The West Australian Rangeland Monitoring System (WARMS) and Biodiversity

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A report examining the applicability of the WARMS program to monitoring biodiversity in the Western Australian rangelands.

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Summary Recommendations and Conclusions

The Western Australian Rangeland Monitoring System (WARMS) are a group of sites established by the Dept. of Agriculture, Western Australia to report on the condition and trend of grazing land within the rangelands of Western Australia.

My brief is to see how these sites may be useful in the monitoring of biodiversity in the Western Australian Rangelands.

In its present form WARMS has considerable biodiversity monitoring value. And these values can be improved by monitoring other aspects of biodiversity (called WARMS+ sites) and locating sites in areas of biodiversity interest.

Recommendations

- Develop a set of priority areas in which to monitor biodiversity within the Western Australian rangelands.
- Develop a set of methods to augment the existing WARMS program that focus on other components of biodiversity (and/or threatening processes) i.e. WARMS+ as outlined in this report.
- Install WARMS and/or WARMS+ sites with biodiversity the primary determinate of location (eg areas of refugia or high biodiversity value, areas undergoing threatening process abatement or biodiversity amelioration programs, or areas that have a low vulnerability to disturbance.)
- Examine opportunities to share costs between departments for biodiversity monitoring.
- See what opportunities there are for rangeland users other than government departments for sampling.

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Introduction

The rangelands constitute almost 90% of Western Australia, with the pastoral industry being the largest user, about 45% of the state (EPA, 2002). They are arid or semi-arid areas not suitable for agriculture, but used for the grazing of sheep, cattle and goats. There is a growing public interest in the rangelands and their conservation, reflecting a growing concern of biodiversity issues more generally. The grazing industry has responded to community concerns with rangeland sustainability becoming a pastoral industry keyword and relevant agencies like Dept. of Agriculture, WA maintaining a number of monitoring sites reporting to the government and the general public. These range monitoring programs have existed in various forms since the early 1970s with the West Australian Rangelands Monitoring System (WARMS) being formalised and adopted as the preferred method in the early 1990's (Watson *et al.*, 2001). Similar programs operate in other Australian rangeland states.

Much has been written about these various existing State and Territory Rangelands monitoring programs and their applicability to monitoring biodiversity (see Whitehead *et al.*, 2001). But, while there is an appreciation of the potential use for these data in biodiversity monitoring there is debate about what questions can be answered with existing data sets (eg Fisher, 2001; Holm, 2001). Of late there have been attempts to find a consensus. Numerous conferences and publications (eg Whitehead *et al.*, 2001) have specifically addressed the issue of monitoring biodiversity by using and/or modifying the existing rangeland monitoring programs.

My brief is to examine to what extent WARMS can be used in biodiversity monitoring in the rangelands of Western Australia. As a practical outcome is required, my analysis and discussion will be driven by pragmatism. The underlying issues within this question are broad and complex and I do not attempt to review the relevant issues. Instead, I present the salient points and discuss and give examples where warranted.

Monitoring Biodiversity: a brief background relevant to this study.

Broadly, biodiversity is multi-scalar encapsulating from genetics and populations to entire ecosystems. The term also includes the ecological and evolutionary processes that drive and maintain biota. Clearly, there is no single measure for biodiversity and that both surrogacy and scale issues need to be considered. Biodiversity surrogates have numerous problems (Vos *et al.*, 2000), not the least being inferring changes in biodiversity from changes in surrogates.

The approaches that appear the most tenable are those that do not try to monitor biodiversity *per se*, but monitor processes that are known to influence biodiversity. Such approaches typically look at threatening and/or higher order processes. The premise of these approaches is that if threatening processes are removed then 'normal' ecosystem processes can continue. And if high order processes are maintained, the lower order ones will look after themselves (Gaines *et al.*, 1999). These processes, unlike biodiversity itself are easier to define, measure and monitor using existing methods. Yoccoz *et al.* (2001) believes that monitoring programs that are not directly part of a scientific study, should focus on attributes that are part of an adaptive management program: why monitor what can't be managed, is the essential argument.

