). There are some indications that the populations of brush wallabies *(Macropus irma)* may also be significantly affected by foxes.

To summarise, medium-sized marsupial populations persisting on Wheatbelt nature reserves existed at low densities or, if locally abundant, crashed in the 1970s and did not recover spontaneously. Some populations declined to extinction. Recovery to conspicuously higher densities ensued under fox baiting programs.

ECOLOGICAL IMPLICATIONS

The message for management is this: in the absence of exotic predator management, medium-sized marsupials experience great difficulties in maintaining viable populations on Wheatbelt reserves (and, for that matter, on other more extensive Crown lands as well). This suggests that the fox is acting as an efficient biocontrol agent affecting a suite of marsupial species and likewise some ground-dwelling or ground-nesting birds (for example, malleefowl *Leipoa ocellata*).

In situations where medium-sized marsupials persist in the absence of predator control, population densities are invariably low. These sites should be viewed as predation refuges that promote survival but do not guarantee population viability.

Predator removal results not only in population increases but also in habitat shifts (that is, expansion of the realised niche) by affected species. Predator control enables affected species to move out from refuge areas and utilise habitat denied to them in the presence of predators. Destruction or disturbance of these predation refuges — for example, through bushland clearing or fire — greatly increases the risk of extinction in the absence of predator control.

In the past, lack of knowledge about the impact of exotic predators has led to distorted ecological perceptions regarding the habitat requirements of species affected by predators. Habitat requirements have been equated to predation refuges, which are characterised by protective cover with food nearby; these refuge sites are not necessarily typical of a species' habitat requirements (niche). Failure to realise this leads to interpretations which promote the view that habitat loss is the major factor causing the demise of many marsupial species. A corollary to this reasoning is the inference that medium-sized marsupials are intolerant to disturbance and thus can only persist in near-pristine environments. Clearly, these concepts should be re-examined in the light of current evidence.

IMPLICATIONS FOR MANAGEMENT

The objective of research into fox control was to test the hypothesis that fox predation is a limiting factor affecting population dynamics of native marsupials — hence the need to nullify as far as possible the impact of fox predation. This has led to baiting procedures for small nature reserves that may well be excessive for management purposes.

Nonetheless, it should be borne in mind that near total removal of foxes by intensive baiting provides a measure of the carrying capacity of a reserve for medium-sized marsupials. This step is mandatory if other limiting factors are to be identified.

Finding the optimum, cost-effective level for baiting will not be a quick or easy exercise. The baiting effort will need to be manipulated and the prey response monitored. Such research raises a difficult question: at what densities should recovered populations be managed? Fifty per cent of carrying capacity? More, or less?

Notwithstanding the above, and to complicate matters even further, there is some evidence that the predation pressure exerted by foxes is variable. Data from the rock-wallaby study (Kinnear unpublished) implies that fox predation is likely to be episodic. The message here is that short-term studies may well result in conflicting and confusing outcomes.

INTERACTIONS WITH OTHER LIMITING FACTORS

Inevitably, periods of drought can be expected to lower the carrying capacity of a reserve, leading to mortality among populations of medium-sized marsupials. Mortality could well be exacerbated due to invading foxes switching from collapsed populations of alternative prey, such as rabbits, on adjacent farmland. Likewise, bushfires, naturally occurring or otherwise, may well increase the predation risk to medium-sized marsupials.

In both of these situations, a higher level of baiting may be required, to avoid excessive losses of medium-sized marsupials. It is likely that a higher level of baiting will need to be maintained during the recovery phase, particularly if the prey numbers are low.

THE FUTURE

The demonstration that control of exotic predators results in recovery of some populations of medium-sized marsupials on Wheatbelt reserves studied should put paid to the prevalent view that habitat loss or degradation has been the single cause of their demise. That some of these species increase significantly in numbers when fox predation is eased shows that they are adaptable, resilient species capable of persisting (as do grey kangaroos) within fragmented, disturbed ecosystems where large areas of bushland remain. Indeed, some species may, locally, achieve minor pest status and thus create management problems.

These realisations provide a basis for greater optimism about the future of some medium-sized marsupials. One can take some heart from the numerous island populations of marsupials that have persisted for many thousands of years.

The ultimate solution to the fox problem is biocontrol. Such research is in progress, but it must be emphasised that this research is high risk and may not yield a solution in the near future. However, much will be learned about the fox as a predator during the course of this work. Unquestionably, some of this knowledge will greatly improve and enhance conventional control methodologies.

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The Use of Remnant Vegetation by Nectarivorous Birds: Biodiversity as a Model for Management in the Wheatbelt of Western Australia

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INTRODUCTION

The successful management of remnant vegetation depends upon the formulation of clearly defined management goals. Broad objectives, such as "management to maintain biodiversity", have been identified, but the implications for managers of such statements have not been specified.

Honeyeaters in the central Wheatbelt provide a model for understanding the functional significance of biodiversity, and for assessing the implications of a reduction in regional biodiversity. This understanding, in turn, can provide a framework for approaching the daunting task of "managing for biodiversity".

Biodiversity encompasses the variation that occurs between individuals, species, communities, landscapes, and broad biogeographical regions. The relationship between honeyeaters and their food plants provides an opportunity to explore the consequences of diversity at all of these levels and to examine the functional significance of this diversity. As pollinators, honeyeaters play an important role in the maintenance of local floral diversity. A decline in honeyeater numbers can affect plant communities by reducing the distance and frequency of gene flow between discontinuous populations (Lamont *et al.* 1993), a problem that is exacerbated in fragmented environments. Changes in floral diversity may, in turn, affect the persistence probabilities of other species associated with, or dependent upon, that flora. By considering these relationships between plants and animals, we can identify the importance of variety at various organisational levels in both plant and animal communities.

PLANT DIVERSITY

Individual Differences

Although most members of a plant species in one area flower synchronously, individual differences result in some plants flowering earlier in the season, while others commence later. These phenological differences may result from variation in microenvironments as well as from genetic differences between individuals. These individual differences result in an increase in the amount of time that nectar is available for honeyeaters.

Species Differences

Differences in the flowering phenology of different species also broaden the range of opportunities for honeyeaters in a given habitat. An array of species which flower synchronously in different locations increases the range of habitats that honeyeaters can utilise.

Community Differences

Edaphic, evolutionary, disturbance and other factors have resulted in Wheatbelt plants forming clear associations in a pronounced vegetation mosaic. The constituent species within these associations have particular flowering characteristics which result in different patches producing nectar at different times of the year. Provided the configuration of these resources is favourable, honeyeaters can move from one patch type to another at different times of the year, further increasing their resource options.

Landscape Diversity

The same vegetation communities at different positions in the landscape often have different phenologies as a result of regional variation in environmental conditions, again expanding the resource base for honeyeater species that can range widely across the landscape.

Regional Diversity

Unfavourable climatic conditions in a particular region may result in poor flowering and hence temporary shortages of nectar over substantial areas. At such times, mobile species are able to move to adjoining regions where a different suite of plant species may provide the necessary resources. The persistence of a species in its preferred habitat may depend upon access to resources in adjoining areas at times when local resources are depleted. For example, white-fronted honeyeaters (*Phylidonyris albifrons*), pied honeyeaters (*Certhionyx variegatus*) and black honeyeaters (*C. niger*) irrupt sporadically into the central Wheatbelt at times of low rainfall in the more arid interior. Nectar-producing plant species in the Wheatbelt may provide a critical resource for these birds at these times.

HONEYEATER DIVERSITY

Not only is a variety of plants important for the persistence of pollinators, but similarly a variety of pollinators is essential for the maintenance of plant diversity. The impact of fragmentation on plant–pollinator relationships will depend upon the capacity of pollinators to deal with the modified landscape. A range of pollinators which respond to the landscape in different ways will enhance the prospect of plant population processes being maintained. The functional significance of honeyeater diversity is expressed primarily at the species level, but individual differences may also influence patterns of pollen dispersal.

Individual Differences

Within some species, some individuals establish territories in which they remain for extended periods of time. Other younger, or less dominant, individuals are unable to establish or maintain territories. They are more mobile, and this results in different patterns of pollen dispersal.

Species Differences

Differences exist between species in the way they move around the landscape. Some species, such as white-eared honeyeaters *(Lichenostomus leucotis)*, are relatively sedentary and tend to remain in territories within remnants. Singing honeyeaters *(L. viriscens)* commonly move back and forth between remnants and adjoining road-verge vegetation. Brown honeyeaters *(Lichmera indistincta)* move widely around the landscape, commonly moving between remnants, and white-fronted, pied and black honeyeaters invade from more arid regions to the north and east. Some species remain in close proximity to vegetation, while others, such as yellow-throated miners *(Manorina flavigula)*, routinely make extended flights over open paddocks. This array of different strategies for exploiting resources provides various opportunities and scales for pollen transfer throughout the landscape.

IMPLICATIONS OF REDUCED DIVERSITY

The value of greater biodiversity lies in the increased numbers of species that mediate important processes, thereby increasing the area and time over which a given process proceeds. Species which play equivalent roles can be viewed as functional analogues. The functional significance of a species in a system is inversely related to the number of its functional analogues. Loss of biotic diversity reduces the number of alternative, functional pathways and hence reduces the probability that a process will occur. Species that have no functional analogues but make a major contribution to a given function may become "keystone" species, and their loss could have serious implications for other associated organisms.

The acorn banksia *(Banksia prionotes)* flowers in early autumn in the central Wheatbelt. No other nectar-producing plants flower in the Durokoppin area at this time — it has no functional analogues. It is heavily exploited by honeyeaters and, because it appears to be a limiting resource, it may influence total honeyeater numbers in the region for the remainder of the year. For these reasons, this species is a keystone species. It does not play the same role in other parts of its range where other species (for example, *B. menziesii*) flower at the same time.

MANAGEMENT IMPLICATIONS

Honeyeaters have been used here to explore the functional significance of biodiversity. This model may hold for a wide range of species and communities, although the scale and number of participants may vary. Several implications flow from this perspective.

Management for Function and Representation

Representation of biodiversity is a necessary objective for the management of native biota, but it alone is not sufficient. It is also essential to consider how different levels of representation contribute to ecosystem function. The greater the functional contribution of a species or community, the more widely should it be represented. Honeyeaters are not a high priority for conservation in their own right, but may be essential for the achievement of other objectives. Consequently, they must be well represented in the landscape. For species that contribute less to community processes, representation in a few locations may be adequate.

The Importance of Scale and Configuration

Management must be planned at an appropriate scale for the species and processes being managed. Because biodiversity encompasses all scales, from individuals to landscapes, it is necessary to have strategies that reflect this diversity. While large-scale, regional assessments of

conservation value must be made, these must then be combined with local strategies which identify those actions that need to be implemented at particular locations. Attempts to achieve an objective within a single remnant will fail if that objective is dependent upon processes that operate at a scale greater than that of the remnant. Management of remnants must be guided by their role in landscape processes and in achieving regional conservation objectives.

The Importance of Objectives

The above point presupposes that regional conservation objectives and strategies exist. Conservation objectives must be identified at catchment, regional and national levels, with local actions targeted towards those objectives which are relevant for the area being managed. For example, some areas may not encompass species or communities that are recognised as regional or national priorities. This cannot be taken to mean that nature conservation is not an important issue for such an area. It simply means that specific objectives have to be identified which address those values that do remain in that region.

Objectives, at any scale, will not be achieved in a short period of time. It is therefore necessary to identify a sequence of actions that will achieve nominated objectives. It is also important to identify those objectives that need most urgent attention, and actions that will provide maximum conservation value for minimum effort.

BIODIVERSITY AS A MODEL FOR SOCIAL MANAGEMENT

If a regional conservation strategy is developed, its implementation will require a coordinated effort by a wide range of individuals and organisations. Diversity at different levels within the human community must also be recognised, and the functional significance of each cultural group identified in order to develop an effective social process for achieving biodiversity conservation. In terms of the biodiversity model presented above, important components of diversity in the human community are as follows:

- Individual differences: Different individuals will have different capacities to contribute towards management of the native biota in a region, depending upon inclination, financial resources, other commitments, etc. Local farm plans or community projects should be designed to recognise these differences, and should enable all individuals to feel that their contribution, no matter how large or small, is an integral part of a larger conservation effort.

- Species differences: Sometimes it appears that the various groups with vested interests in regions are indeed different "species". These "species" comprise the land-holders, and the wide array of government and non-government agencies that are involved. The different perspectives and aspirations of these groups must be acknowledged and incorporated into planning. The functional role of each group must be clearly identified and their efforts coordinated so as to maximise conservation return.

- Community differences: Different areas may have different conservation priorities, depending upon their particular problems. If regional targets can be identified, local communities, together with other groups with appropriate information and expertise, must work jointly towards identifying how those targets can best be achieved in a manner which maximises both conservation return and primary productivity.

The use of "biodiversity" as a metaphor for social organisation will clearly have its limitations if taken to extremes. For example, while a range of functional analogues performing similar roles in a natural ecosystem may enhance the stability of that system, the presence of a number of government agencies all fulfilling equivalent functions will simply result in unnecessary duplication and conflict. Given that government agencies rarely "become extinct", the need for functional equivalents is clearly not desirable.

In contrast, at the level of individuals who are implementing recommendations, it is important to ensure that multiple representation exists. Given the magnitude of the problems in agricultural landscapes, management actions will need to be implemented over a large proportion of the landscape. This requires a clear statement of objectives, identification of the actions to be taken, and the involvement of many individuals in implementing these actions. In the

absence of an integrated management strategy, there will be only small localised responses which will generate limited benefit at a landscape scale.

The comparison of social organisational structures with biodiversity may be more appropriate when considering the functional roles of these organisations. The value of the analogy lies in the recognition that a complex system comprising a number of interdependent components needs to retain all of the essential functions if that system is to persist. In order to achieve sustainable agriculture and maintain biological diversity, it will be necessary to integrate social, agricultural, land conservation and nature conservation objectives.

Only by recognising the diversity within the community and the different contributions that different sectors can make will nature conservation succeed in what is predominantly a freehold landscape. Ownership of, and responsibility for, local conservation must be devolved to the community, with government organisations managing specifically identified, high-priority targets which are beyond the material and knowledge resources of local communities.

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Note that Robert Lambeck's work on honeyeaters, referred to extensively, has not yet been published.

Acquisition and Management of Conservation Reserves in Western Australia

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PREAMBLE

I have been involved with conservation for a long time, first with acquisition of reserves and later with their management. For this paper, I have chosen to give an overview of how and why my ideas developed.

INTRODUCTION

The raw material with which managers have to work — that is, the system of remnant vegetation — is largely an historical accident. This is because what is selected for reservation is merely a remnant of what was formerly more widespread. But, in addition to this happenstance, the success or otherwise of management will be affected by:

- the manager's assumptions about ecosystem processes;
- the initial state of the ecosystem, which is the result of past events;
- the operation of chance in the future.

