Lake Eyre Basin Rivers

Assessment Methodology Development Project

Background Document 4

Review of Ecological Indicators and Assessment Programs

Koonchera Dune Waterhole, Goyders Lagoon, Diamantina River
Photo by Fran Sheldon, Centre for Riverine Landscapes

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Review of Ecological Indicators and Assessment Programs

1. Introduction

Ephemeral rivers occur over much of Australia's inland. However, much of the river health assessment to date has been conducted for rivers that have year-round flows or systems for which there is a significant amount of existing data. These tend to be in the catchments of eastern Australia and other catchments across Australia with intensive land use. Most of the rivers in the arid and semi-arid regions of Australia are ephemeral, and only carry significant flow during the wet season or following infrequent but intense rainfall events. It is not known which, if any, of the existing approaches to river health assessment can be used to accurately assess the health of ephemeral rivers and steams of smaller catchments, such as those around Adelaide in South Australia, or the larger ephemeral rivers of the Lake Eyre Basin.

There are many definitions of ecological 'health' and a review of the concepts in relation to rivers can be found in Norris & Thoms (1999). "River health" is usually defined in terms of ecological integrity and is used to give a measure of the overall condition of a river ecosystem. The working definition of "river health" used by the National River Health Program (NRHP) is: *'The ability of the aquatic ecosystem to support and maintain key ecological processes and a community of organisms with a species composition, diversity, and functional organisation as comparable as possible to that of undisturbed habitats within the region*' (Schofield & Davies 1996 after Karr & Dudley 1981:55-68).

The components of river health have been defined in terms of:

ecosystem **vigour** (refers to activity or rate of processes such as primary production or decomposition),

organisation (refers to diversity and the number of interactions between system components; with healthy ecosystems having a complex structure (both physically and biologically) whereas unhealthy ecosystems often lack complex organisation), and

resilience (refers to a system's capacity to maintain structure and function in the presence of stress; healthy ecosystems have the ability to "bounce back" after a disturbance, unhealthy ones often do not) as well as the absence of ecosystem stress (Rapport et al. 1998).

The latter emphasises the essential ecosystem functions and life support systems, which are key elements of ecological sustainability.

Since 2000 two large and comprehensive regional river health assessment programs have been established (eg. South-east Queensland Ecological Health Monitoring Program and Murray-Darling Basin Sustainable Rivers Audit). For both of these assessment programs comprehensive reviews of existing river health assessment methods and indicators have been undertaken (see Liston, 2001 and Storey et al., 2001). Rather than repeat those reviews, this document summarises each relevant program and then explores its suitability and limitations in relation to the Lake Eyre Basin Assessment Methodology Development (LEBAMD) Project.

There are a number of river and ecosystem health assessment programs currently being utilised in Australia that are relevant for this project. These programs include:

- Design and Implementation of Baseline Monitoring in South East Queensland – Phase 3 (DIBM3). This is a precursor to the EHMP – see below
- Ecological Health Monitoring Program for Southeast Queensland – (EHMP)
- Sustainable Rivers Audit for the Murray-Darling Basin Commission – SRA

- Index of Stream condition
- Australian Rivers Assessment Scheme (AUSRIVAS)
- Stream Invertebrate Grade Number – Average Level (SIGNAL)
- Integrated Monitoring of Environmental Flows (IMEF)
- Pressure-Biota-Habitat project (PBH)
- Index of Biotic Integrity (IBI)
- State of the Rivers (Queensland)

This report summarises each of the above programs and then reviews the applicability of each program, or aspects of each program, for the assessment of health in the Lake Eyre Basin waterways. The extreme variability inherent in these catchments may mean that other assessment techniques need to be explored. The final part of the revew looks at some techniques being used to assess the health of rangelands in the semi-arid zone and discusses their potential use for the Lake Eyre Basin systems.

2. Background

2.1. Aspects of river health

River health is a relatively new but significant concept with application in freshwater ecology and management (Schofield and Davies 1996; Bunn *et al.* 1999) and is thought to be accessible and meaningful to all members of society Karr (1999). However, as stated by Norris and Thoms (1999), the exact definition or markers of river health are unclear. It is considered important to include aspects social, economic and political views within the 'health' definition as they are fundamental to the management of freshwater systems and what will consequently be deemed as acceptable health levels (Fairweather 1999; Norris and Thoms 1999). The management goal implicit in this idea of river health is to maintain or return a river system to a state of integrity considered acceptable among a broad body of assessors (public, scientific and political communities) concerned about the river in question. Thus it is necessary to determine a reference condition of river health as a target level, and also a way of assessing the current state of the river (Norris and Thoms 1999). This review will discuss a number of river health assessment methods, particularly in relation to temporary Australian streams.

It is generally accepted that river 'health' can be assessed by using indicators which signify a river's ecological condition in terms of its physical, chemical and biological attributes. These indicators must not only be efficient, rapid and founded in ecology, but must also be responsive to environmental changes, comparative over different ecological regions and report on the whole ecosystem condition rather than solely describe its elemental parts (Harris and Silveira 1999). There are several such indicator-based methods and systems currently being applied in the assessment river health, including the Index of Biotic Integrity (Karr 1981), AusRivAs (Schofield and Davies 1996), RIVPACS (Wright 1995), and Index Of Stream Condition (Ladson *et al.* 1999). The Index of Biotic Integrity (IBI) was proposed as an indicator of river health at a river reach scale. This index uses a range of ecological fish assemblage characteristics which incorporate aspects of community, population and individual level ecology such as species richness, abundance, indicator taxa, trophic guilds, community structure, and individual fish health (Karr 1981; Harris and Silveira 1999). More recently, the Australian Index of Stream Condition (ISC) was developed and uses indicators to provide a measure of a stream's environmental condition which are then applied by state and regional managers (Ladson *et al.* 1999).

Another river condition assessment method, AusRivAs (Australian River Assessment Scheme) (Schofield and Davies 1996) uses macroinvertebrates as biotic indicators of river health and is based on the British program RIVPACS (River Invertebrate Prediction and Classification System) (Wright 1995). However, RIVPACS was developed in temperate regions and has limitations for use in river ecosystems that undergo unpredictable or highly variable environmental conditions (Wright 1995). In AusRivAs, macroinvertebrates are chosen as biotic indicators for reasons outlined by Chessman (1995) including: their ubiquity and diversity in Australian rivers; their fundamental place in Australian river ecology; their sedentary nature and life cycle duration suitable for identifying responses to disturbance; their size and simple methods of sampling. The expected assemblages of macroinvertebrate families are predicted for undisturbed or reference condition river regions based on environmental data collected from these reference sites. These assemblages are then compared with family assemblages actually observed in the river of interest, and are used as a measure of the potentially disturbed river's comparative ecological condition.