These pragmatic realisations give starting points for an achievable biodiversity-monitoring scheme by monitoring higher order threatening processes, and only monitoring those processes that are manageable. Fortunately, there is considerable overlap between these aspirations and the WARMS program as grazing is a higher order threatening process that can be manipulated through management.

Grazing and its surrogates

While grazing has a definite effect on biota (either directly or through influencing ecosystem function), its effect on biodiversity is not so conclusive due, in part, to different

responses of components of biodiversity to grazing pressure (for example, the grazing increasers and decreasers; Landsberg *et al.*, 1997b). But numerous studies have shown that grazing disrupts ecosystem function (Fleischner, 1994; Ludwig *et al.*, 1997), has a significant effect on redistribution of resources (Friedel and James, 1995) and may have been responsible for some plant extinctions in Australia (Leigh and Briggs, 1992 *in* James *et al.*, 1995). Furthermore, as Australia does not have a history of grazing from large herbivores, larger differences between grazed and ungrazed sites (in species composition, aboveground net primary production, root biomass and soil nutrients) would be expected (Milchunas and Lauenroth, 1993).

The expression of grazing on an area (ie what parameters can be measured to detect a grazing impact) is broadly dependent on soil type and vegetation, though this is mediated by other factors such as slope etc. Typically, a grazing impact is perceived through a change in species composition (ie the ratio of palatable and unpalatable species; Bosch, 1989), an increase in erosion (Fleischner, 1994) or a change in shrub density (Watson and Thomas, 2001). Palatable perennial species are considered good rangeland indicators as they are preferentially grazed particularly during dry periods when grazing stresses are at their most intense (Stafford Smith and Pickup, 1990; Pringle, 2002). Perennial plant persistence and growth, is also a good indicator of ecological processes (Pringle, 2002).

Recommendations: Higher order threatening processes is a tenable way to approach biodiversity monitoring.

Biodiversity and Rangeland Monitoring Programs

A review of the current Australia wide rangeland monitoring programs and their utility in monitoring biodiversity is presented in Whitehead *et al,* (2001). In that document it is suggested that any rangeland biodiversity monitoring program could make use of the existing pastoral monitoring programs because of their:

- large spatial coverage,
- relevance to a number of threatening processes (particularly over-grazing) and
- willingness to value-add extra biodiversity measures.

For instance, all the pastoral monitoring programs collect information about perennial plants, a good indicator of grazing impacts. These measures may also be useful for understanding ecological and biological processes (Whitehead *et al.*, 2001; Holmes, 2001). Here, I will examine the current WARMS program and see what biodiversity measures it contains, and what additions can be made to existing protocols to improve biodiversity monitoring within the WARMS program.

Summary of WARMS (The Western Australian Rangeland Monitoring System)

The WARMS program was established to detect change or trend in some components of perennial vegetation over time. The method collects data on perennial vegetation dynamics and landscape function (Watson *et al.*, 2001).

While the current system has been in place since 1992 many earlier monitoring sites were "upgraded". The data from these previous sites, some established in the 1970's may be of use in other analyses. How these sites (called old-WARMS in some literature) are different from WARMS sites in criteria for site selection and factors monitored will not be discussed here. Suffice to say that many of the old-WARMS sites fitted the criteria for WARMS site

selection and are now monitored under the new procedure. Currently, there are about 1600 sites on pastoral leases in Western Australia (Table 1).

There are two types of WARMS sites, grasslands and shrublands. The former is generally in the Kimberley and the Pilbara, the latter, usually south of the Pilbara. Within each of these areas seven rangeland types (essentially vegetation types), were defined (for example, Grasslands: Pindan, Mitchell grass etc; Shrublands: Eucalypt, chenopod shrubland, Acacia-short grass forbs etc; see Watson *et al.*, 2001).

Table 1: Summary of the two type of WARMS sites.