HISTORY

Initially, selections were based on personal knowledge and what was available for reservation. Later, various committees selected areas for reservation following reviews of the knowledge available, or biological surveys of land in transition zones, or areas not yet represented in the conservation estate. This left the manager areas that had, in many cases, less than all the desirable characteristics. For example, areas were small, boundaries extensive and irregular, and so on.

CRITERIA FOR SELECTION

Early reserve selections were based on a desire to ensure that reservations were representative in some way, either of regions or of biotic assemblages, and management was expected to preserve these qualities. During this early period, habitat preservation was the vogue and minimal interference was the essence of good management. When ecosystems were considered at all, they were thought of as being static, and when disturbances did occur, it was assumed that over time succession would restore the biotic environment to its former state.

More recently, there has developed an international consensus that conservation effort should be devoted to retaining biodiversity, and this adds another dimension to management problems. Biodiversity is a diffuse concept which can be considered to include:

Genetic diversity: where conservation goals are to retain as much of the genetic variability as possible within any population that is being actively conserved. Genetic diversity can be lost by: inbreeding in very small populations; reductions of population size resulting from breeding failure; or catastrophic mortality resulting from disease, drought or fire.

Taxonomic diversity: this literally includes the five kingdoms of organisms but is usually taken as total species richness — for example, representation of species within groups such as eucalypts, banksias, forest birds, raptors, burrowing frogs, trapdoor spiders, or native bees. The range is endless and the management problems diverse.

Phylogenetic diversity: this includes the range of diversity within an evolutionary radiation — for example, within the marsupials, or a genus of lizards, or the trigger plants. Some of these organisms may be classified as rare or endangered, but also included are relicts such as cycads, echidnas, *Lepidogalaxias* (the mud minnow), peripatus, *Archaeochilus* (the granite rock chironomid) and the trapdoor spider *Moggridgia*. Such are to be considered particularly durable species.

Structural diversity: this category includes forest, woodland, shrubland, grassland and the structural stages in regeneration of vegetation following disturbances such as fires or storms. Restricted or relict habitats characteristic of former times fall into this category of diversity.

These basic kinds of biodiversity may be combined to describe more complex forms such as community, ecosystem or landscape diversity.

Such a wide-ranging focus suggests that management is concerned with nothing less than whole ecosystems considered as dynamic entities.

THEORY

Management based on empiricism cannot be expected to cope with the diverse requirements imposed by the foregoing concept. Some theoretical basis is needed. In this sense, theory merely means a schema or system which accounts for or explains a set of observations or phenomena. In terms of conservation management, we need to explain what is there, the sequence of events by which it has been derived, and the way the system is renewed or maintained. A comprehensive theory provides a framework within which the future may be predicted. Thus the consequences of both management practices and chance events can be foreseen or anticipated. Research should provide the knowledge and facts which form the basis of the theory, provide tests of current theory, or provide new knowledge which suggests that theory should be modified. Monitoring the consequences of management practices is a way of testing theory and gaining new knowledge.

But there are five classes of people involved with conservation: the public, administrators, those who write management plans, managers, and scientists. Not all of these consider the managed system as being dynamic; thus when their expectations are not met — for example, when the biota changes — there is a perception that preservation has not been achieved and management has failed. This is of importance in the event that the concept of accountability is extended to management of the conservation estate. Such a literal extension is inappropriate when ecosystems are dynamic, process driven, non-static entities. Furthermore, administrators sponsoring, for example, Cooperative Research Centres look to research to solve problems requiring complex and expensive technical expertise. On the other hand, perhaps in response to public perceptions, the Australian Nature Conservation Agency and World Wildlife Fund for Nature see the study of rare or endangered species as a priority. Not unexpectedly, administrators of management-oriented organisations see scientists as a skilled work force to be used in solving local problems as they arise. At all levels, little attention is given to adding knowledge that might be useful theoretically.

NATURAL SYSTEMS

There is a tendency to view natural systems as the analogue of agricultural, horticultural or forestry systems. In such systems, any reduction in productivity is disfavoured; consequently, diseases, pests, or any factor which reduces the productivity or the quality of the products is regarded as undesirable. However, in natural systems, diseases, pests and parasites reduce the vigour and may even lead to early death of their host. Such happenings make for less than optimal individual health, but conversely, when they affect the common or most vigorous species, they prevent the exclusion of less vigorous species from the community. Thus diseases, pests and parasites, along with predation and natural disasters, are the mechanisms by which dynamic ecosystems are maintained. They are intimately related to biodiversity but completely ignored in its study.

Characteristically, disturbance, of whatever origin, leads to the formation of gaps in the vegetation. It is in such places that the availability of space permits the germination of seeds and the initiation of population changes in the whole biota which sum to the successional stages that follow. But disturbance must not be thought of solely as being caused by physical environmental factors.

Gap creation, whether from branch fall or tree death, is also effective in initiating regeneration. Most often, such deaths are caused by disease induced by fungi or other pathogens. Such mortality is usually scattered through an ecosystem and is a potent source of minor habitat diversity by providing sites for other plants, animals, fungi, protists and bacteria. Managers should appreciate that this sort of habitat diversity can only be provided by natural events which vary in space and over time. They are the basis of patch creation and the dynamics of persistence. Population sizes and distributions are unlikely to be constant when such factors operate. Managers can only ensure that the likelihood of persistence is as high as possible.

The contrasts between static and deterministic versus dynamic and stochastic interpretations of systems maintenance are not merely a matter of academic disagreement. The general public and some biologists follow static, deterministic interpretations of nature — for example, as expressed in the phrases "balance of nature" or "stable population". To those with such beliefs, patch creation by mortality from disease or defoliation by insects is likely to be interpreted as failure of management rather than as a demonstration

of the way that space, light and nutrients are made available to different species or another generation.

Recently, it has become a legislative requirement that the public be involved when management plans are being prepared. Legislation or regulation requires that the aims, goals and requirements are specific — for example, "preservation" may be a stated aim. This implies a static universe which can be preserved. Moreover, management plans require funds, and it follows that there is an expectation that those spending the money are accountable for achieving the legally specified goals. Yet, as indicated above, natural systems are hostage to chance events that are not readily accommodated in a legal system couched in terms of an ideal stable world. The potential difficulties should be anticipated by managers, who might sell their skills by emphasising that, even in a very fragmented, dynamic natural world, managers can retain the conservation values even if static preservation is not possible. Education to achieve a community awareness of what is biologically realistic is a prerequisite before sensible accountability can become a reality.

DISCUSSION

The foregoing sets out what might be included in the concept of biodiversity and so establishes an array of reasons for having reservations. It also sets out a theory of how the contained systems and communities may function and be maintained as dynamic entities. Naturally, I did not develop these ideas as a complete system at one time in a single paper. Initially, the size of reservations was a critical issue, and Main and Yadav (1971) justified arguments for larger reservations than had hitherto been considered adequate by land use planners. A general case for numerous reserves spanning a range of sizes and geographic locations was then developed (Main 1979). At this time, there was a public perception that reserves would preserve nature, especially rare and endangered species. An argument countering this was that rare species were thus because they were on the way to extinction, so it was a waste to reserve useful land for an unachievable purpose. These issues were addressed in Main (1982, 1984).

Allied to the foregoing was the question of reserve management, especially in terms of nutrients (Main 1981a, 1987), fire (Main 1981b), the effect of insect grazing on post-fire regeneration (Whelan and Main 1979), and the response to stress by vertebrates (Main 1986). Many of the problems associated with reserve management were reviewed, and possible solutions tabulated (Main 1987). As soon as it became clear that landscapes needed to be managed as whole entities and that management of nature conservation reserves should be integrated with other uses and landscape goals, it was appropriate to reiterate the basic similarities in the resources required by all living things (Main 1993a). The problems associated with the potential loss of biodiversity in reservations has been addressed by Main (1992a). Additionally, a possible approach to making management decisions when faced with uncertainty was presented (Main 1992b). The implications of climatic change for restoration ecology and management are dealt with in Main (1988, 1993b).

One would expect to see indications that the above interpretations were having an influence on reserve management, in management plans and field responses of managers, perhaps a decade after publication. In general, it is too soon to say whether the ideas developed are, or have been, of use to those involved in the practicalities of management, though I have had some verbal comments that the 1987 paper has been useful.

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Invertebrate Studies Performed through Curtin University

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INTRODUCTION

The scope of this paper is to list invertebrate and other related ecological research that has been performed in the Western Australian Wheatbelt by Curtin University staff and students. We have not included work that has specific relevance to invertebrates in rehabilitated mines (for example, at Eneabba) or areas of primary production (for example, farm paddocks). We have, however, borne in mind any management principles that can be derived from this and other research conducted outside the Wheatbelt region where it has implications for the management of remnant vegetation in south-western Australia.

The major theses and papers resulting from these investigations are listed in the References. In Table 1, these studies are grouped together under broad management topics. For each of these topics, primary research outcomes are briefly summarised, and their management implications and degree of implementation listed.

The major users of our research are considered to be land users, land managers, and those advising these groups.

RESEARCH TOPICS

Research undertaken on invertebrates in remnants and on other related topics through the School of Environmental Biology at Curtin University has focused on the role of invertebrates in ecosystem function and recovery following disturbance (refer to the research topics listed in Table 1). Some of this work has also emphasised the benefits of habitat diversity to the conservation of invertebrates. The general approach to the work has been at an applied rather than a theoretical level.

MANAGEMENT IMPLICATIONS

The implications of research outcomes for land managers are listed in Table 1. The implications are often of a general nature and based on the results of several different projects, some of which have been performed by other research groups.

In some cases, further research is required before our conclusions can be implemented by managers. For example, with respect to our work on corridors, while we have been able to demonstrate that corridors of native vegetation support greater numbers of ant species than do corridors containing large proportions of exotic plant species, we cannot describe the minimum number or cover of native plant species required to ensure that ant communities are maintained. Our findings therefore need to be incorporated with those from other studies before final recommendations may be made.

It is important that the work of conservation managers be guided by well-founded principles that are based on ecological research. These principles should be constantly upgraded in the light of new research findings. For this to happen, it is necessary for liaison to occur between researchers and land managers so that results of research may be disseminated. This process would also enable researchers to hear the needs of land managers and to plan research to fulfil their requirements.

DISSEMINATION OF FINDINGS

We have adopted a broad approach for the dissemination of research findings. For each research project undertaken, we aim to alert relevant persons and organisations to the thrust of research programs and their results. Up to five different methods may be used. These are shown in Table 1 under the heading "Dissemination of Findings". Details of the dissemination methods are provided in the Note (see page 46).

Cooperating with other research institutions and land management groups that have a role in the conservation of remnants is another important part of the information transfer process. Organisations that have been involved in the research undertaken by Curtin University are shown in Table 1.

IMPLEMENTATION OF FINDINGS

It is difficult to know exactly whether, and if so how, research findings have been implemented at the management level, because some findings result in a very diffuse set of implications. It is even more difficult

to establish whether research findings have had some bearing on the development of ideas presented in management plans. It is possible that research findings may have had some influence on a plan, even if there is no acknowledgment of the findings in the final product.

In endeavouring to demonstrate management adoption of our invertebrate research, we have identified three levels at which this might occur (Table 1). Firstly, there are instances where research findings are known to have contributed to management actions or the development of resource information for land managers (a "Confirmed Contribution"). In such cases, verbal acknowledgment or referencing of research material has been forthcoming.

Secondly, there are instances where it is suspected that research findings have contributed to the development of a general management ethos, or the adoption of certain management practices, but these suspicions are unconfirmed (an "Unconfirmed Contribution"). This occurs when the relevant literature does not acknowledge work, and personnel with responsibility for the management of the relevant issue may be unaware of the work. Yet, it is virtually inconceivable that management approaches taken are not influenced by the research outcomes, although this influence may be three or more times removed from the researchers and their work.

The third level at which research findings may have relevance to managers are those instances where the manager is simply not aware of the research, or the relationship between the research findings and the land user or manager is less obvious. An example is the importance of unpredictable, infrequent disturbance events, such as one in one hundred year flood or fire events. While these may have an enormous impact on species and communities, they are poorly understood by managers. As a consequence, we have identified groups of people or organisations who could potentially benefit from such information and listed them under the heading "Potential Contribution". Dissemination of information to these groups probably requires direct consultation as a means of ensuring that the management implications of research findings are adequately disseminated.

Despite efforts to ensure that research findings are appropriately disseminated, we still experience problems in getting our message to users. Reasons for this are thought to include:

- insufficient time for the preparation of scientific papers and conference presentations;
- an absence of mechanisms which support the dissemination of research information to target audiences;
- an absence of mechanisms that provide feedback on the adoption by managers of research findings;
- inadequate knowledge of relevant research findings among users, including landcare officers, training staff and land managers;
- an apparent misconception by users that scientific work is undertaken for academic rather than practical reasons.

CONCLUSION

Research undertaken at Curtin University has relevance to the conservation, management and restoration of remnants in south-western Australia. While there are some instances where research findings are known to have contributed to management programs and recommendations, we believe that much information never reaches target audiences. This occurs despite a substantial effort to inform the community about current research programs and outcomes.

Inadequate communication between researchers and managers is perceived to be a major cause for the poor dissemination of research results. Actions that will help overcome this problem include:

- databases of researchers, managers and their specific interests and projects, to encourage communication of information and ideas between both groups;
- developing feedback mechanisms so that the research community may check that research data are reaching relevant land managers, and also so that land managers can suggest suitable topics for future research;

- setting up a centralised computer system or sorting house for research outcomes that are related to the values and management of remnants for nature conservation, sustainable agriculture, and other uses. This central information base could act as a formal centre for remnant networking. It could be responsible for the development of mechanisms that facilitate the dissemination of information between land managers, researchers and other users. The centre could provide a focus for the development of landscape models integrating nature conservation and agricultural production values;

- dealing with the perceived misconception that research is undertaken for academic rather than applied reasons;

- ensuring that research findings are taught to potential land managers (for example, trainee farmers) by circulating information to coordinators of agricultural courses at secondary and tertiary levels.

We have also identified two other factors that require attention if the nature conservation values of remnants are to be maintained. These issues, which are worthy of discussion at this workshop, are:

- Remnants on private property require protection from ongoing degradation processes. Protection programs must be accompanied by a management program that ensures the ongoing survival of these remnants.

- The importance of invertebrates and microorganisms in the maintenance of remnant ecosystems must be realised by land managers.

Table 1: Summary of research undertaken by the authors and their associates in the Western Australian Wheatbelt, including the broad management implications of each topic.