The reasoning behind such biotic-based indicators is that assemblages of riverine biota demonstrate well accepted responses to physical, chemical and biological disturbance. This is because characteristics such as flow regime, water quality, habitat and community interactions are believed to govern the structure of aquatic biota in streams and rivers (Harris and Silveira 1999). Thus, the apparent beauty of these indicators is that since biota respond to the physical and chemical environment, which in turn are affected by human activities, they may reflect changes to river systems caused by anthropogenic interference (Norris and Thoms 1999). As such, calculating and reassessing these indicators can result in an evaluation of a river's ecological condition based on how it is biologically responding to disturbance.

Bunn *et al.* (1999) augment the above biotic methods of assessing river health which deal with changes in community patterns, by incorporating information on changes within ecosystem processes in streams. The use of this integrated methodology is considered vital for the establishment of reliable indicators of river health (Fairweather 1999) and is based on the understanding that adequate river health assessment requires knowledge of the "sources and fate of energy and nutrients" within stream ecosystems (Bunn *et al.* 1999: 333), that is, knowledge about changes in aquatic processes. Further to this, Bunn *et al.* (1999) attribute degradation of river health to catchment level changes including land use and riparian condition. The impact on river health of these changes may be identified via the assessment of ecosystem process indicators such as gross primary production and respiration. Such assessment methods allow river health to be determined on a catchment scale, which is crucial due to the high amount of river ecosystem disturbance occurring at this level.

Thus, it can be seen that river health is assessed by determining whether a river *lacks* in comparison to what is considered a healthy level of river ecosystem condition. This absence of health, or ecosystem stress, has been used to define ecological health along with assessment of ecosystem vigour (process rates), organisation (physical and biological) and resilience to stress or disturbance (Rapport *et al.* 1998). However, an ultimate goal for successful management of river health may be to develop and combine the use of geomorphological, hydrological and chemical indicators (and their interactions with aquatic biota) with these more established biological indicators (Norris and Thoms 1999). As previously stated, assessing river health encompasses much variation of methodology and is a result of the wide interpretations of what constitutes river health in general.

2.2. Salient features of temporary streams

Since the late 1980s, knowledge of temporary streams has increased (Boulton and Lake 1988; 1990; 1992a; 1992b; Boulton *et al.* 1992; Davies *et al.* 1995). Previously most development in river ecology occurred within the confines of temperate and permanent systems (Davies *et al.* 1995). Temporary streams can be defined as those that dry out completely or become reduced to standing pools for any length of time (*sensu latu* Williams 1998). These streams undergo continual change via cycles of wetting and drying, and range in classification from ephemeral to near permanent on a scale of increasing predictability and permanency of flow (Boulton and Brock 1999). Specific definitions by Boulton and Lake (1988) are as follows: 'temporary' or 'intermittent' streams are those with reasonably regulated, seasonally intermittent flow; 'ephemeral' or 'episodic' streams experience flow subsequent only to unpredictable rainfall events. According to Davies *et al.* (1995), these distinctions are important due to the influence of flow regime on biota with respect to the survival ability of different species and their various levels of desiccation tolerance, escape mechanisms and dependency on flow regimes.

Perhaps the most salient feature of temporary stream classification is the range of spatial and temporal variability (and predictability of this variation) of water regimes in terms of inputs and losses (Boulton and Brock 1999). The importance of this feature of temporary streams is embodied by the statement that variability of flow is fundamental to the functioning of lotic ecosystems (Puckridge *et al.* 1998). Therefore, in studying or assessing the 'health' of temporary lotic ecosystems, an understanding of how these wetting and drying events affect a stream's physical, chemical and biological characteristics is necessary in order to establish reliable 'health' indicators. This is especially important in Australia as the majority of the country's rivers and streams are under significant influence of a water regime lacking in seasonality (Boulton and Brock 1999) and confounded by the effects of the El Nino Southern Oscillation (Davies *et al.* 1995).

In response to this variability, the characteristics of temporary stream biota have altered over evolutionary time (Davies *et al.* 1995). As such, biota inhabiting these systems, especially macroinvertebrates, have life history traits that are variable in themselves (Boulton and Suter 1986). Davies *et al.* (1995: 492) have summarised these invertebrate characteristics as: "high mobility; continuous opportunistic reproduction; rapid development; tolerance of extreme conditions coupled with desiccation tolerance and evasion behaviours". Because of this variability and evolutionary adaptability of the fauna to variation, response and recovery of temporary stream ecosystems to disturbance may take longer than what is expected of more permanent and stable systems (Davies *et al.* 1995). Understanding this feature of temporary streams is therefore essential to any assessment of river health and subsequent management, particularly in Australia, a continent with an extensive arid history and fauna adapted to survive such conditions (Boulton and Lake 1988).

Central to the ability of temporary stream fauna to survive dry periods, such as their evasion behaviour, and the maintenance of the stream's benthic community, is the availability of refugia to these organisms (Boulton *et al.* 1992). For example, research has recently focused on the hyporheic zone as a refuge for epigean invertebrate fauna during drought in Australian intermittent streams (Boulton *et al.* 1992; Cooling and Boulton 1993). The ability of species to survive in refugia affects the composition of species once flow is re-established and therefore the differential biotic survival outcomes of future drying events (unless these systems are highly recolonised by flying invertebrates) (Boulton *et al.* 1992). It has been concluded that the composition of epigean fauna immediately after flow resumes is relatively predictable for Australian intermittent streams; however as time passes, predictability rapidly diminishes (Boulton *et al.* 1992). Once again, variability is highlighted, rather ironically, as the most *reliable* characteristic of temporary streams. However, understanding the physical, chemical and biological links and hydrological exchanges between the hyporheic zone and surface waters may be of significant value when interpreting measurable attributes of temporary streams, such as macroinvertebrate assemblages, as long as limitations due to spatial and temporal variability of such data is taken into account (Boulton 1993; Boulton *et al.* 1998).