	Grasslands	**Shrublands**
Number of Sites (as at 6/6/2001)	586	993
Location	Kimberley, Pilbara and some areas south of the Pilbara	South of the Kimberley, particularly south of the Pilbara.
Installed	1994 to 1996	1993 to 1999
Reassessed	Finished 1999	Began 2000, scheduled to finish in 2004
Reassessment Period	3 years	5 or 6 years
What is recorded	Frequency of all perennial species (quadrats) and an estimate is made of crown cover of woody perennials, landscape function.	Shrub demography and maximum crown dimensions, landscape function.

Sites are stratified based on an index derived from area, productivity and fragility of each vegetation type (Watson *et al.*, 2001). Sites were allocated evenly across the geographic region. At the individual lease level, a maximum number of sites per lease is 10 (south of the Kimberley) or 12 (Kimberley) though this was also influenced by vegetation type. The lease minimum being 2 sites (if lease $<200km^2$ in the Kimberley or $<50km^2$ south of the Kimberley).

Criteria for site location (from Watson *et al.*, 2001):

- Only on pastoral tenured land.
- Priority given to locating sites within the largest grazed area of that vegetation type, isolated or small areas of any vegetation type were avoided.
- Sites were located towards the centre of each area of a particular vegetation type rather than the margins.
- Within each vegetation type on the lease, sites were located according to the proportions of the major land units.
- Efforts were made to sample all major land units within adjoining leases (but it was not considered essential to sample every major land unit).
- Where patchiness was evident in the vegetation, the site was located to straddle the main variation if the patches were less than about 100 m across, or located in the most representative patch if patch diameter was greater than 100 m.
- In the Kimberley, the aim was to locate sites within paddocks or areas of the vegetation type greater than 80 km^2.
- Sites were located at least 1.5 km from permanent water, except on chenopod vegetation types where the stock water was saline. In these cases, the minimum distance was 1.0 km.
- Sites were located to consider ease of re-location and access.
- Sites were not located on isolated examples of actively eroding land, on dynamic areas such as riverbanks, in holding paddocks, or near areas that may otherwise affect them eg tracks and infrastructure.
- In the shrublands, areas with thick shrubs were avoided.

Site Layout and Data Collection

The Grassland and Shrubland sites share a similar layout: a photo site with a number of transects (5 and 3 respectively) laid out behind them. For some attributes the Grasslands and Shrublands have the same data collected. For instance, during establishment the distance to water (to the nearest 0.1 km) and the salinity (ppm) of nearest water is recorded. Similarly, during reassessment, the following are recorded at both WARMS types:

- Landscape Function Analysis: for the Grasslands a modified version from Tongway and Hindley (1995); for the Shrublands, Tongway (1994).
- Comments regarding grazing, fire and flood history, range condition, type of disturbance, recent or proposed changes in infrastructure and overall site comments.

Grassland sites

Five transects, each 50 metres long, are laid out 6.5 metres apart. The frequency of perennial vegetation is taken from 20 quadrats along each transect. Crown cover assessments of woody perennials are made at either end of transects 1,3 and 5.

Range Condition is assessed from using a matrix of vegetation condition (see Table 3 Watson *et al.*, 2001) and area and type of erosion (see Tables 5a and 5b Watson *et al.*, 2001) this reports an index of 1 to 3.

Plants are only recorded if the rooted basal diameter exceeds 1cm or height exceeds 10 cm, or (for prostrate species) diameter exceeds 10 cm. If a lot of the area has been burnt and species identification is not possible the site is not assessed.

Shrubland sites

Shrubland sites were established to assess population dynamics and size of individual woody species. At each site three permanent transects are established. Transect dimensions are dependent on shrub density with the aim of including at least 50 individuals of the most common shrub and at least 100 individual shrubs in total on the site. Short lived perennials and climbers are not recorded. The maximum transect size is 100m by 4 m. Each shrub is identified to species and its location along the transect is recorded. For each of these shrubs an estimate of the maximum living canopy width and height (205 cm height, and above, is recorded as 205 cm), is also recorded.