Research Topic*	Summary of Research Outcomes	Management Implications	Dissemination of Findings					
			Scientific Publication	Conference Participation	Popular Articles	Semi-formal Discussions	General Media	Co-operative Research
PAST RESEARCH								
A. Seed removal by ants (1,6,10).	Direct seeding operations may be impeded by: • certain species of ants • temporal factors • site characteristics.	Maintain vigilance for problem ant species. Avoid direct seeding at vulnerable times. Treat vulnerable seeds to avoid seed removal.	✓	✓	✓	✓	✓	CSIRO
B. Herbivory by native caterpillars (11,12,13).	Magnitude of damage by bag shelter moths varies with: • temporal factors • site characteristics.	Depending on the extent of the outbreak, control of leaf defoliation may be required in: • outbreak years • nutrient enriched areas (e.g. road verges and remnant edges).	✓				✓	CSIRO CALM
C. Role of termites in nutrient cycling (7).	*Drepanotermes tamminensis* has a major role in nutrient cycling within certain ecosystems.	Maintenance of remnants should include: • the retention of dead plant material as habitat for soil fauna and the maintenance of nutrient cycling • the protection of termite structures from damage.	✓	✓				CSIRO
D. Use of ants as bioindicators of environmental health (4,8,9).	Ant community composition is a useful indicator of the degree of: • habitat degradation • habitat restoration • habitat similarity.	Assessment of the ant community can provide a rapid indication of the state of the environment.	✓	✓	✓	✓	✓	CSIRO CALM Mining Co's
E. Conservation potential of remnants and corridors of native vegetation (1,8,9).	The biotic composition and ecology of remnant habitat is influenced by its: • physical features • management.	Corridors of native vegetation will have greater conservation potential if they: • are wide rather than narrow • comprise native rather than exotic plant species • are adjacent to native habitat.	✓	✓		✓	✓	MRD
		Edge effect impacts on remnant habitat must consider: • the ecosystem component for conservation • the imposing disturbance regime.						CSIRO
		Remnants should be fenced to exclude farm livestock.						
		Restoration of remnants will require amelioration of: • altered microhabitats • soil physical changes • soil nutrient imbalances • altered plant and animal composition and dynamics.						
F. Influence of prescription burning on invertebrates (2,3,5).	Prescribed burning of remnants influences invertebrate: • abundance and diversity • recovery time.	Findings may have relevance to deciding the timing and periodicity of burning regimes.	✓	✓		✓		CALM
NEW RESEARCH								
G. Abundance of arthropods and birds on trees in paddocks, corridors and native vegetation.	Potential of trees in different spatial arrangements to support invertebrates, avifauna and food web processes.	Trees remaining in corridors and paddocks may form a nucleus for landscape restoration.	✓	✓		✓	✓	UNE MOT
H. Re-establishment of biota and nutrient cycling in revegetated habitats.	Degree to which different revegetation strategies facilitate the re-establishment of nutrient cycling processes. Value of revegetated habitat to the maintenance of regional biodiversity.	Re-establishment of soil and litter biota and nutrient cycling may be influenced by revegetation practices.				✓		CSIRO UWA STSCG

* Numbers refer to relevant references in list on page 46.

Implementation		
Confirmed Contribution	**Unconfirmed Contribution**	**Potential Contribution**
Adoption of seed predation control measures (e.g. pelletisation) by revegetation organisations (e.g. MRD, mining companies).	General recognition of the problem in direct seeding operations.	• Conservation organisations • Mining companies • Shire councils • Schools • Revegetation organisations
Control measures (e.g. shire councils) have not been required to date.	Could influence choice of trees for road verge plantings.	• MRD • Shire councils • Conservation groups
	Maintenance of ecosystem processes by remnant and reserve managers. Protection of termite habitat and structures from destruction.	• Conservation managers • Farmers managing remnants on private property • Revegetation organisations
Other research and publications involving research on ecosystem status and habitat restoration.	The incorporation of ants as bioindicators of environmental health in every State and territory of Australia.	• Conservation organisations • Mining Companies • Shire councils
Contributed to the justification of widening of road verges (MRD). Strengthened the need to plant or seed native species on road verges (MRD).		• Conservation organisations • Shire Councils
Literature providing guidance on the management of remnants (Hussey, B.J.M., and Wallace, K.J., 1993. *Managing Your Bushland.* Department of Conservation and Land Management, Perth).	Supporting the thrust of the Remnant Vegetation Protection Scheme.	• Technical education of landcare advisers (e.g. LCOs) • Managers of remnants on private property • LCDs and other rural groups
	Findings have stimulated further research on the impact of prescribed burning outside the jarrah forest.	• Conservation managers • Managers of remnants on private property • Managers of road verges
Awaiting results	*Awaiting results*	• Managers of remnants on private property • Conservation managers
Awaiting results	*Awaiting results*	• Managers of remnants on private property • LCDs • Revegetation organisations • Conservation managers

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NOTE: APPROACHES USED BY CURTIN UNIVERSITY TO DISSEMINATE RESEARCH FINDINGS

The methods used by Curtin University to disseminate its research results, shown in Table 1, are outlined below.

Scientific Publication

Publication in scientific journals, conference proceedings and books (for example, *Australian Entomological Magazine,* Australian Society for Soil Science and the "Nature Conservation" book series). This is done either during, or within one to three years of completing, a project.

Conference Participation

Oral and poster presentations at scientific and management oriented conferences (for example, Australian Entomological Society, Australian Mining Industry Council Environmental Workshops, Enviromine).

Popular Articles

Publication of popular articles in magazines such as *Ecos, Curtin Gazette* or publications aimed at schoolchildren.

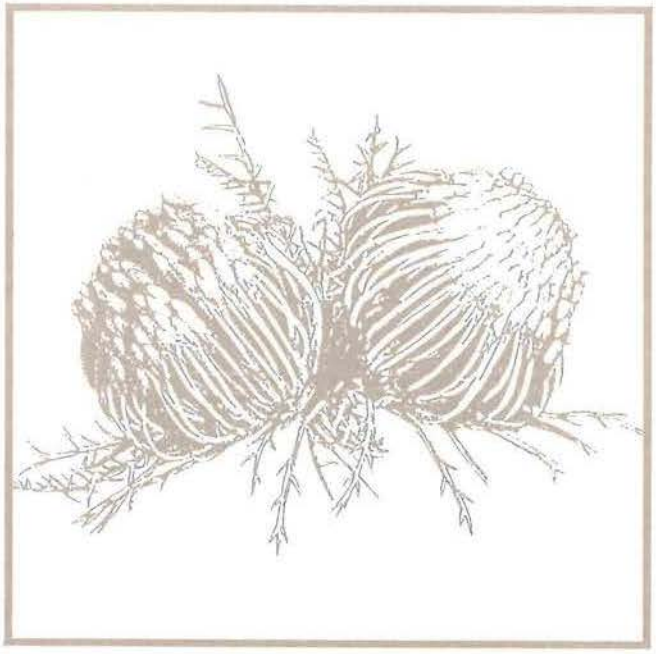
Semi-formal Discussions

Semi-formal and informal discussions and presentations to local people and potential end-users during the course of field study programs. Talks and discussions with rural land users (for example, Men of the Trees at Dowerin, opportunistic discussions with local farmers, talks to catchment group Annual General Meetings, Lions Club talks).

General Media

Publicity through local and State newspapers (for example, articles in the *Countryman*), radio (for example, *The Science Show)* and television networks.

MANAGERS' PERSPECTIVES



Setting the Scene–Remnant Management during the Past Decade

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INTRODUCTION

In this short paper, I summarise ways in which management of native vegetation remnants has changed over the decade 1983–93. My aim is to sketch the more significant changes and thus provide a context for later papers that will necessarily have a narrower focus.

At Busselton in 1985, I outlined (Wallace and Moore 1987) five elements crucial for effective management:

- an adequate research database;
- an adequate technical database;
- an informed and sympathetic public;
- adequate staff and financial resources;
- an accepted philosophy/methodology for drawing together the above and implementing management.

These provide a useful framework for examining the changes over the decade; however, the term "knowledge" is more appropriate than "database", and the inadequacy of the third point will be discussed below.

Of the five points listed, the first is discussed in detail within other workshop papers, and is therefore not considered further here. Also, no attempt is made to comprehensively describe changes; rather, the aim is to sketch the major shifts and issues.

CHANGE AND THE ELEMENTS OF EFFECTIVE MANAGEMENT

Technical Knowledge

The technical information and knowledge among, and available to, managers has improved over the decade. The many advances have included: the more effective field use of herbicides, better techniques for fox control, improved availability and use of computers, and refinements concerning the safe use of fire, particularly in coastal and near coastal ecosystems of the South West. Also, the quality of vehicles and other equipment has generally improved.

However, the value of new technologies has not always been realised, or been accessible to managers. For example, the promise of Geographical Information Systems and remote sensing has not been generally realised (Burbidge and Wallace 1995), and the outlay of resources in these areas should be justified in relation to alternative projects.

Despite these concerns, managers have mostly gained from changes in technical knowledge and equipment. Computers, in particular, have been an important factor in counterbalancing some resource constraints, especially with regard to clerical aspects of management.

An Informed and Sympathetic Public

Since 1983, growing concern due to land degradation has resulted in greater support for management of remnant vegetation. This change is paralleled by increasing public concern for the environment, at least in the United States (Dunlap 1987, 1991). Dunlap's work is of particular interest as it shows that although public support for environmental issues has increased, this is not necessarily reflected in electoral voting patterns. While I know of no Australian equivalent to Dunlap's work, surveys by the Australian Bureau of Statistics (Castles 1993) show significant community concern about environmental issues. Furthermore, although 75% of people sampled were concerned about environmental problems, only 10% had acted to register their concern during the preceding 12 months. Translating concern into effective action is an important and challenging issue.

Despite changing attitudes, uncertainty among key groups as to the value of remnants in landscape functions, together with the rural recession, has countered the positive social changes and detrimentally affected the translation of community concern into action. Specifically, we have failed to convince the public that conservation of remnants is crucial to a satisfactory lifestyle for each human. In my view, nothing less will allow us to achieve our nature conservation goals with remnant vegetation.

Therefore, as a management goal, the heading for this section does not go far enough. The community must not only be informed and sympathetic; it must be personally committed to acting in ways that conserve remnants.

If conserving remnants of native vegetation is not crucial to a satisfactory lifestyle, then we must review our goals. Although there have been some attempts to describe the values of remnants for a wider audience (for example, Hobbs and Wallace 1991), the community has not been convinced.

Furthermore, while aspects of communication and education have greatly improved over the last decade — for example, some of the educational materials and publications produced by the Department of Agriculture, Western Australia (DAWA), and the Department of Conservation and Land Management (CALM) — there have been notable failures. In particular, our inability to effectively educate the community about the complexity of land management issues and the personal values of remnants has been a blow to their protection. Organisational constraints (Wallace 1992; Burbidge and Wallace 1995), political constraints, and the lack of a coherent philosophy (see below) are some of the many factors contributing to this failure.

At the same time, the economic recession, with its attendant cultural change including increased illegal activities and a more fundamentalist approach to economic and political issues, has not helped land managers. While essential, social changes involving Aboriginal issues are also complicating management.

Therefore, although there have been modest gains in education and communication over the past decade, these have not achieved the social change necessary to ensure conservation of remnant vegetation. Additionally, social issues complicate the managers' task and present new challenges for which they are generally ill equipped. Some of these issues and their solution are discussed in Burbidge and Wallace (1995).

Resources

General

Over the decade, resources allocated to management of remnants have increased through a number of sources including:

- increased allocation and better distribution of resources with the establishment of CALM;
- increased interest in remnant vegetation by DAWA, reflected most significantly in the Remnant Vegetation Protection Scheme and its management;
- operation for six years of the State's Remnant Vegetation Protection Scheme;
- allocation of Federal resources to protection of remnant vegetation — for example, through Save the Bush, the States Cooperative Assistance Scheme, funding for threatened communities and species programs, the National Estate Program, parts of both the National Landcare Program and the One Billion Trees Program;
- growing interest in, and assistance with, remnant vegetation protection through the activities of groups such as Greening Western Australia;
- greater protection of remnants by freehold land-holders themselves, independent of any external funds;
- involvement of the Water Authority of Western Australia in remnant protection within higher rainfall areas;
- greater research by CSIRO and tertiary institutions on nature conservation issues in agricultural areas;
- the advent of the landcare movement and the formation of land conservation district committees.

While these increased resources have helped, they are not sufficient to prevent further losses of biodiversity from remnant vegetation in agricultural areas. The need for public and community support is again apparent.

Management Expertise

A second, often forgotten, aspect of resources lies in the quality of managers. Well-trained, enthusiastic

managers achieve much more than untrained or unenthusiastic managers.

As a manager, I cannot claim objectivity in discussing this issue. However, in my estimation, our current managers are on average more technically competent and better informed than they were 10 years ago. This is counterbalanced in part by increased community expectations of managers, and the overwhelming amount of important information that is poorly integrated and largely inaccessible to managers.

Also, a major concern is the difficulty of attracting professional people inland. This has always been so, and affects all government agency managers with whom I have discussed the topic. Given the economic and biotic importance of inland agricultural areas to the State, resolution of this matter is vital. The issues concerned are well beyond the scope of this paper. However, conservation goals will be achieved more often if a larger group of effective professional officers is attracted to rural communities to work and participate as community members. Perhaps it is time to examine the incentives used to encourage people to move to the north of Western Australia. The same techniques may be relevant to southern rural areas.

Finally, the lack of a clear management philosophy to guide managers and help them integrate complex issues into effective management strategies is of concern.

Management Philosophy and Effective Decision-making

One of the needs for successful management I defined in 1985 was an effective management philosophy. While there have been papers that have considered some of the relevant issues (for example, Fairweather 1993; Lefroy and Hobbs 1993; Burbidge and Wallace 1995), they represent work on the foundations of a philosophy rather than a completed structure.

If management is to be coherent, driven by a vital vision, and characterised by effective setting of priorities and decision-making, then the development of an explicit management philosophy is very important. To fully achieve such a philosophy, which ideally should reflect community ethics and cosmology, will be a challenging task in such a young nation with so many divergent, cultural strands.

CONCLUSIONS

Management of remnant vegetation is undoubtedly more effective and better resourced than it was in 1983. However, management is neither sufficiently effective nor well enough resourced to conserve the existing biodiversity at a district or regional level. Furthermore, resourcing is likely to go into decline given the current economic climate and the associated re-ordering of social, cultural and political priorities. An important means of countering these trends is to show people that vegetation remnants and their biodiversity are crucial to them as individuals.

I am not sure if it is increasing age or increasing understanding, but more and more I perceive conservation problems as requiring socio-cultural changes as much as, if not more than, biological research and operational management. Biological researchers and land managers are not equipped to deal with social issues. It is time that we sought the help of social scientists and related workers.

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Remnant Management over the Last Ten Years–An Agricultural Viewpoint

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RESEARCH IMPLEMENTED

Fencing of Remnants

This form of remnant management is by far the most widespread in the agricultural zone of the State. Farmers accept that results can be obtained by fencing, and either do it as part of normal farm operations or make application for special grants. The continual over-subscription of the Remnant Vegetation Protection Scheme is one positive indication of the farming communities' attitudes.

Protection of Remnants by Buffer Planting

This form of management is necessary, to protect native remnants from rising watertables, which cause waterlogging and salt encroachment. While nowhere near as popular a management method as fencing, it is being increasingly used in the State by farmers interested in preserving their remnant vegetation areas.