2.3. Integration - assessing the health of temporary streams

Within such a variable flow regime, can wetting and drying events be considered as disturbance? Drought in lotic systems is traditionally considered a disturbance event, as it is often associated with recordable changes in various stream characteristics (Lake 2003). However, disturbance is only detrimental to river health if the river ecosystem is unable to recover within an acceptable period of time and to an acceptable degree. This is why an implicit understanding of what constitutes an acceptable level of river health, particularly for temporary streams, is so important. For a disturbance event to be considered unhealthy, the influence of natural variation inherent in unstable systems, such as temporary streams, must be distinguishable from 'unhealthy' variation. Norris and Thoms (1999) recommend that the only way to successfully accomplish this is to undertake continual monitoring of these streams in order to gain a more complete picture of the physical, chemical and biological variation existing in these systems.

The need to include the history of wetting and drying disturbances in any assessment scheme that utilises macroinvertebrates as indicators, as well as interaction from physiochemical effects, is emphasised by Boulton and Lake (1992a; 1992b). More recently, Boulton (2003) described the response of macroinvertebrate communities to drought as 'stepped', shifting from gradual change as pools reduce to sudden alteration upon their complete disappearance. This type of change embodies the concept of spatial and temporal variation inherent in temporary streams. In regard to this, Boulton (2003) again stressed the importance of long-term data collection in temporary stream health assessment.

The spatial and temporal heterogeneity of any measure can be assessed by the magnitude (severity and size of disturbance) and frequency of deviations from its long-term tendency (Townsend and Hildrew 1994). This concept again comes down to the ultimate amount of predictability a river ecosystem possesses (cf. Boulton and Brock 1999). That is, predictions about biotic communities in disturbed *versus* reference condition streams can only be accomplished if the spatial and temporal variation can be quantified or statistically modelled, and at appropriate scales (Townsend and Hildrew 1994). Therefore, multivariate analyses are necessary for interpreting complex, variable systems that encompass a number of interacting environmental and biological variables (Boulton and Lake 1990). If long-term data collection and analyses of temporary streams is performed at a range of spatial and temporal scales, a certain degree of confidence may be established regarding the normal (or 'healthy') range of variation that occurs within the system, including the variation which occurs after disturbance and what constitutes acceptable recovery. Thus, any deviation away from this acceptable range of variation may reliably imply that the stream ecosystem is unhealthy and may be unable to recover from certain disturbance events. Use of macroinvertebrate indicators as measures of river health can therefore be applied to temporary Australian stream assessment if used in this way.

Confounding these issues of temporary stream health is the fact that many dryland rivers throughout the globe have been regulated to some extent (Davies *et al.* 1995). As a result, the river ecosystem is forced to deviate from its normal patterns of flow variability to a regulated and/or continuous regime, which then increases the potential severity of environmental disturbance on the system (Davies *et al.* 1995). This makes monitoring and assessment of temporary stream health more difficult to interpret. However, if such factors can be incorporated into a probabilistic model of variation, then determining the health of disturbed temporary rivers and streams will become a more realistic and attainable objective.

3. Assessing River Health Approaches

3.1. Reference Condition Approach

The “reference condition” approach relies on comparing test sites with others in “reference condition”. The term “reference condition” may or may not refer to sites in a natural (or unimpacted) condition. In many instances, and especially in upland streams, reference condition is defined as natural. However, in many lowland rivers or entirely urban catchments reference condition is based on “best available” natural habitats. Different sources of information (eg. historical references and expert opinion) can be used to improve the description of “reference” for any given site or catchment. The use of a referential approach does not equate with returning rivers to a pristine condition. Its aim is to allow quantification of the existing condition of a site or river. The acceptable level of condition and/or appropriate target for condition are values set by the community.

The reference condition approach is used in the following programs

- Sustainable Rivers Audit for the Murray-Darling Basin (SRA)
- Australian Rivers Assessment Scheme (AUSRIVAS)

3.2. Disturbance Gradient Approach

The disturbance gradient approach was used in the Ecological Health Monitoring Program for South-East Queensland (EHMP) (see Storey et al., 2001). The same approach has previously been used in marine monitoring programs where various indicators were trialed against a disturbance gradient to determine which ones responded. Those indicators that were best able to detect changes in ecological condition were then included in national and international monitoring programs.

The design phase of the South-East Queensland Ecological Health Monitoring Program (EHMP) the DIBM3 Project was the first time that this style of approach had been used to objectively compare a range of indicators for freshwaters. The study focussed on the contribution that diffuse, catchment-scale disturbances have on the ecological condition of south east Queensland’s waterways. For this reason, rather than establish an in-stream disturbance gradient, a catchment-scale disturbance gradient was chosen.

3.3. Indicator species or group

An indicator species or group may be defined as a species (or assemblage) that has particular requirements with respect to a known set of physical or chemical variables (Johnson *et al.* 1993). The indicator taxon should be (after Cranston 1990):

- Exposed by its ecology to the environmental parameters of concern;
- Functionally important;
- Widely distributed;
- Not dominant;
- Readily identifiable;
- Easily sampled;
- Responsive to environmental perturbation at a convenient and detectable scale.

There are both advantages and disadvantages to using 'indicator taxa' when comparing reference condition and test sites.

The use of indicator species or groups is comparatively taxonomically simple when compared with approaches that use community composition (Rutt *et al.* 1993). Indicator species identify habitat characteristics which are likely to be impaired (Rogers & Biggs 1999) and they facilitate diagnosis.

Despite these advantages relying on an indicator species or group limits interpretation to only certain attributes of river condition (Barbour *et al.* 1995) and little or nothing about river condition is revealed if the indicator is absent (Johnson *et al.* 1993). The assessment misses crucial changes in community interactions, and complex cumulative impacts if it relying on single-species testing (Barbour *et al.* 1995). The use of indicators also requires evidence of degrees of tolerance to relevant impacts in the geographic region of interest (Rutt *et al.* 1993).