Only a subset of the Range Condition attributes recorded at Grasslands sites are recorded on Shrubland sites. At these sites extent and type of erosion, pasture condition, site modification, disturbance factors (e.g. recent fire, old burn, grazing, road effect, flooding, mining), increaser species, exotics, vegetation cover and vegetation structure are recorded

There are numerous conventions that apply. Recruits are only recorded if higher than 10cm and have a basal stem diameter of at least 4mm and are branched. For some species, (mostly where accretionary mounds make separation of individuals difficult) individuals are only recognised as separate plants if the closest rooted bit is at least 30 cm away from its neighbour.

Biodiversity and the Current Warms Program

WARMS was designed to monitor change or trend in perennial vegetation over time (Watson *et al.*, 2001). Thus, there are considerable restrictions when trying to interpret these data in other contexts. However, there are implicit biodiversity values within the data set and these data can, and have, been used in numerous ways from local scale interpretation through to ecological questions and links with remote sensing. In this section I will look at the existing WARMS data and its analyses, its shortcomings in the context of biodiversity and opportunities to modify the existing program to make it more biodiversity relevant.

Existing analyses of the WARMS data

Whitehead *et al.* (2001) suggest that analyses of the existing rangeland monitoring data would lead to an early warning system of adverse change in vegetation communities, a greater potential to link with biodiversity monitoring and with remotely sensed indicators. The existing WARMS data has been used in an attempt to address a number of ecological questions and to generate links between biodiversity and a suite of variables. For example, the WARMS sites have been used with remote sensing to either ground truth (Thomas, 2001a, b, c), or to determine site selection (Duckett, 1997b; Wallace and Thomas, 1998). Vegetation change has been examined (Duckett and Holm, 1996; Duckett, 1998, Duckett *et al.*, 1999a, b; Watson and Thomas, 2001), protocols for reporting established (Duckett, 1999b) and links with LFA examined (Duckett 1999a; Holm 2001). Below I have focused on a number of studies that are relevant to later discussion.

In an early analysis of the WARMS southern shrubland data, Duckett (1995) attempted to determine environmental influences (climatic trends, grazing history and landscape features) on vegetation. To do this, presence/absence and density of the four major regional plant species was modelled against rainfall histories, stocking rate histories, distance to water, topography, soil depth and calcium in the soil using multiple regression.

The results, a description of the broad parameters that dictate plant species distributions and threats, are an excellent example of the utility of WARMS in autecological studies.

In the same study, Duckett (1995) examined change within each vegetation group (defined by dominant species). She ordinated each vegetation group and derived a number of "vegetation states" or "subtypes". She speculated that these vegetation states can be used to examine other attributes such as biodiversity and grazing desirability, but later studies (Duckett 1997a, 2001) identified long gradients between vegetation types when separating by species. Maybe because of these gradients that "vegetation states" have not been further examined.

Holm (2001) was asked to examine a number of aspects of LFA and WARMS data including (i) the relationship between vegetation and LFA; (ii) the importance of each of the three components of LFA; and (iii) protocols to summarize, interpret and present LFA data at the site and district level.

Holm (2001) defined a Resource Capture (RC) Index which is the ratio of resource-capturing patches and transect length from the LFA transect on the WARMS site. Holm reemphasized the need to collect both landscape function and vegetation data and that there may be opportunities to generate inferences between the two. He argues that the stability component of LFA is more indicative of grazing impacts and meaningful for reporting because, for instance, this indicator is not prone to sudden changes *cf* leaf litter. A matrix method of interpretation using RC index and stability rating was devised that reported on vulnerability to disturbance. For instance, areas with a low RC index and low stability are highly vulnerable to disturbance; in contrast areas with a low RC index and high stability were ranked as degraded but stable and probably productive. Thus at the site scale there is a mechanism for reporting disturbance potential of an area. And by assessing changes in the RC index for each stability class, Holm presented a categorical way of

reporting if the RC index declined (eg requires urgent remedial action; degraded but stable and probably productive; alert – precautionary action recommended, or stable).