The choice of species in these plantings is very important, with the preferred option being species native to the district and hopefully of types similar to those in the remnant vegetation.

Economic Value of Remnant Vegetation in Farm and Catchment Planning

The incorporation of remnant vegetation management in the catchment planning process has been widely accepted. This will increase in future years, with a greatly increased demand for technical information on nature conservation issues.

The utilisation of managed remnant vegetation to provide products for commercial return is a growing practice. Wildflower and seed picking, apiary sites, and firewood gathering are uses that most readily come to mind. There is also a valuable role for remnant vegetation in the farm stay industry. This industry is already widespread in the lower South West of the State, but has not yet expanded to the same degree into the Wheatbelt.

WHY HAS OTHER RESEARCH NOT BEEN IMPLEMENTED?

Economics

Many farming communities have planned for land and nature conservation at farm and catchment levels, but this has not been translated into works on the ground. The main reason for this is the continued depression of the agricultural commodity markets.

Revegetation is the one form of remedial action that has continued through the depressed times. The reasons for this are many, and vary from district to district, but, above all, probably indicate that the community has accepted the extension message on this topic.

Landscape Importance

The other factor which hinders implementation is linked to economics, but is mainly about education. The role of remnant vegetation in the dynamics of the rural landscape has not been fully appreciated by the majority of the farming community. This may reflect the way the concept has been presented.

Education material which targets all sectors of the rural community is needed so that the rural community eventually sees the ecosystem, or "big picture" of the landscape in which they farm. Specific targeting of schoolchildren and women is suggested as a way of reaching receptive and influential sectors of the community.

Technical Extension

Increased awareness of the importance of the "big" landscape picture by the farming community, together with the trend to more broad-scale planning by land conservation groups, could increase the need for technical information in the future. Improved economic conditions will expand this need.

Currently, there is a lack of detailed information about the biology of Australian native species that live in remnants. Also, while there is much information on land management in scientific papers and manuals, this needs to be collated and presented to managers in readily accessible forms. Weed scientists present us with a model on how this should be tackled.

THE FUTURE

The role of remnant vegetation as an important component of the landscape will continue to grow in the perception of the rural community. The challenge for all scientists and extension specialists will be to have meaningful answers that enable rural communities to retain and expand both the areas and the species composition of the remnants.

Managing My Bushland

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INTRODUCTION

My brief from Ken Wallace was to outline what has been done to preserve remnant vegetation on our farm, and to outline the information on which we base our management.

John and I farm "Koobabbie", which is part of the Waddi Forest district of south-east Coorow. The land was selected by my grandparents in 1906, and developed by them and by my parents. The development was carefully planned, and waterways, granite, diorite and lateritic hills, and areas showing signs of natural salinity were not cleared. Strategically placed belts of woodland were retained for shelter. Unfortunately, only one rocky hill was permanently fenced from livestock.

My parents died prematurely, and by 1966 John and I were farming "Koobabbie" on our own account. We now own 6 855 ha, of which 4 028 ha is arable or used for grazing.

The remaining 2 857 ha, or 41.5% of the farm, can be described as uncleared salt lake country not grazed by stock (1 864 ha), rocky hills, most of which are fenced from stock (521 ha), and timber belts, most of which are fenced from stock (472 ha).

There are three major soil and vegetation types: sandplain on lateritic soils above the Darling Scarp, woodland on duplex soils, and saline lakes (Beard 1976).

MANAGEMENT OF REMNANTS

The property has approximately 196 km of fencing. Of this, 43 km is fencing necessary to fence the bush from livestock, and 5 km protects salt-affected land from grazing by sheep.

The fenced-off remnant vegetation is in 47 separate areas, ranging from 2 to 1 682 ha in area. Many of the fenced remnants are only separated because of the necessity to have a laneway for stock and vehicles to access paddocks. Of the 47 fenced remnants, only six are islands in cleared paddocks. The remnant vegetation fencing program began in 1970.

We still have 12 remnants that urgently require fencing but, unfortunately, they require long lengths of fencing for small total areas of bush.

The only financial assistance received has been $625 towards fencing, and 1 200 seedlings as part of a Greening Western Australia grant to the Waddi Forest Landcare Group.

The program to fence off remnant vegetation was given great impetus in the early 1970s, when I read *Between Wodjil and Tor* by Barbara York Main (1967). This book clearly demonstrates the profound changes wrought on the natural ecosystem by even minimum interference by agriculture. Although depressed by the realisation of the degradation of our bush, I resolved we should endeavour to preserve all the remnant vegetation, no matter how degraded. As a result, we have given first priority to fencing remnant vegetation, and our tree planting endeavours are aimed at reconstructing the more degraded areas, in preference to planting in cleared paddocks. Ideally, the bush would not need managing, but because of the impact of weeds, feral animals, and changes in indigenous flora and fauna, intervention is required.

At about the same time, I met the late Charles Chapman, who farmed at Winchester (32 km north-west of "Koobabbie"). He was a dedicated amateur botanist, and on that first meeting named three species of plants. Because of his encouragement, I became very interested in learning about the local flora.

In 1976, Roy Casey came to work for us. At last, we had an expert fencer, and the fencing program began in earnest.

It was in approximately 1980 that Brian Jack purchased an area of bush west of Coorow and established a plant nursery. Until the early 1980s, the idea of tree planting in our district was to make an annual purchase from the Forests Department nursery at Dryandra, usually of goldfields species or *Eucalyptus camaldulensis* (river gums), and 50 was a large order.

Brian quickly convinced me of the importance of growing local flora, preferably using seed collected on the farm, and ideally from the site where it was to be

replanted. Since the mid-1980s, I have been collecting seed which Brian grows for me. He pasteurises his soil, and supplies plants free of soil-borne diseases and weeds. We no longer purchase or receive plants from any other source.

In the early 1980s, Brian and Victoria Syme were instrumental in establishing a wildflower group in the district. As the emphasis of the group changed to natural history in general, many interesting people addressed our meetings, and often stayed at "Koobabbie". I cannot stress too much the importance of having people like Roger Edmiston, Penny Hussey, Denis Saunders, Barbara and Bert Main, etc. coming into the area, providing ideas and encouragement, and recommending sources of information. Fortunately, Roger Edmiston was one of the first speakers, in approximately 1982. We were using the post-hole digger in our clay to make tree planting easier. Since Roger's visit, we have ripped the soil before tree planting. After reading about a specially developed auger attachment for tree planting in *Rural Research*, we purchased one. It is useful for planting among existing trees, but requires a strong armed man with plenty of time to operate it.

In 1987, an area of 2 208 ha, consisting mainly of salt lake country 2 km west of our house, came on the market and we purchased it. We farm the 348 ha of arable land, and exclude stock from the remainder. It is a very interesting area with a wide variety of habitats, and is regenerating well. Nine hundred plants of a new species of *Halosarcia* grow around one lake, and will eventually be described as *H. koobabbiensis*. The other exciting discovery was *Ptilotus caespitulosus*, collected by James Drummond in 1842 and not collected since. An area like this provides little long-term grazing, and should be preserved in perpetuity. Excising the area as a reserve has management problems. I would like to see a legal mechanism developed so that land-holders can, if they wish, place permanent preservation orders on areas of bush they have preserved, which transfer with the land title.

Some areas of bush we have fenced have *Gastrolobium parviflorum* (box poison) regenerating. Because this species is poisonous to introduced species of vertebrates, it provides some protection to the bush. Legal protection will still be necessary to prevent clearing, but the poison will ensure farmers do not allow stock to graze on a short-term basis.

In 1987, an article appeared in the *Countryman*, an important line of communication to farmers, in which Denis Saunders called for volunteers to keep a checklist of birds sighted each week. We still keep the list, and have learnt a lot about birds in the process.

About the same time, Denis spoke to our wildlife group, and alerted us to the plight of the Carnaby's cockatoo that nests in the timber belt that runs past our house, and on the salt lakes.

In 1990, we commissioned Dr Stephen Davies to undertake a survey of the wildlife of "Koobabbie". Stephen spent two weeks here in autumn and spring. It was my first experience of using pit and Elliott traps, and mist nets. We already had some information on reptiles present, because Betty Wellington has made a number of visits here. Our CSIRO bird checklist was the basis for the bird list, and I made a plant list.

At present, the list of reptiles recorded for "Koobabbie" stands at 18, bird species total 93, and the very incomplete plant list numbers 313. There is not sufficient information on frogs to make a list, but they are here.

In the late 1980s, the Waddi Forest Landcare Group was established. At one stage, with Viv Read and Phil Bellamy as advisers, our group conducted some valuable workshops on mapping, salt land revegetation, and remnant vegetation. However, the office bearers tend to be overwhelmed by the bureaucracy and the paperwork the landcare movement generates. For the little financial support provided by governments, it has been suggested we would be better off incorporating and financing ourselves. At present, our group is lacking momentum and ideas.

The work on remnant vegetation done in the last decade is now reaching farmers in publications like *Managing Your Bushland* by Penny Hussey and Ken Wallace (1993), and *Revegetation Guide to the Central Wheatbelt* by E.C. Lefroy, R.J. Hobbs and L.J. Atkins (1991). A similar publication for the northern agricultural areas is currently being prepared.
For John and me, long-term farming goals are very

important. We rarely use insecticides, are involved in a Department of Agriculture biological program for the control of insect pests in pastures, and endeavour to minimise the use of herbicides and fertilisers. We strive to ensure that farming on "Koobabbie" is sustainable in the long term environmentally and economically, and aim to keep our farm as an interesting and pleasant place to live and work.

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INTRODUCTION

As a manager, I've witnessed a number of changes over the last 10 years in the management and research of remnant bushland.

Initially, I was involved solely with the management of Dryandra, a relatively large area of State forest, where the conservation values are obvious. Following the formation of the Department of Conservation and Land Management (CALM), my management role expanded to include many small reserves that, in my mind, had very little value. However, with time and the assistance of research scientists, I now view these areas as being critically important for the protection and conservation of different species and communities of the Wheatbelt.

In addressing the topic, I will list the main research projects that have occurred in the Narrogin District in the last 10 years, state examples of where research results have been incorporated into management, suggest how liaison between managers and researchers could be improved, and, finally, outline future directions for research in the Narrogin District.

RESEARCH PROJECTS

Narrogin District, which covers much of the central Wheatbelt, has been the focus for a variety of research projects. This diversity is illustrated by the following list of projects that have commenced in the last 10 years:

- fire ecology studies, including regeneration and fauna recolonisation, in Dryandra and Tutanning, by both CALM and tertiary institutions;
- flora and fauna studies — for example, Tony Friend's work on the biology of the numbat (*Myrmecobius fasciatus*);
- tertiary institution work, including whole community monitoring, such as Jonathan Majer's study of invertebrates in Dryandra;
- arboretum and tree establishment plantings, completed by departmental staff;
- fauna ecology and other studies by CSIRO in the Kellerberrin area;
- the establishment of the Tree Research Centre (now defunct), which primarily studied the regeneration of woodland communities;
- rare flora, species management, disease management and weed control research by CALM staff. This research in some instances was conducted by local staff;
- wetland monitoring — in particular, bore monitoring at Lake Toolibin;
- taxonomic reviews;
- continued tertiary monitoring and research;
- sandalwood research and development, including seed collection and trial plot establishment;
- research into tree establishment by CALM and the Department of Agriculture.

INCORPORATION OF RESEARCH INTO MANAGEMENT

Overall, the above projects have provided the Narrogin District with a broad research base for management. Specific examples of where research results have been incorporated into management are listed below:

- preparation of area management and recovery plans on the basis of research and operational work (for example, the Draft Dryandra Management Plan);
- amendment of fire regimes in the Dryandra Woodland in accordance with research recommendations;
- introduction of predator (fox) control on an operational basis;
- development of direct seeding techniques by the

Tree Research Centre, which have been tried with mixed results;

- successful translocation of numbats to Boyagin Nature Reserve. District staff assisted with this work;

- establishment of further sandalwood seed resources in Dryandra, following research and development by scientists and local staff.

MANAGER AND RESEARCH LIAISON

We at Narrogin have been fortunate that important research work has happened on our doorstep and the researchers involved have always made time available to spread their message. Consequently, our whole group, from district manager to maintenance worker, is exposed to the latest research results. Other research happening elsewhere is not as accessible, so we rely on relevant "readable" publications such as *Landscope*, *Managing Your Bushland* (1993), and rare flora publications, to provide us with up-to-date information.

I believe liaison with researchers is the regional ecologist's role. Hopefully, he or she can keep district personnel informed of relevant research and its application to management. This task could be achieved by providing district managers with periodic reviews of current practices. Recommendations in such reviews need to be clear and have measurable outcomes if they are to be incorporated into management.

To further improve liaison, researchers should brief district staff when a research program is to be implemented in their district. Some ownership and involvement by the district personnel are essential. I commend Tony Friend in this area for his past liaison work with the Narrogin District staff.

Finally, all recommendations generated by research have a cost. It is important that researchers address the cost of incorporating results into management programs.

FUTURE RESEARCH DIRECTION

As a manager, I now take the opportunity of listing areas that we in the Narrogin District believe researchers should investigate further.

Fire

Fire ecology, particularly with respect to woodland and heath regeneration, remains an important research task. The Narrogin Tree Research Centre was, I believe, breaking into that area of research when it closed.

Remnant Management

Minimum specifications for the successful management of communities and species within small reserves are required. Guidelines are also required so that managers may evaluate whether communities or species are in decline.

Corridors

Specifications for the development of corridors are required. For example, what is the minimum width of an effective corridor?

Plant Regeneration by Seed

Information on seed production and the natural storage of propagules from understorey species in Wheatbelt reserves is required.

CONCLUSION

My conclusions are:

- Some research projects have provided the Narrogin District with a sound scientific basis for management.

- The most successful research projects have included close liaison between researchers and managers, with operations staff assisting researchers and gaining first-hand understanding of the project and its implications for management.

- The regional ecologist has an important role to play in reviewing local operations and synthesising research results into management prescriptions.

- New research — for example, on corridors and regeneration — could assist my district to manage remnants more effectively and to regenerate the degraded areas better.

Our district looks forward to the continued good working relations with research personnel, and hopes the feeling is mutual.

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The Dongolocking Corridors Project

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INTRODUCTION

Dongolocking is in the Dumbleyung Shire and lies 22 km north of the Dumbleyung township and approximately 210 km south-east of Perth. The district of Dongolocking and the Dongolocking Nature Reserves are high in the landscape, and lie roughly halfway between Toolibin Lake and Lake Dumbleyung.

The Dongolocking Nature Reserves are made up of 13 separate blocks which total 2 269 ha in area. They are home to at least 82 species of birds, seven species of frogs, 23 species of reptiles and 10 species of native mammals. The Dongolocking Corridors Project aims to link these separate blocks, other public reserves, bush on farms, and roadside vegetation with substantial passages of revegetation consisting of local species.