4. Ecological Health Monitoring Program for South-East Queensland (EHMP)

A full overview of the EHMP program, support material and outcomes of a number of assessment rounds can be found at the following URL:

http://www.healthywaterways.org/index.html

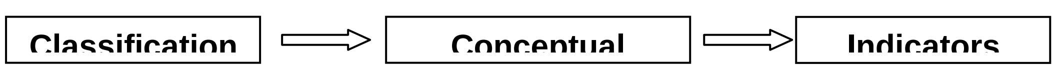
4.1. Background

The EHMP is an integrated monitoring program that monitors 120 freshwater sites throughout South East Queensland. The health of the streams and rivers is determined using a range of biological, physical and chemical indicators (see below). EHMP also takes into account natural processes such as rainfall, water temperature and wind, as well as human impacts such as catchment alterations and point source discharges (e.g. sewage treatment plants). Experts use the information collected in combination with their knowledge and understanding of waterway ecosystem health to generate ‘report card’ grades (A to F) for the freshwater systems of South East Queensland.

The Ecological Health Monitoring Program for South-East Queensland started with the “Design and Implementation of Baseline Monitoring for Stage 3 (DIBM3) Project” of the Healthy Waterways Strategy. The overall aim of DIBM3 was *“to develop a cost-effective, coordinated monitoring program for the freshwaters of the region that is able to measure and report on current and future changes in ecological health”.*

The DIBM3 project and the resulting EHMP used a disturbance gradient approach to evaluate the indicators (as compared with a referential site approach). Land clearing was the primary disturbance gradient against which the indicators were assessed. Descriptors of the land clearing disturbance gradient included channel condition, catchment land use, in-stream habitat, flow related variables, riparian condition and water chemistry.

The process used in developing indicators was to initially classify the rivers and streams in the study region, so like streams and sections of streams could be compared with like. Conceptual Models depicting the major processes within these streams were then developed. The Conceptual Models were used to suggest the indicators that would be useful in assessing impact. Indicators were then trialled for the ability to detect change across the land clearing disturbance gradient.



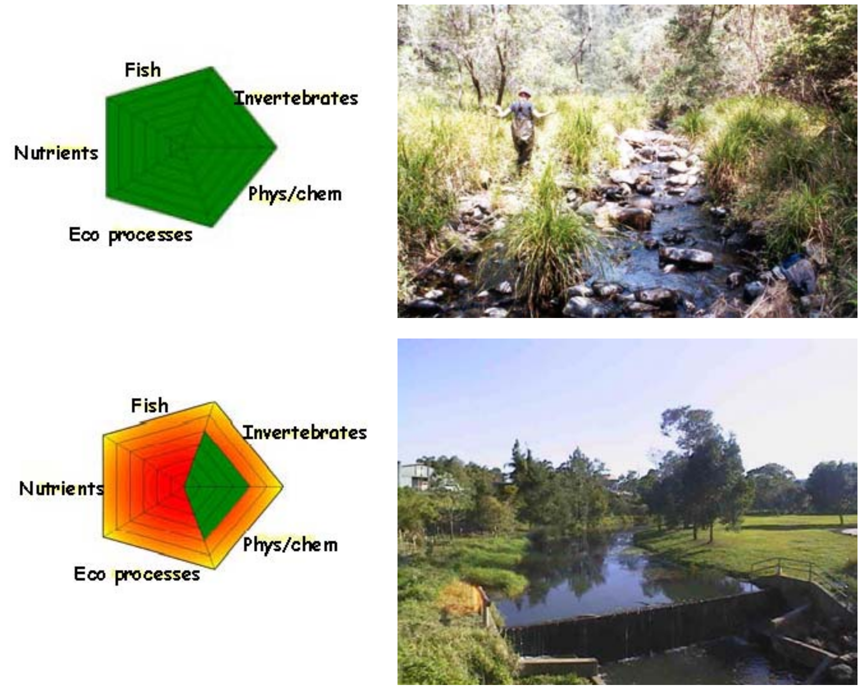
In the DIBM3 Project (see Story et al., 2001) a wide variety of ecosystem health indicators were assessed against this land clearing disturbance gradient which included a range of catchment and reach scale descriptors. After assessing the response of the chosen indicators to the disturbance gradient, those indicators which provided the most significant response to the gradient were selected as being suitable for inclusion in the EHMP for freshwater waterbodies of South East Queensland. Those indicators selected are summarized in the table below.

The DIBM3 project went one step further and recommended these indicators only for use under “ambient” or base-flow conditions (Table 2.1). The indicators were not deemed suitable for assessing condition in relation to nutrient or sediment loads or after episodic events such as floods. Different assessment approaches were recommended for these other monitoring situations.

The reporting of ecosystem health in the EHMP is done using a "traffic light approach". A healthy site is represented by an all-green pentagon, while a heavily degraded site is depicted by an orange and red pentagon. The examples given in the DIBM3 report have been reproduced below (Figure 2.1). The first site is a minimally disturbed reference site on Back Creek near Canungra, whereas the other site is a heavily disturbed site on Petrie Creek, Nambour. The latter site scored zeroes for fish (absence of predicted native species, 100 % exotic species), ecosystem processes (extremely high GPP) and physical and chemical indicators (high diel variation in DO and temperature); and as such there is no green shown for these three facets (wedges). Based on a conceptual understanding of how each indicator

Table 2.1. Indicators selected from the DIBM3 project for inclusion in the ambient EHMP. The approximate r^2 is the variance in the land clearing gradient explained by the indicator.

Indicator type	No.	**Recommended indicator**	**Approximate r^2%**
Physico-chemical	1	Conductivity	60
	2	pH	46
	3	Diel change in Temp(includes max & min)	60
	4	Diel change in DO (includes max & min)	82
Macroinvertebrates	1	PET richness (Edge)	67
	2	SIGNAL score (Edge)	61
	3	Family richness (Edge)	55
Fish	1	% Of Native Species Expected (PONSE)	73
	2	% exotic individuals	87
	3	Fish assemblage O/E50	65
Ecosystem	1	GPP	89
processes	2	R24	91
	3	δ13C(aquatic plants)	92
Nutrients	1	δ15N(plants)	79
	2	Algal bio-assay	72



A

B

Figure 2.1. Examples of the pentagon-approach to presentation of EMHP results using data from (a) DIBM40 (Back Creek) and (b) DIBM8 (Petrie Creek). Photographs of both sites have been included. From Story et al., (2001) Chapter 11.

The EHMP for streams and rivers in South East Queensland has been undertaken twice a year since 2001 and the results of the monitoring for each year can be found summarised on the Healthy Waterways website:

http://www.healthywaterways.org/index.html
The background to the DIBM3 project and the establishment of the EHMP can also be found at this web address.