At the district level Holm reallocated vegetation groups to one of 5 structural country types. These structural country types were defined by the structural form of vegetation (eg clumps and groves) and transport mechanisms (eg high infiltration rate, thus little flow in the sandplain or sheet flow and wind transport in shrub-steppe). Holm used the WARMS transect data (ie RC index) to allocate some vegetation groups to structural country types.

Holm also presented a provisional framework for interpreting (or hypothesizing) about structural change in vegetation (eg tussock grassland to annual grass) in relation to RC index and stability. And a rating scale based on the proportional change of desirable and undesirable plants.

Watson and Thomas (2001) analysed 223 WARMS shrubland sites, predominantly from the Gascoyne and Murchison bioregions. They reported increases in a number of attributes (population size, canopy area and species richness etc) in the majority of sites across the area. They related these improvements to recent, above-average rain years as well as the impact of good management on conditioning the resource to respond to rainfall.

Clearly WARMS in its present form has biodiversity value. This value is not only inherent in the data collected (palatable perennial plants and LFA) but also it is a potent tool for helping to understanding rangeland ecosystems, their dynamics, study methods, and data interpretation. The main focus of WARMS-grazing impacts-is one of the key threatening processes identified in the rangelands (Whitehead *et al.*, 2001). The challenge now is to see what modifications can be made of the program to improve biodiversity measures and reporting.

WARMS in a biodiversity context

In its present form WARMS data can be interpreted in a biodiversity context as it reports on changes and trends in perennial vegetation and landscape function (i.e. grazing impacts) on the Western Australian rangelands.

Monitoring threatening processes is a pragmatic approach to any broad scale biodiversity monitoring program (see *Monitoring Biodiversity: a brief background relevant to this study*, above). Table 2 looks at the utility of the present WARMS program and modifications required to detect the Rangeland threatening processes as listed in Whitehead *et al.* (2001). An improved WARMS based biodiversity monitoring scheme would monitor some of these threatening processes. But, as these threatening processes are not ubiquitous it is not necessary to monitor the full suite of threatening processes at each site.

For some threatening processes the present WARMS methods are not suitable nor are the full complement of techniques required. If part of the biodiversity plan is to monitor presence of goat grazing on a breakaway with known DRF, the full site layout (see *Summary of WARMS*, above) is not required. Maybe a WARMS based biodiversity monitoring program, in some areas for some threatening processes, will not use the present WARMS methods at all. Rather, they may use methods relevant to the threatening process in question. The application of WARMS in this instance is using the WARMS data collectors as they are already in the field and the extra costs could be shared between agencies.

To understand what a biodiversity monitoring program would look like it is relevant to ask how it would be reported. Not all aspects of biodiversity can be recorded so it may be that in some instances presence of threatening processes will suffice. In others, though, the relative intensity of the threatening processes is required. It is these types of questions that will dictate the type of sampling required.