The Dongolocking Corridors Project was set up while I was employed by Greening Western Australia. I had worked and lived in the general area for 11 years. During this time, seminars on Wildlife on Farms, Ribbons of Green, and Fox Control had been held in the Great Southern Region, and bus trips had taken place with the general theme being remnant vegetation, and its plants and animals, among farmland.

ACTIVITIES

Before starting our corridor fencing, we held a public meeting for all farmers in the Dongolocking district, with short talks, "cuppa" tea, discussion and then a field trip. Most farmers were willing to cooperate, with only two farming families declining the offer of subsidised fencing for the protection of bush.

Our first step was in 1987, when we planted native species on the road verge of the newly made Tincurrin Road, which runs parallel to the Dwelyerdine Road and intersects the Dongolocking Road to the south. In 1991, with the help of schoolchildren, the local Dongolocking community planted several kilometres of the old Dwelyerdine Road, shortly after it had been realigned by the Dumbleyung Shire Council. This corridor connects two Dongolocking Nature Reserves (Reserve Nos 19082 and 19083) with the Dongolocking Road.

In the same year, a Save the Bush grant enabled 14 Dongolocking farmers to fence 32 km of unformed road reserve and several more kilometres of connecting corridors to bush on farms, roadsides, public reserves and Dongolocking Nature Reserves. This linked 11 reserves into the corridor system. Within these corridors on private property, we are now replanting and direct seeding local gene pool plants to recreate bush for the movement of plants and animals from one remnant to another. With supplementary plantings of understorey this year, most plantings will have included both canopy and understorey species.

RESEARCH

We have just become the volunteer "legs" for scientific research, or "barefoot biologists", to answer our own questions of:

- "How wide do we make our corridors?"
- "What is going to use our corridors?"

To do this, we have begun a six year study of three of the corridors planted in 1992 and 1993, under the guidance of Drs Graeme Arnold and Graeme Smith, Senior Research Scientists, CSIRO Division of Wildlife and Ecology, Perth.

We began monitoring the movement of birds from one patch of bush to another in March of this year (1993), by listening and looking for birds at either end of, and along, our corridors. We record species and numbers seen and will continue to survey bi-monthly until 1999. We are about to set up pit traps to see what small invertebrates and vertebrates are using our man-made corridors, and we will monitor these for a week at a time in December, January and February for the following six years.

We are fortunate in having Graeme Arnold's guidance, expert advice and teachings and Graeme Smith's direction and support. We also have support and help from the friendly and enthusiastic people who work in the Narrogin and Katanning offices of the Department of Conservation and Land Management. We have been helped and encouraged by easy access to people dealing in remnant vegetation research.

We have a reasonable reference library, including the important publication by the WA Museum (Chapman *et al.* 1978) that provides the basic biological reference on the Dongolocking area. It is an invaluable guide for our revegetation work.

Our efforts have taken a lot of time, money and "hard slog". The project requires seed collecting and sorting, weed and rabbit control, site preparation, direct seeding, planting and fencing, and we are still far from recreating bush with all of its diversity of plants and age groups — only time and plant succession will do that. The bush corridors we are growing are small in area — 19 ha in total — and compare sadly with the 240 ha of remnant vegetation adjacent to the Dongolocking Reserves cleared in the past 10 years.

We cannot make long-term advances without adequate extension programs to publicise our results and their practical applications. For example, at a recent Dumbleyung Land Conservation District Committee meeting, a motion was passed to support a local farmer in his intent to clear 197 ha of virgin bush. This is disappointing in a Shire where only 6.3% of private land occurs as remnant vegetation (Coates 1987). Furthermore, less than 1% of remnant vegetation in the Shire is of a size and condition to be of ecological significance (Environmental Protection Authority 1993), and 197 ha accounts for a considerable proportion of this meagre total.

The amount of public land under vegetation in the Dumbleyung Shire is estimated at 4.1% (Coates 1987).

CONCLUSIONS

It is heartening to see a positive change of attitude to bush and its worth among our volunteer work force at Dongolocking. We have enjoyed extensive coverage of our activities in the local, regional and State wide press. Regrettably, we still have a hard road to hoe to convince the local farming community of the importance of remnant vegetation.

More emphasis needs to be placed on extension work promoting the retention, management and appreciation of the little remaining bush that we have.

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A Farmer's Perspective –Management of Remnant Vegetation

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INTRODUCTION

Throughout the Jerramungup Shire, to my knowledge, the only research finding relevant to remnant conservation that has been implemented is the necessity to fence stock out. Certainly, on our farm this has been the case.

No doubt all or most of you would have read the book *Managing Your Bushland* by Penny Hussey and Ken Wallace (1993), who list fencing as virtually the first action in the first year of a program to conserve remnants.

However, if we look into paddocks when driving around the country, it is immediately evident that only a very small percentage — perhaps 5%, or even only 0.5% — of remnants are actually fenced. Does this suggest that the research finding is wrong, or is it irrelevant? And what do we mean or conjure up in our mind when we talk about remnants? Do we think of once pristine areas now slightly, or greatly, degraded?

To address the second question first, I believe the need to fence remnant vegetation applies equally to all remnants that are to be conserved, irrespective of their condition. But what of the first question? My opinion is that, generally speaking, fencing remnants from livestock works well. However, there are costs and difficulties simply because there is no such thing as a "free lunch".

COSTS AND DIFFICULTIES

For today's exercise, I have identified five costs and difficulties.

Costs of Erecting Fences

The first and obvious cost is dollars — $1 400/km for materials and $450/km for erection to complete conventional fencing, or $700/km plus $300/km for erection of electric fencing, not counting the energiser and other initial costs. Bank managers and farm consultants are usually interested in "the bottom line". Despite the long-term benefits that may arise from conserving remnants, there is no immediate benefit in terms of dollar returns from fencing them. Also, once the fence is there, it has to be monitored and maintained forever if the remnant is going to be successfully conserved. This adds an ongoing annual cost.

Costs of Damage to Fences

Damage to fences is an additional cost. This can happen in a few ways:

Pressure of stock (literally): Modern cropping techniques require the elimination of grasses before sowing cereals. Therefore, before sowing, pasture paddocks need to be heavily grazed during spring, summer and autumn. If remnants are within these paddocks, then fence damage is likely due to "the grass being greener on the other side of the fence". To reach green vegetation, sheep will push on fences, thus causing damage.

Flooding: If the remnant adjoins a waterway, heavy summer or autumn rainfall may result in fences being washed over or away.

Farm machinery: All farm fences are subject to damage by careless use of machinery or vehicles, especially during the cropping phase.

Wildlife: Kangaroos or emus caught in fences can break wires and cause considerable fence damage.

Fire: Apart from wildfires, deliberately lit fires are also a factor causing fence damage — for example, where stubble burning is being practised on the farm. This controversial practice has begun to reappear as farmers experience difficulty seeding legume crops into heavy cereal stubbles. Higher yielding crops, and their associated heavy stubbles, are occurring due to the rapid adoption of new technology.

Firebreaks

These are costly in many ways. In some shires during summer — Jerramungup, for example — firebreaks must be constructed and maintained around the boundaries of bush. Like all firebreaks, those around remnants suffer from water erosion, which may become costly.

Encroachment by Annual Pastures or Weeds

If remnants adjoin a waterway, it is virtually impossible to prevent pasture residues and seeds being washed into them. To prevent extra contamination with weeds, these patches would need to be sprayed annually with a herbicide.

Loss of Shelter for Stock

This applies particularly to protection of lambing ewes or freshly shorn sheep. Remnants, at least in the Jerramungup area, cannot be used as shelter for stock unless the farmer is prepared to eradicate native poison plants and accept the loss of the understorey through grazing. Grazing will, if it is intensive enough and over a sufficiently long period, result in the loss of a remnant due to ringbarking of trees and shrubs by stock. Some pristine or partly degraded remnants have been fenced to provide some protection to stock, but these are far fewer than those that are unfenced and partly degraded, and where stock can get right in among the bush.

SUMMARY

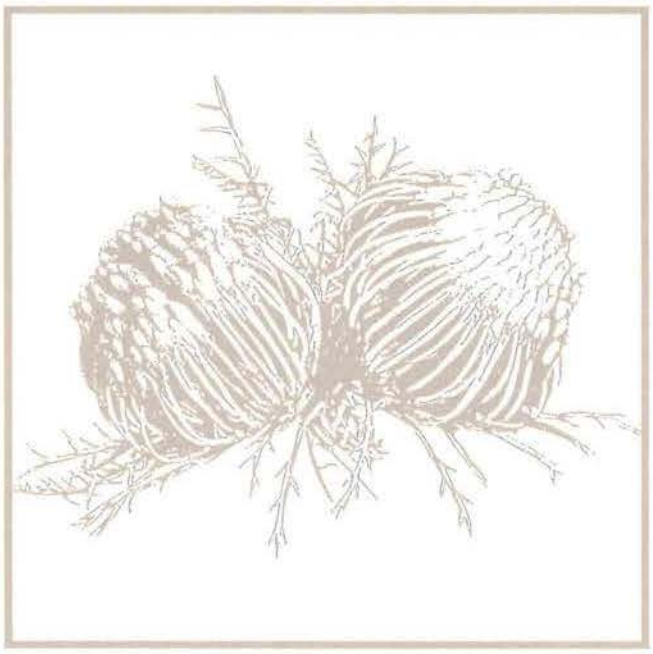
In summary, then, I wish to make just three points:

- Only one research finding has been generally implemented by farmers, and even that in a minute proportion, although the finding works well.
- Protecting remnants is expensive and very time-consuming and shows no immediately obvious annual return in terms of income.
- Perhaps future research needs to address the low adoption of a basic finding.

REFERENCE

Hussey, B.J.M, and Wallace, K.J., 1993. *Managing Your Bushland.* Department of Conservation and Land Management, Perth.

WORKSHOP REPORTS



Workshop Reports–Introduction

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PROCESS

Following the presentation of papers by managers and researchers, a plenary session was held. During this session, participants identified ideas and issues crucial to the effective management of remnant vegetation. These ideas were then grouped into categories and ranked for consideration by small discussion groups.

After discussing their topic, groups reported their conclusions to a final plenary session. Each group provided a written summary of its discussion, together with any relevant points that arose during the final plenary session. Reports from the small group workshops are presented in the following pages. The plenary session points that stimulated each topic are listed with the relevant report.

ISSUES LISTED, BUT NOT DISCUSSED

Due to time constraints, a number of topics and many issues were not discussed, despite their importance. Issues that were not covered by small groups are listed below. This list supplements the workshop reports by providing insight into the range of matters pertinent to the effective management of remnant vegetation.

Research Issues

- Start a "gene collection" from those remnants that will become entirely degraded.
- Remote sensing is not widely used by the Department of Conservation and Land Management (CALM). Why?
- Describe fauna diversity in the same manner as Stephen Hopper's paper (this volume) on flora diversity.
- A database on Crown remnants is required.
- Research and management program required concerning buffers for remnant vegetation on farmland.
- Problem: as rare fauna increase — for example, as a result of fox baiting — there may be a detrimental effect on flora.
- Need to understand fauna and flora dynamics. Do not necessarily want to keep "maximum" population numbers of animals. Animals do not necessarily need to be visible.
- How do you cater for cumulative and synergistic episodic events?
- What level of fox baiting do we require?
- District trials on fox baiting are required — for example, to determine the most effective baiting regime.
- How degraded is too degraded?
- How do we make sufficient seed available for revegetation?
- Disturbance: how do you get the right disturbance?
- What is the functional hydrologic unit for a farmer?
- Definition of functional units for management targets.
- Integrating values in assessing land clearing proposals.
- The role of native pests in revegetation (for example, twenty-eight parrots, kangaroos, insects, etc. may all have a detrimental effect on revegetation work).
- The need to develop commercial products to ensure sustainable agriculture.
- List, on a species basis, constraints on regeneration. What is the role of shade, space, moisture, fire, nutrients, etc.?
- Water harvesting in remnants: how does it occur? What are implications for revegetation? Implications for use of local species of plants?

- What is the relative importance of cats and foxes as predators?
- Understanding of soil processes, including the role of fungi.

How Do We Make Land Management Decisions?

- What is an easy way for farmers to monitor the health of remnant vegetation?
- Networking within organisations is a more effective way of getting things done than using formal hierarchies.
- In relation to rising watertables, there is a need for "risk evaluation" for remnant vegetation (determining management priorities).
- The "bottom up" approach is possibly the most effective means of decision-making.
- Issues of male–female relationships in decision-making.
- Who makes decisions and how?
- Are expert systems an option?

What Are the Values of Remnant Vegetation?

- What is the dollar value to farmers of retaining remnants and of revegetation?
- Does the community accept nature conservation as a worthwhile goal in its own right?
- Is "uniqueness" a value of remnants?
- We need a better description of remnant value.
- Does real conservation lead to increased production?
- Does the value of the remnant equal price?
- Ecotourism: does it have value for remnants?

The Messenger

The "messenger" is the person charged with the task of explaining to key decision-makers the degree to which land degradation has already occurred, and just how much worse it is likely to become.

- Who is going to be the messenger? Who is credible?
- Equity issues in catchments — for example, who is going to tell the politicians that there is a problem?

Other Issues

- Minimise resources required to implement research.
- Agricultural systems require an overhaul of the production system.
- Nintendo numbat game — an example of a way of promoting some of the issues.
- "SNAG Farmers" are required.
- Databases of managers and their interests. But who maintains? Must be well packaged.
- How do we overcome community prejudices against invertebrates?
- Database of "facts" for managers? Who maintains? Should develop a proforma that forces people to focus on implications of research.
- South West is biggest island from Cretaceous — we must get across to people the extreme history of the flora.
- The role of drainage in agricultural production and land conservation.
- Is the "groundwater" message getting through to the public?
- What about clearing controls?
- There is a delay in the implementation of research results by managers. Researchers should quantify the management implications of their work — this may enhance management adoption.
- Is rare species conservation valuable, given the urgent need to expend resources on fixing big processes?

How Do We Achieve Communication within and between Agencies?

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Workshop Group
Helen Allison, Ken Atkins, Gordon Friend, Richard George and Ken Wallace.

Points from Plenary Session
The following points, raised during a plenary session, stimulated this workshop topic:

- Regional ecologists — are they the appropriate interface between research and management?
- How do you get researchers and managers to talk to each other?
- Do we need a central focus group? What should it be?
- Formal networking on remnants. Who organises it?
- Technical extension and remnant management.
- Technical advice on species for advisers — for example, "facts" sheet on proposed species introductions.
- Wanton oversights by end-users.

STAKEHOLDERS AND PROCESS

Before discussing particular issues and actions, the group first listed stakeholders and dealt with aspects of the communication process.