4.2. Suitability and Limitations

The process undertaken in developing the EHMP for South East Queensland (the DIBM3 Project) provides a rigid framework for developing and testing indicators that could easily be used within the LEB project. There are a number of useful attributes, these include:

Classification: The classification approach for "grouping" like streams and rivers with like should be applied within the Lake Eyre Basin project.

Conceptual Models: The development of conceptual models within the EHMP process provided a graphical approach to summarising the scientific understanding of the processes within the waterbodies. This approach should be undertaken within the LEB project.

Indicators: A broad range of indicators were trialled within the DIBM3 project and assessed for their suitability for inclusion within the EHMP. The range of indicators trialled as part of DIBM3 should be reviewed with the aim of recommending a subset of these for initial trials within the LEB project.

The EHMP uses an ecosystem approach for assessing the health of a site and waterbody. It does not rely on any one single indicator. This is a useful approach for the LEB project as single indicator assessment may not be rigid in rivers where variability is high.

5. Sustainable Rivers Audit (Murray-Darling Basin)

5.1. Background

The Sustainable Rivers Audit (SRA) is an annual and comprehensive five-yearly review of the condition of waterways in the Murray-Darling Basin. The SRA was designed to assist the setting and monitoring of valley targets for catchment and river health, provide a trigger to review threats to the rivers of the Basin and, where appropriate, review management actions required to address these threats (Whittington et al., 2001).

The approach taken for developing the methodology for the SRA involved the development of conceptual models of river function which enabled the significant elements and processes to be identified and assist for the development of indicators. The different functional zones were based on geomorphic divisions of the river valleys within the Murray-Darling Basin (MDB). The processes undertaken was similar to that used in the development of the EHMP for South-East Queensland.

In the SRA river health was measured as the degree to which aquatic ecosystems sustain processes and communities of organisms and habitats relative to the species composition, diversity, and functional organisation of natural habitats within a region (Whittington et al., 2001). The SRA used a referential approach where existing site condition is assessed relative to the expected natural condition of that site.

The SRA recognised biota (fish and macroinvertebrates) and biological processes as the fundamental measures of river health and developed indices for each of these. The following indices are used:

Macroinvertebrate Index: scores for both AUSRIVAS O/E taxa and SIGNAL were recommended for use in deriving the macroinvertebrate score. For reporting at the river valley scale it was recommended that the macroinvertebrate index be assessed annually at 30 sites per river valley.
Fish Index:
Water Quality Index: two types of physical and chemical water quality indicators were recommended:
Potential modifiers of ecological processes (flow, temperature, SS, nutrients (TP, TN) and salinity
Indicators of outcomes of ecological processes (TOC and composition, DO, pH and Chlorophyll a, alkalinity, residual nutrients (NO_x, NH_4, DRP)).
To report at the valley scale the SRA recommends that the water quality index be assessed annually with 4-6 sampling occassions per year at 18 sites per valley.
Hydrology Index: The recommended hydrology index included four sub-indices: Mean Annual Flow, Flow Duration Curve Difference Index, Seasonal Amplitude Index and Seasonal Period. The hydrology index was then calculated as the Euclidean Distance between unimpacted hydrology condition and the condition defined by the four sub-indices in a four dimensional space. The Hydrology Index is expressed on a scale of 0-1, with 1 being unimpacted. The Hydrology Index should be calculated at least once in each 5-year period.
Physical Habitat Index: The Index was recommended for calculation at three spatial scales: floodplain (km), channel feature (100m) and in-channel patches (1m) using a combination of remote sensing and field data. An O/E score would be generated at each spatial scale, the physical habitat index should be assessed once every five years at 20 sites per river valley.

Before a complete audit of the rivers within the Murray-Darling Basin the SRA recommended a Pilot Audit of all indicators across four river valleys, the outcomes of this Pilot Audit were due for release in late 2003.

This Pilot Audit will provide a substantial amount of useful information about the reliability and robustness of the chosen indicators.

5.2. Suitability and Limitations

The development of the SRA has been undertaken using a similar approach to that applied in South East Queensland; Classification of rivers, conceptual model development, indicator development and indicator trials in pilot assessments. The SRA trialled a number of indicators in selected catchments within the Murray-Darling Basin. The SRA chose a different suite of indicators for inclusion in the Pilot Audit on selected catchments compared with those trialled in the DIBM3 Project. The outcomes in the Pilot Audit have not yet been published, but when released it will be useful to compare the indicators chosen for the full Audit with those included in the EHMP.

6. Australian Rivers Assessment Scheme (AUSRIVAS)

http://ausrivas.canberra.edu.au/index.html

6.1. Background

AUSRIVAS (Australian River Assessment System) is an Australia-wide rapid prediction system used to assess the biological health of Australian rivers. It operates under the National River Health Program. This assessment uses a rapid, standardised approach for assessing riverine ecological health.

The objectives of the National River Health Program are to:

- Provide a sound information base on which to establish environmental flows;
- Undertake a comprehensive assessment of the health of inland waters, identify key areas for the maintenance of aquatic and riparian health and biodiversity, and identify stressed inland waters;
- Consolidate and apply techniques for improving the health of inland waters, particularly those identified as stressed; and
- Develop community, industry, and management expertise in sustainable water resources management and raise awareness of environmental health issues and needs of our rivers.
- AUSRIVAS has two streams, Bioassessment and Physical assessment. These correspond with rapid biological assessment protocols and rapid geomorphic, physical and chemical assessment protocols respectively. There different bioassessment streams: Macroinvertebrates, Fish, Diatoms, Macrophytes and Riparian Vegetation.

Of these, the Macroinvertebrate stream is the most highly developed and tested.

AUSRIVAS has recently been further developed to include river health assessment techniques appropriate for urban streams (Urban AUSRIVAS). The original AUSRIVAS models were not specifically developed for use in urban areas and it was thought that models developed for areas immediately around urban zones may provide greater sensitivity to urban disturbances than larger-scale regional models (see Breen et al., 1999).

A similar process may also been undertaken for streams in highly disturbed landscapes, these have been termed "Dirty Water Models" (see Norris et al., 2000).

AusRivAS is a multivariate approach to river assessment and like all methodologies has a number of advantages and disadvantages. These are summarised below.