Threatening Process	Capability of existing or modified WARMS program to detect or identify	Comments
Tree clearing	None	WARMS area too small and question not addressed specifically. This data could be satellite acquired if necessary.
Damage to key sites by grazing animals	High, but see comments	At present key sites (in a biodiversity context) are not monitored by WARMS. One recommendation above was to improve biodiversity monitoring by monitoring such sites.
Changed water regimes	N/A	WARMS gives no indication of the alterations of water regimes but, additions and removal of water points are retained in government records.
Introduced predators	Virtually none at present, modified program may provide opportunities,	Some (but largely fortuitous) utility in locating scats and/or tracks under present sampling regime.
Feral herbivores	Medium/High	Present WARMS can detect presence of herbivores, identifying type will require scats, a larger search area required. Browse lines and heights (as per EMU Level 1) are useful measures also.
Climate change	Unknown	Present WARMS vegetation data may be able to contribute to an understanding.
Displacement of native perennial grasses and palatable shrubs through grazing	Medium	Present WARMS detects density (through demography) of palatable shrubs and frequency of grasses plants and change over time but attributing causation may be difficult to show.
Commercial harvest	None	WARMS not suitable. State government records would show location, type and yield.
Unsuitable fire regimes	Suitability of fire regimes: low Presence: low	Presently, WARMS records fire in the comment field. A modified WARMS program could record some attributes (eg scorch height). Fire distribution can be derived from NOAA AVHRR data. WARMS plots may contribute to understanding of this topic. Fire presence can be easily determined from coppicing, burn marks, removal of fire sensitive plants etc.
Invasion of exotic grasses	Low	WARMS area too small to be responsive i.e. the exotic may be in the area well before it is detected on a WARMS plot. Modifications of the Pastoral Lease Inspection may be more useful.
Disease	None	WARMS not suitable.
Mining	None	WARMS not suitable. State government records.
Hunting	None	WARMS not suitable.

Table 2: The utility of the existing and modified WARMS programs in detecting/identifying the threatening processes as listed in Whitehead *et al.* (2001).

There are two types of enhancements to improve the utility of WARMS and biodiversity monitoring: enhancing the program to monitor other threatening processes and adding new sites presently not monitored.

Modifying WARMS site location

WARMS sites are biased to areas of high pastoral productivity, and this reduces the utility of WARMS to biodiversity more broadly. Thus, adding WARMS (or WARMS-like) sites in areas of biodiversity interest will improve both coverage and interpretation value. These areas could include reference sites for each vegetation association, areas of high biodiversity value like refugia (from, for example, Morton *et al.*, 1995) or other sites of interest. There is the potential for substantial cost savings in using the existing WARMS sampling team. The new 'biodiversity sites' may be sampled while doing the existing WARMS sites.

A level of pragmatism is required in determining what sites should be added. Is the interpretation value of reference sites more important than, for example, than the addition of more sites with active threatening processes or refugia? If the expected outcome of a modified biodiversity related WARMS program is R&D, reference sites may be critical, but if a result of a broader biodiversity monitoring program is required than other sites, like refugia, may be more important. Priorities need to be determined.

Recommendations:

- Sites need to be positioned with biodiversity the primary driver.

Enhancing WARMS methods

Hopkins and Watson (2001) suggest enhancing the existing WARMS methodology by collecting additional biodiversity-related information. They called these sites WARMS+ sites. There are two broad scenarios for WARMS + sites:

1. Upgrade all sites to WARMS+. Here, modifications of existing WARMS methods need to be slight so that the WARMS data collectors will also collect the biodiversity component. Because of the constraints of field time and re-training, additions would have to be qualitative.
2. Upgrade only selected sites to WARMS+. The sites selected may be those of special interest and/or part of a research project. These upgrades may be slight such that a WARMS data collector can still collect the data (as per above), or more involved (using specialist personnel only). The latter case, using specialist personnel, is considered not suitable for a WARMS+ program.

Slight modifications to WARMS methods could monitor the presence of some of the threatening processes from Table 2. One option is to design a sampling strategy for each threatening process and add them to the WARMS methods only where applicable. For example, if fire is considered a regional threatening process then WARMS+ sites in that area may have a fire sampling methodology.

From Table 2 it is clear that the size of the WARMS is inhibiting monitoring of some threatening processes. The WARMS site is small (between 30 m^2 and 1200m^2 for shrubland site transects) and it is unknown how representative it is of the surrounding area. Obviously, expanding the existing WARMS methods to cover a much larger area is not a viable option as this would cause a considerable increase in costs. But qualitative data from an area surrounding the present WARMS sampled area may aid in recording other threatening processes. These data may simply be dung present or absent, average height of fire scars, presence/absence of weeds. The EMU Level 1 "Reading and Monitoring the Landscape" sheet gives an example of simple but effective data collecting. Likewise, one

of the main outputs from the Expert Technical Workshop held in Alice Springs in October 2002 will be tool box of relevant biodiversity monitoring techniques that are threatening process focused.