Stakeholders
The main agencies involved in remnant vegetation research and management are:

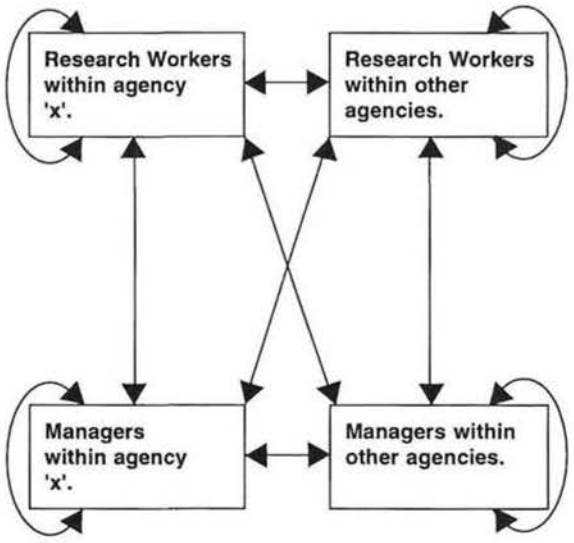
Federal
- Australian Nature Conservation Agency
- Department of Primary Industry and Energy
- CSIRO
- Land and Water Resources Research and Development Corporation
- Rural Industries Research and Development Corporation
- tertiary institutions.

State
- Department of Agriculture, Western Australia (DAWA)
- Department of Conservation and Land Management (CALM)
- Department of Environmental Protection (DEP)
- Department of Planning and Urban Development
- Integrated Catchment Management Group
- Kings Park and Botanic Garden
- Office of Catchment Management
- Water Authority of Western Australia
- Waterways Commission.

Non-government Organisations
- Australian Conservation Foundation
- Conservation Council of Western Australia
- Greening Western Australia
- Men of the Trees
- World Wildlife Fund.

Communication Flow Diagram

The interactions within and between researchers and managers are generalised below. The arrows indicate the direction in which information and ideas are communicated.



Means of Communication

Communication between individuals and groups may be through one or more of the following channels:

- paper formats (letters, notes, published, unpublished, etc.);
- verbal (including teleconference);
- computer.

Processes for Communication

Linkages between groups and individuals who share a common interest may be maintained by using a range of methods including:

- informal network;
- formal network;
- research working group;
- workshops and technical workshops;
- computer network (for example, that maintained by DAWA);
- register of contacts;
- information sheets and bulletins.

DISCUSSION

Transfer of Information between Researchers and Managers

Within and between agencies, there is a need for effective internal and external communication of research information. This communication should involve both researchers and managers. It was agreed that communication within agencies is not adequate. Furthermore, a specific problem was identified with regard to accessing information from universities, where many graduate and undergraduate projects have the potential to contribute to the knowledge base. Unfortunately, this latter information is not widely available.

One model to resolve this problem is provided by DAWA. It has a computer facility which lists, for each research scientist, their research projects and results. This allows ready access, by scientist name or topic, to the current work being undertaken, and also allows access to unpublished results. It was considered that it would be beneficial to link all institutions undertaking research — at least in the natural sciences and, in particular, those related to land management — through a common database. Institutions that should be involved include CALM, CSIRO, DAWA, DEP and universities. A problem was seen, however, in maintaining these databases. In DAWA, it is each researcher's responsibility, but this may be harder to achieve in the universities.

Action

CALM (Ken Wallace) to write to Jim Armstrong, suggesting that CALM's Science and Information Division develop a computer network system similar to that used by DAWA.

Action

Promote the use of a similar database in tertiary institutions.

Action

Development of a network across organisations. With regard to access to computer networks in rural centres, it was noted that DAWA and CALM are linked at South Perth, and DAWA has a network to major rural centres. It is therefore feasible to have CALM and DAWA regional centres linked through the existing networks.

Information Integration

A problem was identified regarding the integration of information into a form suitable for managers to use. Options were developed that would improve communication to managers. It was recognised that options must be tailored for the particular circumstances of each agency and management or research group.

Action

Agencies to adopt a suitable strategy for communicating research information to managers, using one or more of the following options:

- employ a regional person to integrate information — for example, a regional ecologist;
- employ an organisational person to integrate information — for example, an information officer as used by CSIRO;
- expect research scientists to integrate information and produce prescriptions for managers based on their research;

- ❖ develop collaborative projects between managers and researchers, including university students where practicable, to achieve specified targets. Such projects involve integration from the outset, and are driven by feedback from project results.

It was commented that, to ensure that research is applicable to management requirements, managers need to drive research projects.

Manager Involvement in Research Projects

In line with the fourth option presented above (and the comment), managers should be proactive in identifying research requirements and seeking means to have research undertaken.

Action

Managers to identify and describe research projects that are a high priority. They should then circulate their proposals to all research bodies and promote funding under, for example, Federal grants, and the research programs of agencies and tertiary institutions.

It was pointed out that CSIRO has a model operating with universities, whereby research projects are listed with the intent of them being taken up as student projects. This model should be developed as a means for other agencies to promote their research requirements. It was noted that the provision of some funds by the sponsoring agency was not essential, but it helped. Also, it was noted that joint agency submissions could improve the chances of getting funds.

Action

J. Majer and CSIRO to circulate to managers and agencies the model or procedure for the listing of research projects at universities.

Coordination of Research Activities

Research steering committees in agencies are intended to establish protocols and policies for interagency research cooperation. Thus this level of committee does not provide for communication or interaction between researchers and managers.

The objective of a research coordinating committee is to ensure that research within an area or topic is appropriate and coordinated. An example of this functional level is the Agroforestry Working Group. This level of interaction was seen as being more applicable for communication between researchers and managers.

Action

CALM to set up a research coordinating group for remnant vegetation management.

Extension to Managers

It was agreed that field based, topic driven technical extension workshops were very effective for providing information to managers. These are best organised as interagency meetings where all relevant workers are able to contribute. Results from field days should be collated and distributed to participants and other relevant agencies, to confirm agreements and to provide a basis for planning future research and management actions.

Action

Agencies to promote interagency technical extension workshops and technical review days from which proceedings can be produced.

Networking for Information Exchange

It was agreed that there was a continuing need for informal and formal networking. While informal networking (between officers) provides valuable contact, regular "formal" meetings are required, to ensure that all agencies are aware of current management and research actions and to provide a forum for the exchange of information and ideas. This is (at the time of writing) being provided through the DEP Native Vegetation Network Group.

Action

Agencies to be aware that the Native Vegetation Network Group is to continue meeting at DAWA.

How Do We Integrate information into a Form Accessible for Land Managers and Researchers?

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Workshop Group

Greg Beeston, Anne Brandenburg, Steve Gorton and Terri Lloyd.

Points from Plenary Session

The following points, raised during a plenary session, stimulated this workshop topic:

- Who creates the "Big Pitcher"? Does this really help?
- Looking at "nuts and bolts" (see paper by Richard Hobbs, this volume) can help set priorities, but synthesis is required.
- "Big Pitcher" requires an integrated and interdisciplinary approach.
- Problem: management implications of research are very site specific.
- Remove land from production? If so, then re-allocate priorities for land use.
- Integrating information into packages.
- Is there too much information?

INTRODUCTION

Researchers and managers of remnant vegetation in south-western Australia have indicated that the protection and management of remnants must be further improved if the conservation value of remnants is to be maintained and enhanced. Presentations by researchers and managers at this meeting have pointed out that there is a lot of information available on remnants, but this is not necessarily being implemented by managers. Furthermore, remnant managers are not necessarily being supported by appropriate research and information support systems. Poor communication between researchers and managers of remnants was considered a major cause of these problems.

Integration and communication of research information and management needs must be enhanced if problems are to be overcome. The sheer bulk of information on remnants and site specificity of research results compound problems of inadequate communication systems. Furthermore, conservation efforts must also involve an interdisciplinary approach, to achieve better management of remnants. This report summarises a workshop discussion and points emanating from the plenary presentation which specifically addressed these problems and asked the question: "How do we integrate information into a form accessible to land managers and researchers?".

THE "BIG PITCHER"

The synthesis of research information and the development of a unified, cohesive vision for remnant conservation (affectionately termed the "Big Pitcher") were identified by the meeting as integral to maintaining the conservation potential of remnants. The workshop group took the concept of the "Big Pitcher" on board, and at all times discussed the integration and presentation of information for land managers and researchers within the context of a "Big Pitcher".

DEVELOPMENT OF THE "BIG PITCHER"

Development of the "Big Pitcher" was conceptualised as being through a small organisation that would provide a base and framework for the coordination and communication of information between individuals and groups with an interest in remnant conservation. It would also act as a base for the strategic planning for remnant conservation. This would include such aspects as conservation planning, policy development, and the promotion of an improved conservation ethos for remnants which must be instilled in the wider community if remnants are to be conserved in the long term. Hence, the "Big Pitcher" would be operational at both applied and strategic levels.

SPECIFIC ROLES OF THE "BIG PITCHER" AGENCY

Applied Operations

At an applied level, the role of the "Big Pitcher" agency would be to undertake a series of tasks relating to the management of research results, identifying

management needs, and stimulating information transfer and extension. Outlines of some information management tasks follow.

Research

- Synthesise research outcomes.
- Develop the management implications of research outcomes if these have not been done by individual researchers.
- Develop holistic databases and landscape models that can be used and implemented at the on-ground, remnant management level.
- Disseminate synthesised research information to the appropriate land managers.

Management

- Identify the information needs of remnant managers.
- Synthesise management needs into information packages for remnant researchers.
- Disseminate information on management needs to the appropriate research institutions.
- Collate a database of management needs for the "Big Pitcher" management committee to use when considering the future direction of remnant research.

Information Transfer

- Coordinate the design of information packages on remnant conservation. These must be appropriately targeted, presented and packaged for users. Interactive packages with interesting, informative and prescriptive material written in "simple English" were considered key elements in the design of good information packages (for example, *Managing Your Bushland* by B.J.M. Hussey and K.J. Wallace, Department of Conservation and Land Management, Perth, 1993).
- Identify the most receptive and influential group of land managers for receipt of remnant information packages. Children and rural women were perceived as being ideal initial targets.
- Disseminate remnant information to target groups. Such information should include a bibliography of research work done in south-western Australia and a mailing list of persons from the various interest groups and government organisations involved in remnant research and management. For the landowner, dissemination of information would include one-to-one interactions wherever possible. All avenues for information dissemination should be explored (for example, television, radio and audiovisual material).
- Feed the synthesised information that identifies research outcomes and management needs for remnant conservation to the "Big Pitcher" management committee and, thus, facilitate strategic planning for remnant conservation.

Extension

- Develop and coordinate remnant conservation extension programs.
- Employ the skills of specialist extension personnel (for example, have nature conservation officers that operate in parallel to landcare technicians and project officers).

The workshop discussion stressed that information management must involve two-way communication between researchers and remnant managers. While researchers require an avenue for dispersing their research findings, managers must also have an avenue for identifying their research needs.

Strategic Operations

The strategic planning role of the "Big Pitcher" would include identifying conservation objectives, developing remnant conservation policy, and promoting a conservation ethos among the wider community. Some ideas of what this work would involve included:

- developing a vision for remnant conservation in south-western Australia. This would involve defining conservation goals and objectives for the region, as well as developing principles and guidelines for

remnant management. This process would be facilitated by the provision of synthesised information collected by the "Big Pitcher" agency and would also include inputs from the wider community;

- developing the concept that remnant conservation is a land use in its own right;
- promoting the integration of various land uses within the agricultural landscape;
- supporting economic incentives that facilitate landscape and remnant conservation (for example, taxation benefits for nature conservation purposes);
- developing and promoting legal mechanisms for the voluntary protection of remnants in perpetuity;
- providing support to persons with a "bent" for remnant conservation and a positive influence on others;
- identifying the direction of remnant research.

STRUCTURE OF THE "BIG PITCHER" AGENCY

It was considered that the "Big Pitcher" agency should be an autonomous, non-government agency comprising a committee that broadly represents remnant researchers and managers. The committee would be responsible for managing a group of skilled personnel employed to undertake the specialists tasks of the organisation (refer to "Applied Operations" above). The organisation should be located at a site in Western Australia which experiences the problems we are trying to solve.

Other suggestions for an operational format for a "Big Pitcher" agency which were discussed during the workshop or plenary session included:

- creating a remnant conservation section within a current government agency;
- extending the current brief of the Remnant Vegetation Steering Committee;
- expanding the current Save the Bush scheme;
- adopting the Roadside Conservation Committee type model;
- extending the conservation commitment of on-ground land managers (that is, land conservation districts and local government agencies). Discussion of this option highlighted the importance of recognising land ownership as a critical factor influencing adequate remnant conservation;
- adopting a management authority approach (for example, Kings Park Board, Rottnest Island Board);
- adhering to the current situation, with interested persons doing more work on remnant conservation within their individual work environments.

A series of problems with setting up any type of new conservation agency or management authority were identified during the plenary session. The development of a new bureaucracy would require the injection of a large amount of funding, which could prove difficult to obtain. It may also pose a threat to current conservation agencies and land managers, and would probably prove a politically sensitive issue with which to deal. Furthermore, assuming that an organisation such as that proposed would be affiliated with at least one government authority as a consequence of funding arrangements and the need for organisation credibility, it would be virtually impossible for the "Big Pitcher" agency to remain completely autonomous and not be committed in some way to the expectations of its supervising authority. A better approach to attaining an integrated and accessible information transfer system may be to facilitate the networking process that is currently in place. However, given the constant reminder that there are a series of problems working against remnant conservation, there seems to be a trend for a more integrated, interdisciplinary approach to conservation planning developing.

How Do We Integrate Nature Conservation with Other Land Uses in the Context of the Western Australian Wheatbelt?

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Workshop Group
Penny Hussey, Greg Keighery, Jonathan Majer, David Mitchell and Denis Saunders.

Points from Plenary Session
The following points, raised during a plenary session, stimulated this workshop topic:

- Clearing and values of resultant remnants in the context of land conservation and nature conservation (incremental degradation is occurring, only 10% left, etc.).
- The farmer requires solutions from advisers, not just information or problems (value returns need to be quick).
- Is "fixing" the agricultural system a prerequisite for nature conservation? Is it a prerequisite for sustainable agriculture?
- Is fencing of degraded remnants worthwhile?
- Local versus non-local and exotic species in revegetation — which should be used and when?
- What is the role of economic plants in revegetation?

INTRODUCTION

In the Wheatbelt, we have a matrix of cleared land enclosing scattered remnants of uncleared native vegetation (Crown and private) of varying size and shape. The remnants are the responsibility of numerous different managers. Their management responsibilities are imposed over, rather than aligned with, a mosaic of soil and drainage patterns.

Research indicates that the current system of nature reserves will not sustain the biota of the region within their boundaries, and that degradation of these areas and their biota is occurring at an increasing rate.

Management staff are beset by "day to day" problems and are therefore unable to manage these areas with a long-term conservation goal.

What is required is a sustainable (this implies profitable) system of land use that does not compromise nature conservation values. It was noted that it may be possible to develop a "long-term system" that does not take into account nature conservation; however, many would question the long-term viability of such a system.