6.2. Suitability and Limitations

The AusRivAS method samples and processes different habitats separately (Smith *et al.* 1999, Marchant *et al.* 1999) or focusses on only one habitat (Marchant *et al* 1997). In this way it avoids confounding differences due to habitat representation with differences in community structure. The method includes temporal replication (Marchant *et al* 1997, Smith *et al.* 1999) with early results suggesting that model predictions appear to be relatively stable between years (Smith *et al.* 1999) for those areas in which models have been developed and tested. Seasonal fluctuations are considered significant (Marchant *et al* 1997) and consequently regions have both autumn and spring models. The methodology includes an objective procedure for matching environmental variables and macroinvertebrate community structure (Marchant *et al* 1997, Smith *et al.* 1999, Marchant *et al.* 1999).

Some disadvantages of the method are that the cut-off O/E ratio for impairment is relatively arbitrary, and will need rigorous testing in a variety of ecoregions and river types (Marchant *et al* 1997, Smith *et al.* 1999). Although the method is still being widely trialled, in variable streams it will need to be tested and refined over a alonger temporal period. At this stage there is limited data for variable systems as to how the O/E score responds to natural degradation, as happens when flow stops and the river naturally begins to dry – this would suggest that as well as seasonal models, such rivers may need both dry and wet time models. The O/E score for sites in the Georgina-Diamantina catchment showed considerable variability, in the absense of any major human disturbances – this variability could only be attributed to natural changes in assemblages associated with waterbodies drying (Sheldon et al., 2003). Given this, there is a risk that the method may detect only severely degraded sites (Smith *et al.* 1999), particularly in large floodplain rivers (Wright *et al*. 1993, Turak *et al.* 1999) such as those of the Lake-Eyre Basin. The methodology has been trialled and applied so far only to macroinvertebrates (providing only a partial picture of river condition).

For its sole use in either Ephemeral rivers and streams and/or the rivers of the Lake Eyre Basin, issues of temporal / spatial scale and temporal / spatial variability would need to be more systematically addressed. Biological community data from a given scale of study are most likely to show associations with environmental variables that vary over comparable scales (Marchant *et al.* 1999), so the scales at which major degrading processes are likely to operate must be considered in survey design.

However, the AUSRIVAS methods for macroinvertebrate assessment have been now been used across a wide range of streams and regions. A range of models have now been developed for these regions and in many cases samples have been collected over a number of years which provides information on temporal variability.

The macroinvertebrate stream of AUSRIVAS is commonly being used as one attribute of a macroinvertebrate index in the comprehensive ecosystem monitoring programs currently being developed or in use (eg EHMP, SRA). In this manner it would be useful to incorporate AUSRIVAS O/E scores into a macroinvertebrate index for both Ephemeral Rivers and the rivers of the Lake Eyre Basin. Given the limited information on natural changes in O/E scores in variable rivers (outside seasonal fluctuations) it would be unwise to rely solely on the AUSRIVAS O/E score for assessment of river health. Thus the O/E score should comprise one component of a macroinvertebrate index of condition – as used in the Sustainable Rivers Audit (Coysh et al., 2001).

For both projects it would be useful to examine the existing data for a range of sites to assess temporal variability in AUSRIVAS O/E scores. For the ephemeral streams of South Australia there is considerable existing AUSRIVAS data which will allow for temporal variability in the scores to be assessed. For the rivers of the Lake Eyre Basin there is less available existing data but the Western model for Queensland contains some data for sites in the Georgina-Diamantina catchment and the Cooper Creek catchment and the South Australian models contain data for the lower Cooper and Diamantina.

The use of AUSRIVAS scores should be explored in any pilot trial of assessment methodology. Existing AUSRIVAS data could be used to explore temporal changes in O/E scores for sites and catchment. A gradient style approach in using AUSRIVAS O/E scores that allows for natural declines in condition in association with drought and drying should be explored.

7. The Index of Stream Condition

7.1. Background

The Index of Stream Condition (ISC) was developed in Victoria as a tool to assist the management of Victoria's waterways. It was designed to assess the "health" or condition of rural streams, with results reported approximately every 5 years for stream reaches of lengths between 10 and 30 kilometres long. For each stream reach the ISC provides a summary of the extent of changes to:

- Hydrology (flow volume and seasonality)
- Physical Form (stream bank and bed condition, presence of, and access to, physical habitat)
- Streamside zone (quantity and quality of streamside vegetation and condition of billabongs)
- Water Quality (nutrient concentration, turbidity, salinity and acidity); and
- Aquatic life (diversity of macroinvertebrates)

The ISC was intended to provide measures of the health of both the aquatic biota and the drivers that may impact on this health. The following sub-indices are included in the overall condition index.

Hydrology Sub-Index
Within the Hydrology sub-index the following indicators were chosen to inclusion in the ISC:
Ammended Annual Proportional Flow Deviation
Flow variation due to a change in catchment permeability
Flow variation due to peaking hydroelectric stations

Physical Form Sub-Index
Within the Physical Form sub-index the following indicators were chosen for inclusion in the ISC:
Bank and bed stability
Impact of artificial barriers on fish migration
Instream physical habitat

Streamside Zone Sub-Index
Within the Streamside Zone sub-index the following indicators were chosen for inclusion in the ISC:
Width of streamside zone
Longitudinal continuity
Structural intactness
Cover of exotic vegetation
Regeneration of indigenous woody vegetation
Billabong condition

Water Quality Sub-Index
Within the Water Quality sub-index the following indicators were chosen for inclusion in the ISC:
Total phosphorous
Turbidity
Salinity / Conductivity
Alkalinity / Acidity (pH)

Aquatic Life Sub-Index

Within the Aquatic Life sub-index the following indicators were chosen for inclusion in the ISC:

AUSRIVAS Scores
SIGNAL Scores

7.2. Suitability and Limitations

The mix of both pressure and response indicators in the ISC is appealing for the LEB project. The limitations of the ISC are in the inclusion of only one aspect of aquatic life (macroinvertebrates). Macroinvertebrates may not be an ideal biotic monitor in the highly variable large rivers of the Lake Eyre Basin. Both AUSRIVAS scores and SIGNAL scores are considered separately here and their inclusion in an assessment of the LEB rivers would need to be initially tested in a Pilot study.

8. SIGNAL

8.1. Background

SIGNAL (Stream Invertebrate Grade Number – Average Level) (Chessman, 2003) is a scoring system for macroinverebrate samples from Australian rivers. The SIGNAL score gives an indication of the water quality in the river from which the sample was collected. High SIGNAL scores suggest samples from sites with low salinity, turbidity and nutrients and possibly high levels of dissolved oxygen. When combined with taxa richness at a site, SIGNAL potentially provides an indication of the types of pollutants and other physical and chemical factors affecting the community.