Qualitative methods of assessing changes in vegetation associations already exist. Some, like the state-and-transition approach (Westoby *et al.*, 1989), and Duckett's (1995) derived vegetation "states" require significant research. In contrast Range Condition Scores are already part of the pastoral monitoring programs including WARMS in the Grasslands. The score, derived from a matrix of extent of soil erosion and condition of vegetation, gives a categorical output (good, fair or poor). This kind of assessment may also be used in new locations to monitor grazing impacts. Tongway (1994) took a pictorial approach. He defined a number of the pictorial condition classes for soils in different Rangeland types within the Western Australian rangelands. He presented vegetation communities with photographs showing degraded, intermediate and good conditions. In particular these photographs were related to their ability to capture water. Much of this record may come from the photographs already taken at the WARMS sites. Unfortunately, using this or the Range Condition approach, masks much of the variability within a vegetation association as each has only a number of categories, and these categories apply to specific rangeland values. For example, an area may be good at capturing water because it has high grass cover, such that it would score well in the Rangeland Condition technique and be recorded as good in Tongways's approach. But this ground cover may be of an introduced grass. However, the approach is simple, quick and repeatable and makes for easy reporting.

Recommendation:

- Present WARMS methods only record some aspects of threats to biodiversity. Other methods may need to be added depending on the location and priorities.
- WARMS+ sites should be established with location dependent on biodiversity priorities. Priorities may be driven by, for example, areas of refugia or high

biodiversity value, areas undergoing threatening process abatement or biodiversity amelioration programs or areas that have a low vulnerability to disturbance.

- Prescribe qualitative monitoring techniques that are useful for each threatening process. The methodology should examine higher order processes and be quick to assess, EMU Level 1 sheets and the outcomes of the Expert Technical Workshop held in Alice Springs would be helpful.

An amalgamation

What types of higher-level (i.e. process based) biodiversity data and information can be gleaned from a WARMS based biodiversity program? And, equally importantly, how can this information be reported? The present WARMS program reports on two aspects of grazing impacts: palatable perennials and LFA. In the long term (as rangeland responses tend to be over long time scales), changes in condition can be reported, i.e. changes in erosion and changes in plant composition (principally increaser/decreaser ratios). The reporting in this instance is changes due to grazing but mediated by other processes (eg rainfall). Other biodiversity measures, as recommended above, are the extent and intensity of other threatening processes. These can be reported as operative with some relative measures of intensity.

These are not trivial. At present there is little reporting on the location and intensity of threatening processes in the rangelands. Location of some threatening processes can be determined from government records (i.e. waterpoints), others are accepted as being widespread (i.e. predation by feral cats), but of others little is known. For instance, refugia or areas of high biodiversity value (i.e. ecojunctions, see Tinley, unpub.) are not presently being monitored for threatening processes and it is these that would benefit from a monitoring program.

The general conclusion is that WARMS does record meaningful biodiversity-based data, but more sites need to be established and, in some instances/locations other types of data need to be recorded. WARMS+ sites, it is envisaged, would monitor one or a suite of threatening processes in areas where biodiversity monitoring is the primary determinate of site location.

The Western Australian rangelands are vast, imposing a significant cost in merely getting to sites. Possibly, these costs can be shared among projects and departments. The downside is that site surveying will only occur between 3 to 7 years, during the WARMS

site samples. This may be too infrequent for some programs. Alternately, other groups such as mining personal, LCDCs and pastoral type programs may be utilised. But, as biodiversity monitoring is becoming increasingly desired and funding increasing difficult to procure, such alliances are vital for the long-term success of any rangeland biodiversity monitoring program.

Recommendations:

- Examine opportunities to share costs between departments for biodiversity monitoring.
- See what opportunities there are for rangeland users other than government departments for sampling.

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