The necessity of change is generally accepted, with models having been developed on how such a system would work (see, for example, paper by E.C. Lefroy, R.J. Hobbs and M. Scheltema in *Nature Conservation 3: The Reconstruction of Fragmented Ecosystems*, eds D.A. Saunders, R.J. Hobbs and P.R. Ehrlich, Surrey Beatty and Sons, Chipping Norton, 1993), and there is research aimed at widening the range of agricultural products and systems. However, much of the above is occurring as an uncontrolled experiment, with "bits" being undertaken by individuals, groups and agencies. The timescale of change is more than 20 years, the process is unstructured, methods and results are unrecorded, and information transfer is essentially by osmosis.

How do we assist, hasten and direct this experiment?

PROCESSES

To coordinate and enhance a sustainable system of land use, the following processes are required:

- multilayered education;
- economics (commitment of resources);
- coordination and integration of land management;
- transfer and communication of information.

What actions may participants in this workshop group undertake to increase their effectiveness?

EDUCATION

This topic was dealt with by another workshop group. However, our group highlighted the need for a multilayered effort, including formal education (schools, agricultural colleges, adult education) and informal education (popular media, workshops,

meetings). There is also a need to define what it is we want to teach. Are we raising the general (biological and ecological) knowledge base of land managers so that they can make informed decisions, or at least understand decisions made for them? Or do we require reliable, informative and "user friendly" summaries and "recipes" from research results?

Action

Anyone (scientists, managers, etc.) who is committed to change needs to be able, and perhaps required, to allocate a large proportion (15–30%) of their time to communicating with communities concerning nature conservation issues. This involves talking to both the converted and the unconverted. This commitment should include writing research summaries, media liaison, participation in workshops, talks to landcare groups, etc. Currently, our focus is still too directed to publishing in the scientific literature and talking to the professional land management community. Communication beyond these groups will foster a two-way flow of experience and ideas between all land managers.

Action

Pass on the results of this workshop to decision-makers, by proceedings, media releases, personal contact, and any other available means.

ECONOMICS

A profitable, self-funding system of agricultural land use is a basic requirement. The establishment of such a system will require input from all Australians. It is beyond the scope of this workshop to recommend the allocation of funding to this change; however, the actions recommended will assist in highlighting this need to the public and politicians.

Action

As well as allocation of money, there needs to be a re-allocation of priorities and resources within bureaucracies. All workshop participants are now better placed to enunciate these changes within their groups or organisations.

COORDINATION AND INTEGRATION OF LAND MANAGERS

There is a need to increase effective communication between farmers, shires, Department of Agriculture, Western Australia (DAWA), Department of Conservation and Land Management, Main Roads Department, Westrail, non-government organisations, etc., to ensure that a sustainable land use system is attained.

This and other actions will require additional resources in terms of funding. The scale at which action should take place, and the primary body for integration are difficult to determine. The Environmental Protection Authority and DAWA have defined 84 ecological units in south-western Australia; there are 114 Land Conservation District Committees (LCDCs), and many shires, agencies and individuals (who will do most of the work).

The workshop group felt that the importance of local "ownership" made LCDCs (or similar "grass-roots" based groups) the best bodies for integration. However, they will require additional resources to hire and select personnel, and to maintain a capability to train others.

Action

A focus on interagency cooperation is required. It is essential to speed this with a commitment of additional funding, including recruitment of new staff. These extra jobs cannot simply be "dumped" onto any existing person's or group's current workload. Workshop participants must assist in ensuring that people outside the region (cities and Eastern Australia) realise that funding these changes is a "whole community" responsibility. This will eventuate in the establishment of a self-funding network in the Wheatbelt in the future.

TRANSFER AND COMMUNICATION OF INFORMATION

There is a need for a system that encourages and records the current unplanned experiments. Currently, there exists a growing knowledge base — not enough, but enough to warrant more action than at present. There are several useful models and experiments to build upon. However, managers cannot spend all their time attending open days and workshops.

It would appear that the best action workshop participants can undertake is the first listed above — namely, to spend more time in communicating their research and management results in a wide variety of formats such as local papers, radio, television, meetings, etc. This should ensure that the "message" will reach the target audience and be adopted by some of them, who in turn will spread the message to others.

What Are the Philosophy and Goals for Managing Remnant Vegetation within a Landscape Context?

Don McFarlane
Department of Agriculture, 128 Albany Highway, Albany, WA, 6330

Workshop Group
Mike Fitzgerald, Kelly Gillen, Angas Hopkins, Robert Lambeck, Don McFarlane and Barbara York Main.

Points from Plenary Session
The following points, raised during a plenary session, stimulated this workshop topic:

- What are the goals for land and nature conservation? How are these goals integrated?
- Researchers should recognise that they are servers.
- What are the conservation objectives and targets for the Wheatbelt? We can't look after everything, so what and how do we choose what to save?
- There is a strong need to develop a landcare ethic.
- People need to develop a vision for the future of agriculture and nature conservation on private property.
- Better definition of goals and objectives.

DISCUSSION

Philosophy Needed for Managing Remnant Vegetation
Society needs to develop a deep love for the land (landcare ethic) similar to that held by indigenous people, making abuse of the land unacceptable. Society also needs to accept its responsibility for managing the conservation estate on both private and public land. The strong affinity for the land needs to override issues of boundaries and ownership, and landowners must be custodians for future generations. In this regard, there is a dilemma between the rights of the individual who owns the land and the responsibilities of that individual to the community and future generations.

Conservation was seen as being possible once the basic needs of individuals, families and society were met. As the benefits of remnants are shared by the community, there needs to be government assistance for owners, particularly when times are hard. Assistance should not be through compensation, but in the form of technical and financial help, to ensure that the nature and land conservation values of remnants are maintained. Private owners should be encouraged to voluntarily enter into agreements to manage remnants, with this commitment being registered on land titles. Imposing values and management constraints on individuals is unlikely to result in the proper management of privately owned remnants. The maintenance of private ownership supports good management through personal identification with the piece of land.

The intrinsic value of biota in the Wheatbelt must be recognised in its world-wide context. While it may be possible to develop sustainable farming systems without retaining nature conservation values, this would result in a loss of biodiversity, ecosystem function, aesthetics and an Australian identity.

Primary Goal
Stakeholders need to develop their own goals, objectives and strategies so that they have ownership of them. To assist in this process, a first attempt was made by the group. The primary goal proposed was: "To have a long-term, profitable land use, while maintaining ecosystem function and biodiversity and minimising any off-site deleterious effects".

It needs to be accepted that some parts of the landscape may have highly profitable uses, whereas other parts may not. The overall system needs to be profitable for nature conservation values to be protected.

Process
The primary goals need to be accompanied by sets of objectives, strategies and actions that are specific at the State, regional, catchment and enterprise level. Some of these objectives have already been set (for example, the State Conservation Strategy, State Salinity Strategy, Decade of Landcare Plan, landcare district and catchment group objectives, strategies and actions).

Key ecological parameters need to be identified for developing management strategies (for example,

hydrologic water balance, energy and nutrient cycles, key species in ecosystems). Some of these will become the means of monitoring the health of the agro-ecological system, providing feedback for managers. It was accepted that both the native vegetation and farming systems would be in a state of dynamic flux.

Actions

Representatives of the major stakeholder groups need to be drawn together to reach consensus on goals, objectives and strategies. This may take the form of identifying and coordinating existing structures at the State, regional, catchment and enterprise level. It was thought necessary to raise awareness of nature conservation values in some groups that were not currently giving these values sufficient emphasis.

A specific example of this process would be for the Department of Conservation and Land Management (for example, Ken Wallace) to liaise with the Department of Agriculture's Program Leader for the Great Southern and the Blackwood Catchment Coordinating Group (BCCG), to see how the groups could integrate farming and nature conservation objectives to everyone's advantage. This could become a model for other areas. It was stressed that we should not try to come in over the top of existing initiatives being taken by groups such as the BCCG, which are already developing a nature conservation strategy.

Implementation

The integration of production and nature conservation objectives may require legislative changes and changes to statutory procedures. These details were not developed.

How do We Ensure that Community Education and Extension Maximise Remnant Conservation?

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Workshop Group
David Bicknell, Mal Graham, Steve Hopper, Bert Main and Anthony Sutton.

Points from Plenary Session
The following points, raised during a plenary session, stimulated this workshop topic:

- The importance of direct personal contact (for example, researchers devoting a fixed percentage of their time to direct communication).
- Networking using local people at a face to face level.
- Promote nature conservation through logos, etc. (that is, start nature conservation movement at a local level).
- Tangible examples of the value of remnant vegetation are required (for example, positive stories, pamphlets, natural histories, walk trails).
- Take advantage of simple stories which capture people's enthusiasm.
- Is one to one contact with a researcher the only (most) successful extension method?
- Are there useful social models to help us interest rural people in nature conservation?
- Issues of male–female relationships in communication and information.
- Education of new farmers in tertiary institutions.
- Technical extension and remnant management.
- Should we have "bushwatch" for schools?

Following detailed discussion of these points, a vision for education and extension was created, the major issues were identified, and actions were drafted.

VISION

Workshop participants considered that community support and action were required if areas of remnant vegetation were to be conserved. To achieve this, it was agreed that the long-term vision for education and extension programs was: "To foster people's interest to the point where the community actively seeks information to conserve remnant values".

ISSUES

From both management and research perspectives, the participants then identified key issues that needed to be resolved in order to achieve the above vision. Specific action items stemmed from these discussions.

Direct Personal Contact
Workshop participants agreed that direct "face to face" contact between researchers, managers and the community was an effective means of communication, especially in rural areas. However, as this method of communication is extremely time-consuming, small group meetings addressing a series of issues were considered the preferred medium. The participants also noted that people with the most knowledge were not always the best people to deliver a message. In rural communities, it was considered that the ideal communication method was to have local people giving information to a local audience.

Action
Identify and support the good communicators within agencies and local communities.

Promotion of Nature Conservation at a Local Level
Workshop participants quickly agreed that the promotion of nature conservation within rural communities required that the uniqueness of local environments be highlighted. It is also important to raise the awareness of each local community to the values of its landscape. Through these means, it was considered that local people would develop a sense of ownership for local bushland and consequently protect the values of these areas.

Actions

- Develop simple nature conservation stories that are pertinent to local people, and include themes or elements that are unique to their landscape. Stories with a local historical perspective should be sought.

- Document and promote specific examples of people's nature conservation efforts in rural areas — for example, the Doleys' story(see page 57). Provide "hands on" experience of the values of remnant vegetation so people may internalise the nature conservation ethic — for example, through guided bush walks or the involvement of local communities in fieldwork.

- Support people's nature conservation efforts by promoting their achievements in the mass media.

Nature Conservation and Education

The basics of nature conservation are not taught in schools or in agricultural training courses, such as landcare courses and the Bachelor of Agriculture. The participants believed that the integration of nature conservation units into existing school and university courses was an essential step towards the long-term conservation of remnant bushland.

Actions

- Ensure researchers and managers involved with the conservation of remnant vegetation have input into landcare courses.

- Introduce a natural science course into teaching and land management degrees. This course would form part of the first year syllabus and cover geology, zoology, botany, geography and hydrology.

- Provide information for a basic textbook which covers the natural history of Western Australia.

- Support community conservation programs, such as "bushwatch", which have an important educational role.

Technical Extension and Remnant Management

The workshop group acknowledged that technical information on the management of remnants should be readily accessible and interpreted at different levels of expertise, ranging from newspaper articles to journal publications. The participants then resolved that an effective technique for explaining remnant management to the rural community was to use agricultural analogies. For example, the basics of remnant management could be illustrated by explaining that the processes underlying agricultural systems (the nutrient and water cycles, and the flow of energy and genetic material) also sustain natural ecosystems, but on a different timescale.

Action

Ensure information on the management of remnant vegetation is readily accessible, is interpreted at different levels of expertise, and concentrates on systems and processes.

Women in Remnant Conservation

Within the group, anecdotal evidence was presented to show that, in some cases, women were more caring land managers, and had better long-term vision, than men. However, with further discussion, the group resolved that for successful long-term conservation of remnants, it was essential that the whole community be involved. This includes all sectional groups, for example:

- women, children and men;
- Aboriginal people;
- land managers;
- rural and urban communities;
- local people.

Action

Seek to involve the whole community in remnant conservation.

CONCLUSION

In summary, the workshop participants considered that for education and extension to be successful, they must:

- be relevant;
- be credible;
- be interesting;
- result in action;
- lead to success;
- be "followed-up".

Conclusions

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The seminar objectives provide a useful structure around which to summarise the conclusions from the seminar. Specific objectives for the seminar were:

- to list significant research results for remnant management;
- to assess whether conclusions from research have been implemented;
- to develop a list of actions to improve both the relevance of research and implementation of its results.

Each of these is considered below. In writing these conclusions, I have not tried to summarise all the recommendations and research outcomes. Rather, I have aimed to provide an overview, to highlight priority issues, and to develop conclusions based on the seminar papers as a whole. Throughout this section, the word "manager" refers only to those responsible for managing remnants of native bushland, including farmers and government officers with direct responsibility for managing land.

SIGNIFICANT RESEARCH RESULTS FOR REMNANT MANAGEMENT

The significant research outcomes, as identified by both managers and researchers, may be separated into three categories: development of theory, proof of operational hypotheses, and results with direct application. While some work contributes in all three categories, most emphasises only one.

Development of Theory

As pointed out by Bert Main, the success or otherwise of management is partly determined by managers' assumptions about ecosystem processes. These assumptions are based on the theoretical constructs they adopt, and thus the development of effective ecosystem theories is crucial to the work of both managers and researchers.

Research results presented in this seminar have contributed to the fund of ideas, theories, and models that form the essential platform on which effective management is based. The papers by Bert Main, Richard Hobbs, Stephen Hopper and Robert Lambeck best exemplify the development of concepts and "big picture" contexts. Whether emphasising the importance of taking a Gondwanan perspective of our biota, or the role of disease, parasites and predators in maintaining biodiversity, or the need to better assemble these and other ideas into a bigger picture, the theory and concepts described in these papers give valuable guidance to managers. Although some managers are reluctant to study and understand theory, in practice, unsound theory often results in ill-directed and ineffectual management. This suggests either that managers should be better trained in theory, or that they require more comprehensive guidelines and prescriptions. While both would enhance management performance, I note that adaptive management, which should be a goal, requires that managers are competent in ecosystem theory.

Even when research work does not itself develop theory, ideas generated may help to create a socio-cultural climate that influences political and management decisions. In their paper, Jonathan Majer and Anne Brandenburg provide examples of how this may occur. Such ideas and "bits" of information must be synthesised into theory or a "big picture" if they are to provide maximum benefit. Unfortunately, this task is often ignored, or given too low a priority (see comments in papers by Hobbs and Main).