SIGNAL was first developed with use in the Hawkesbury-Nepean River system in New South Wales with a specific emphasis on detecting the impacts of discharges from sewage treatment plants. SIGNAL was originally released in 1993 and updated with a more rigorous and more widely tested version SIGNAL 2 in 2001.

The sampling protocol for SIGNAL uses standard macroinvertebrate sampling procedures (as in the AUSRIVAS scheme) with the desired aim of collecting more than 100 macroinvertebrates from any one site, and collecting as many different types as possible. Each macroinvertebrate type recorded is then given a grade number, as outlined in the SIGNAL 2 manual and the number of specimens of each type recorded. Using the abundance value for each type collected an abundance-weighted SIGNAL 2 score is calculated for each site. The resulting SIGNAL 2 score is then plotted on a bi-plot against the number of taxa (families or orders) in the sample. The bi-plot is then divided into quadrants with the borders of each quadrant dependent on the geographic area and habitat type sampled. Each quadrant reflects a different "condition" of the site.

The full citation for the SIGNAL system is:
Chessman B, 2003, *SIGNAL 2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers*, Monitoring River Heath Initiative Technical Report no 31, Commonwealth of Australia, Canberra.

The report can be found at the following URL:

http://www.deh.gov.au/water/rivers/nrhp/signal/

8.2. Suitability and Limitations

The SIGNAL scoring system using macroinvertebrate samples was found to explain 61% of the land clearing disturbance gradient in the DIBM3 project for South East Queensland. As the system relies on the sensitivity of taxa to certain pollutants and disturbances it may not be sensitive enough to detect impact in the rivers of the Lake Eyre Basin. In these systems the macroinvertebrate assemblage is mostly dominated by resilient fauna, those found in more polluted environments elsewhere. Thus, sites may well plot in the disturbed quadrants when they are in fact unimpacted. Despite these limitations, SIGNAL 2 scores should be calculated and tested against both disturbance gradients and gradients of ephemerality for the LEB project.

9. Integrated Monitoring of Environmental Flows (IMEF)

9.1. Background

www.dlwc.nsw.gov.au/care/water/imef/

The IMEF project was established by the New South Wales Department of Land and Water Conservation (DLWC) to provide an understanding of the response of seven major rivers and their associated wetlands to the provision of environmental water allocations.

The objectives of the IMEF were to:

- Investigate the relationships between water regimes, biodiversity and ecosystem processes in the major regulated rivers systems of NSW and the Barwon-Darling River
- Assess responses in hydrology, habitats, biota and ecological processes associated with specific flow events targeted by environmental flow rules, and
- Use the resulting knowledge to estimate likely long-term effects of environmental flow rules and provide information to assist in future adjustment of rules.

Variables suggested for measurement::

- Flow volume (use of gauge data)
- Wetted Area (surveying, satellite data)
- Current velocity (hydraulic current meters)
- Channel Morphology (surveying)
- Temperature
- Turbidity
- Dissolved Oxygen
- Salinity
- Nitrogen & Phosphorous
- Sediment laminae
- Organic matter (dissolved and particulate organic carbon)
- Cyanobacteria (chlorophyll a)
- Bioflims (floristic analysis; pigment analysis)
- Water plants (transect / Quadrat surveys)
- Invertebrates (sweep and kick nets)
- Fish (electrofishing)
- Frogs (call identification)
- Water birds (transect or point surveys)
- Production & respiration (chamber measurement)
- Food sources (stable isotope analysis)

9.2. Suitability and Limitations

Many of the suggested indicators have also been used and incorporated in other Assessment Programs (EHMP & SRA). Many of the variables would be useful to trial at the site level in the LEB Project. The performance of any of variables in the Barwon-Darling system can't yet be assessed as final reports have not been completed and not all variables appear to have been trialled in this system. Fish were selected as one of the indicators for the initial trial and results of the 1999-2000 sampling are available. The available data suggested that the "% exotics" indicator was a good indicator of health.

10. Pressure-Biota-Habitat Project (PBH)

10.1. Background

The Pressure-Biota-Habitat project (PBH) provided a framework for the assessment of the environmental conservation value and health of New South Wales rivers. It aimed to provide a structured approach to:

- identifying bio-physical attributes of rivers that may be considered of special significance for conservation (i.e., natural assets),
- identifying attributes of rivers that may be detrimental to the maintenance or restoration of assets (i.e., problems), and
- providing a baseline from which to evaluate river ecosystem responses to management.

The framework was tested using a Multi-Attribute River Assessment (MARA) procedure at 122 sites on unregulated streams across 12 sub-catchments within four catchments in New South Wales. These trials were done in order to:

- test the PBH framework for practicality using provisional MARA procedures,
- refine the measurement of variables and the calculation and interpretation of attributes, and
- assess the spatial variability of the attributes and their performance in terms of cost and relevance.
-

The assessment comprised visual assessments, measurements and sampling of water quality, flow, physical structure, diatoms, riparian and aquatic vegetation, macroinvertebrates and fish over a 200 m reach at each site. The survey data were used to generate 32 attributes classified under the criteria of physical diversity, biodiversity, vigour, rarity and risk factors. Predictive relationships were established between 21 of these attributes and site catchment area, elevation and slope, allowing adjustment for natural spatial variation associated with these physical factors.

Attributes measured include:

- Biota (diatoms, macrophytes, riparian vegetation, macroinvertebrates, fish)
- Water Quality
- Physical Habitat
- Hydrology

10.2. Suitability and Limitations

Again, many of the variables suggested for inclusion in the PBH approach have been included in the EHMP and SRA projects and would be considered at the site scale for the LEB Project. There is no available information on the implementation of the PBH project on New South Wales rivers and so it is difficult to assess its performance. As many of the suggested indicators performed well in the DIBM3 project and this were included in the EHMP project they should be considered for trial in the LEB.

11. Fish Index of Biotic Inegrity (IBI)

11.1. Background

The Index of Biotic Integrity (IBI) was originally developed in the USA (Karr, 1981) . In Australia it was apapted by NSW Department of Fisheries for NSW riverine fish assemblages by Harris (1995) and Harris and Silviera (1999). It was also used in the assessment of river health for a number of South Australian streams by Hicks & Sheldon (1998, 1999a, 1999b, 1999c). The IBI is based a series of .metrics. that measure various attributes of the biological community (Karr and Chu, 1999).