Ideas and theories change with new knowledge. One of the values of Denis Saunders' review paper is that it describes conceptual changes that have occurred in relation to remnant management. It is important that the history of theory and research is documented — we cannot afford to waste resources unnecessarily revisiting ideas that have proved unproductive. Also, such reviews show that ideas change slowly. This is an important lesson for anyone who aims to make a major contribution in the land management field: they must be prepared to commit 10 to 15 years to effect changes in attitudes and management practice. To document the history of management practice is also an important task.

Proof of Operational Hypotheses

A second category of research tests ideas based on unquantified observations and anecdotal evidence. Often, these have been, or are proposed to be, implemented operationally. For example, the value of fencing remnants and linking isolated areas of bushland with corridors had been operationally "known" before research quantified the advantages of these management actions. Some of the research outcomes reported by Jonathan Majer and Anne Brandenburg fall into this category.

This category of research is important. While anecdotal wisdom is valuable and should be better documented, it is unwise, and may be very expensive, to use such information uncritically.

Ideally, research in this category should also contribute to the development of theory and management prescriptions. Unfortunately, this does not occur as often as it might.

Results with Direct Application

This is the category of research most sought by managers. Managers want concrete prescriptions they can implement immediately and effectively to solve an existing problem. Examples reported in this seminar are represented best in the papers of Gordon Friend, Richard George and Don McFarlane, and Jack Kinnear. From a manager's viewpoint, the work by Jack Kinnear is ideal: it provides a practicable, operational technique that has a rapid, positive effect on populations of endangered animals. This is not a common outcome from research.

Although the work of Friend, and George and McFarlane contains elements that may be immediately and usefully implemented, valuable collaborative projects between managers and researchers are also a logical consequence. In the case of the work by George and McFarlane, this is happening with the direct application of management action at Toolibin Lake, with valuable help from Richard George. Not only is Richard's contribution essential for effective management, he has an opportunity to test first hand the validity of his predictions. The value of this on-ground, collaborative translation of concept into action is inestimable.

It is appropriate here to note Bert Main's observations concerning the dangers of creating unrealistic community expectations for biodiversity management. While strictly not a research result, his comments concerning "static and deterministic versus dynamic and stochastic interpretations of systems maintenance" should be read by all managers. Bert's comments are an example of practical wisdom based on a comprehensive understanding of theory, bureaucracies and politics.

Summary

Each of the research categories described is important. In the context of research as a whole, one category should not be emphasised at the cost of the others: there should be a balanced contribution from each. Looking at the results from this seminar, there is, certainly from a manager's viewpoint, a need to give higher priority to research that explores the actual implementation of theory, and research that directly addresses the needs of private land-holders so that they are able to combine economically the synergistic benefits of land and nature conservation. The challenge is for researchers to consider more thoroughly the application of their work. Such consideration should not be an appendix to research; it must also occur during the development and implementation phases.

IMPLEMENTATION OF RESEARCH RESULTS

Among the presentations by managers, it is notable that all three farmer presentations focus on fencing remnants as the predominant, and necessary, management action. In Terri Lloyd's paper, fencing is specifically linked to revegetation and the development of corridors. Bob Twigg's paper asks several very pertinent questions about implementation — in particular, why fencing of remnants is not more widespread. There is a need for researchers and government agencies to address the benefits of remnants and revegetation, and to determine why there is so little implementation of fencing as a basic management action.

Apart from fencing remnants and creating corridors — activities that have been validated, rather than stimulated, by research — the best examples of research results being implemented are fox baiting to protect populations of medium-sized marsupials (see paper by Kinnear), and the fire research represented by the work

of Burrows *et al.* (1987, not presented at this seminar) and, more recently, Gordon Friend. The fire research produced specific guidelines and also showed that fire management principles should not be transferred uncritically between regions. Accordingly, the research has affected management plans and action. Steve Gorton also points out the direct application of some of the revegetation research. Unfortunately, this research group has now disbanded.

Apart from these aspects, and the operational actions discussed by Ken Wallace, only a comparatively small amount of research results has been implemented. Why is this so?

In part, the answer is probably that a critical mass of theory and ideas must be developed before writing guidelines and prescriptions becomes a common activity. If this is so, then we can look forward to a welter of helpful guidelines, or at least more action oriented research in the next decade. However, there are other important barriers to the transfer of research results into management action. From the workshop discussions, and comments during presentations, it is apparent that implementation of results is also impeded by inadequate communication and liaison between researchers and managers.

ACTIONS TO IMPROVE RELEVANCE AND IMPLEMENTATION OF RESEARCH RESULTS

A common theme running through many of the presentations and workshops is the need for better two-way communication of ideas and information between researchers and managers. Numerous ways are listed for achieving this end — see, for example, the workshop papers by Ken Atkins and Helen Allison, and Anne Brandenburg and Greg Beeston. Proposals include establishment of network groups, committees, computerised databases, and a new, integrating agency.

These ideas should be explored and those that are cost-effective implemented. Nevertheless, one cannot help feeling that, worthy as many of these ideas are, some could become a barrier to achieving change where it is most required — at the individual level. Researchers do not need organisations to enable them to liaise and communicate with other groups, and neither do managers. That this is so is shown through three of the five manager presentations specifically mentioning the great importance for their work of one-to-one contact with researchers. (The latter point raises another challenge — one-to-one relationships are important but very expensive of an individual's time. How do we extend new ideas to managers in a cost-efficient way? David Bicknell [pers. comm.] has suggested support networks for early implementers so they may use their properties as demonstration sites and themselves become extension sources.)

To improve the relevance and implementation of research, the most urgent need is to increase collaboration between individuals and groups, between managers and researchers, across agencies, and across disciplines. There are many examples of effective collaboration between managers (including farmers) and researchers, and across disciplines and agencies. Although this process will occur more readily in a sympathetic organisational environment, such a milieu is not essential. Thus there is a challenge to individuals, irrespective of their organisational environment, to create collaborative projects and networks.

Not discussed in detail, and perhaps it should have been, was the responsibility for converting research results into management guidelines. Some see this as a specialist task — for example, for regional ecologists. Others view it as the responsibility of each researcher, and others argue that managers have the skills and should use them. I suggest that the best method for converting research results into management guidelines is through collaborative efforts between managers (including planners) and researchers. This is an efficient means of bringing together the skills necessary to achieve implementation of research results. For best results, researchers need to collaborate with land managers at all stages of project development.

Many other ideas to improve the relevance and implementation of research results were presented at the seminar, and these should be explored. Of particular note is the suggestion by Richard Hobbs that we recognise and reward researchers who synthesise and liaise effectively to achieve implementation of results. Similarly, we need to recognise and reward managers who build successful partnerships with researchers, to develop and implement effective management.

ACTIONS RECOMMENDED DURING THE SEMINAR

A number of actions were recommended during the seminar.

Workshop Actions

Nearly 30 recommendations for action are listed in the workshop section. Most of these recommendations focus on communication and education within and between the many groups involved in conservation of remnant vegetation. The better integration of management and research is the subject of many action statements and is covered in the previous section. Three other issues should be stressed in these conclusions.

Firstly, the development of visions, objectives and priority actions for the conservation of remnant vegetation and their biota has been inadequate. This deficiency should be redressed immediately, and the workshop report by Don McFarlane provides ideas on how this should progress.

Secondly, education has been better addressed in recent years, but our efforts could, and should, be substantially improved. The workshop report by Anthony Sutton and David Bicknell gives some guidance in this area.

Finally, all seminar participants agreed that a credible "messenger" was required, to inform key decision-makers of the degree to which land degradation has already occurred, and just how much worse it is likely to become. Given that seminar participants generally believed that a "messenger" was likely to be "shot", it is not surprising that there were no offers for this task, and no groups wanted to address the issue in their workshop discussion!

Research Actions

Identifying new lines of research was not a major focus of the seminar. Some 20 ideas were listed in one of the plenary sessions, and other suggestions were developed in presentations. These diverse ideas defy ready description — the reader is encouraged to scan the list on pages 71-72. Most urgent for remnant vegetation is the need to tackle the problems of landscape hydrology (see paper by George and McFarlane). Although the rising watertable and related hydrological problems are a potential tragedy, they also provide a compelling process through which to integrate productive agriculture and nature conservation. It is vital that we seize this opportunity.

Consequently, it is crucial that researchers and managers work hard, and with urgency, to develop:

- Practical means and prescriptions for controlling groundwater that protect nature conservation values and are, at the same time, economically viable for farmers.

- Systems of sustainable agriculture, particularly those that advance the synergism between conservation of natural biodiversity and profitable agriculture.

Such work should be undertaken as collaborative projects, and should involve landscape scale experiments. There is sufficient theory to guide action but insufficient resources to permit the luxury of further theory development in isolation from actual action.

Another important research area raised during the seminar is the value of addressing cultural and social issues (see workshop reports and the papers by Lambeck, Saunders and Wallace). While not discussed during the seminar, the social models we use for interaction and decision-making are a fundamental factor in land management. These models, often implicit rather than explicit, may assist or impede collaboration and decision-making.

For example, it has been fashionable to talk of "top down" and "bottom up" approaches to planning and decision-making. More recently, the concept of "empowering" people has again become widely used. While these concepts can be useful, when dealing with complex land management issues it is more helpful to view planning and decision-making as involving interaction between a number of subcultures, whose relative powers vary from situation to situation. In this view, it is the responsibility of each subculture to consider and describe its own goals and priority actions, and then to negotiate and debate these with other subcultures. Decisions which result will reflect a range of situational factors, including the personalities of the participants.

The accuracy of this model is open to debate and should be researched. However, from a manager's viewpoint, it describes the fluid, somewhat chaotic, interactions and decision-making processes. Such a model provides a workable basis for planning and interpreting interactions.

There are many other examples of research topics that would benefit through the involvement of social scientists. Researchers and managers should aim to increase the involvement of social scientists in their work. While this will only be appropriate in specific projects, it is time we acknowledge through our actions the importance of social processes identified in this and other seminars.

Two other areas of research merit specific comment. Firstly, Bob Twigg in his paper stressed that land managers do not understand the values of remnant vegetation. While there has been some work in this area, it is vital that the economic and other values of remnant vegetation be clearly detailed (see Wallace 1994 for a starting point). Similarly, the values of biodiversity are not sufficiently explained. It is often assumed that maintaining natural biodiversity is either a prerequisite for achieving sustainable agriculture, or the most profitable means of doing so. Such statements should be tested and the outcomes explained in terms that all land managers understand.

FINAL REMARKS

From my management viewpoint, I had hoped that the workshop would generate far more specific implications for managers, based on research from the past decade. That this did not occur is partly because the period has been one of developing ideas and theory rather than management prescriptions. However, there are other reasons for the infrequent transfer of research results into management action. During this seminar, the most important barrier identified, at least at the individual level, was the poor communication and liaison between researchers and managers.

Despite outstanding examples of collaboration, the general failure of researchers and managers to work together effectively has decreased the values of both research and management. While this was of less concern during a period when new ideas and theory development were pre-eminent, if allowed to persist, it will severely affect nature conservation in the future. We now have an opportunity to develop projects of collaborative, experimental management that effectively tackle the major challenges that the next decade holds. We are at the leading edge of a wave of at best local, at worst global, extinctions and losses in agricultural production. The value of working together has never been higher. Not only should we look to corporate change, we should act now as individuals, to ensure that effective collaboration occurs. For maximum effect, projects should address the nexus between hydrological problems, revegetation and remnants, farm profitability, and nature conservation.

If collaboration is so important, how, then, should we achieve it? Actions to achieve collaboration may, for convenience, be divided into those at the corporate level, and those at the individual level.

Although there is a continual, and important, need to review corporate cultures critically, to ensure they are designed optimally to achieve community and corporate goals (see, for example Norgaard 1992 and Wallace 1992 for discussion of some of the issues), this is usually not the most crucial factor. Ultimately, the success or failure of collaborative groups depends on the individuals involved.

In my experience, successful projects involving different groups work because a "network" of people with a common interest has come together of their volition, to achieve a task that meets their individual needs. This does not mean that all involved must have the same need; rather, their needs must be sufficiently congruent to drive each to attain the collaborative goal. No doubt there are other collaborative methods that work; however, that described is the most effective in my experience.

Therefore, the challenge is for land managers, researchers and others themselves to form highly motivated project groups driven by common goals and compatible personalities (see the Note on the next page for one formula for collaboration). At the same time, these goals should involve tasks that develop the nexus described above, and either test, or add to, the structure of theory and unifying concepts.

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NOTE

A formula I recommend for developing collaborative projects is given below. For simplicity, it is written addressed to a researcher, but is, with minor adjustment, applicable to any group involved in land management.

Forming a Network

Fundamental to developing a collaborative project is already having a network and a knowledge of practical issues. Suggestions in the following two points will help individuals achieve these outcomes:

- Involve yourself in at least one committee or other group that has an interdisciplinary and interagency component. Such a group should involve managers and researchers. Working with a committee will not only help you to build a network across disciplines and agencies, it will help you to gain other perspectives on land management issues. Committee members should develop a working relationship, and this often leads to empathy. This is a more effective way to develop a cross-cultural network than the most common means, the conference. The latter, while valuable, tends to build networks within subcultures rather than across them, and does not provide the "forced empathy" aspects of a good committee. If there are no committees that are appropriate, consider joining an organisation or group that contains diverse views. In rural areas, organisations such as Apex, Rural Youth, etc. may provide this contact.

- Make opportunities to visit people from other disciplines or agencies. It is particularly important to do this in the field where problems may be discussed and related to a physical example. In these circumstances it is often much easier to understand the specific viewpoint of others. The value of "kicking the dust" with others of different views and background cannot be over-emphasised.

Developing a Collaborative Project

1. When you have a project that is strategically important for remnant conservation, and personally important (a project for which you have real enthusiasm), then use your broad network of people to develop the project and initiate design. This phase will include those who have time to advise, but not time to participate as project team members. When you have your project in a reasonable form, cast around for a group who are prepared to participate as part of the project team. These will be people who:
   - are interested in the same project outcome (they do not have to have the same ethos or the same goals — but theirs must be compatible with yours);
   - will work effectively with you;
   - will commit to and contribute effectively to the project.

   The project team should be small — say, four people. Maintain good contact within the group, and meet only as necessary. The responsibility of each team member to the project should be clear. It is important that any meetings:
   - be held for a good reason;
   - consider important issues;
   - result in concrete action.

Notes on meetings should be kept and circulated to all those whom you wish to involve in the project (this will often stimulate ideas and will ensure misunderstandings are clarified). There is no need to be formal, but it is important to be accurate.

2. Very early in the development of the project, discuss the project with managers and include at least one on your project team. It is particularly important that their needs are met, and that their ideas are, where appropriate, incorporated.

3. Maintain contact with managers throughout the project, and feed information back to your broader network as appropriate.

4. When the work is finished and you are clear on the outcomes, turn them into management guidelines or ideas in conjunction with a manager. Do not wait for the publication of results before implementing them. Participate in extension activities.

5. Always acknowledge the involvement of those who have helped — this is not only courteous; it builds ownership.

6. Review the success of your project, both in terms of applying research results and as a collaborative exercise.

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