For NSW riverine fish assemblages, the metrics used are as follows (Harris and Silviera, 1999):

1. total number of native species,
2. number of riffle-dwelling benthic species,
3. number of pool-dwelling benthic species,
4. number of pelagic pool species,
5. number of intolerant species,
6. percentage of native individuals,
7. percentage of native species,
8. proportion of individuals as microphagic omnivores,
9. proportion of individuals as microphagic carnivores,
10. proportion of individuals as macrophagic carnivores,
11. number of individuals in the sample, and
12. proportion of individuals with disease, parasites and abnormalities.

In calculation of the NSW IBI, fish are sampled at a test site using standard techniques, and the value of each metric is derived. The value of each metric is then converted to a score of either 1, 3 or 5, according to a set of criteria.

In South Australia the IBI was used in the biotic surveys of the Wakefield (Hicks & Sheldon 1998), Broughton (Hicks & Sheldon 1999a), Gawler (Hicks & Sheldon 1999b) and Light rivers (Hicks & Sheldon 1999c). The following metrics were used in these particular streams

1. total number of native species,
2. number of pool-dwelling benthic species,
3. number of pelagic pool species,
4. % of species that represent degraded habitats,
5. % of native individuals,
6. % of native species,
7. % of individuals as microphagic omnivores,
8. % of individuals as microphagic carnivores,
9. % of individuals as macrophagic carnivores,
10. number of individuals in the sample (expected/observed), and
11. % of individuals with disease, parasites and abnormalities.

The IBI approach has been criticised by a number of authors (see Suter, 1993; Taylor 1997) with many of these criticisms being real issues with the use of an IBI approach. The recent calculation of an IBI for fish samples collected from a range of waterholes on Lake Eyre Basin rivers as part of the ARIDFLO (Pritchard pers comm.) project demonstrated problems with its blanket use. In this case the IBI in an individual waterbody declined with increasing time since the last flood – as would be expected in a stressed and changing fish assemblage. The declining IBI was real but did not reflect any human induced disturbances, rather and natural decline in habitat quality.

11.2. Suitability and Limitations

Some of the limitations of the IBI have been discussed above and its performance on fish data collected from the ARIDFLO project would suggest that it needs modification before it could be reliably used in variable rivers such as those of the LEB. However, a number of the metrics that are used to compute the IBI could be used alone to assess the health of fish assemblages

12. State of the Rivers (Queensland)

12.1. Background

www.nrm.qld.gov.au/science/state_of_rivers/

The aim of the State of the Rivers assessment was to obtain data that accurately described the condition of the streams surveyed. The methodology also provided a way of assessing the extent of stream degradation, the potential for problems to exist, and identified the possible causes of degradation. The methodology does not establish current or historical trends, nor does it indicate the rate of change in stream condition. However, by conducting follow-up projects, it was anticipated that historical trends may be obtained due to the rapid survey approach employed by 'State of the Rivers'. The final output of the State of the Rivers is a document describing the physical and ecological condition of a catchments streams (State of the Rivers), and a comprehensive data base of the data sheet information collected during the project. An extensive library of photographs of all the sites is also obtained during the project.

The State of the Rivers procedure was developed to provide the Queensland DPI with a tool to assess the physical and environmental health of rivers and streams. The approach focusses on the collection of habitat data (geomorphology and vegetation).

The following attributes are measured:

- *Reach environmental condition* – assessment of land-use, vegetation, floodplain features, tenure and an estimation of waterlevel
- *Channel Habitat Diversity* – assessment of the range of channel habitats such as waterfall, riffle, rapid, run, pool etc. in a reach
- *Bed, Bank and Bar Condition* – assessment of the distribution of bars, the stability of banks and bed and any restrictions to fish passage
- *Vegetation* – assessment of the aquatic and riparian vegetation recorded in terms of percentage cover, structure and presence of key species
- *Aquatic Habitat* – assessment of the diversity of in-stream habitat types (eg. Logs, branches, substrate etc).
- *Scenic, recreational and conservation values* – assessment of the recreational opportunities, scenic quality and conservation status of the stream

12.2. Suitability and Limitations

At present this is a geomorphic – habitat approach to determine river health. An initial exploration of the State of the Rivers reports the Cooper Creek system within the Lake Eyre Basin suggests it may have little relevance to such systems. Assessments are not related back to a "natural" state and thus the Cooper Creek catchment assessment suggests:

- Channel Diversity - 65% very low channel diversity & 30% low diversity
- Riparian Vegetation – 11% very poor, 28% poor, 20% moderate
- Aquatic Habitat Condition – 39% very poor, 38% poor, 16% moderate

These assessments suggest a catchment in poor condition, however, it is probably little changed from natural condition and the low diversity is a reflection of its character as a desert river.

The State of the Rivers Assessment procedure as currently applied and reported does not appear to be relevant, or helpful, for dryland rivers where lower levels of diversity (vegetation, channel, habitat) are natural phenomena.

13. Catchment Based Techniques: Remote Data Approach

13.1. Landsat Thematic Mapper (TM) Images

Background

Satellite images provide a powerful tool in monitoring landscape variations such as soil salinity, soil erosion, water quality (turbidity) and land cover in arid environments (Gutierrez et al., 2004).
Using image enhancement techniques Gutierrez et al. (2004) were able to detect changes in soil salinity and riparian vegetation over a 10 year span. The Landsat image analysis was verified by ground truthing. The techniques required considerable up-front investment on exploring image preparation and enhancement and also in ground truthing the image analysis. Once the relationships between image and ground data are established the technique offers considerable savings for ongoing monitoring.

Suitability and Limitations

Monitoring and assessment techniques that utilise satellite data offer a number of advantages for arid and semi-arid catchments, which are often remote with difficult access. Such techniques may prove very useful for both the Lake Eyre Basin Rivers Assessment project and the ephemeral rivers (QHER) project. At this stage in Australia such techniques have not yet been applied to monitoring of riverine basins but there has been considerable investment in exploring the use of these techniques within the rangelands context (see below). It is feasible that these techniques could easily be adapted for riverine catchment monitoring with adequate groundtruthing.

14. Indicators from the Australian Rangelands Information System

The Australian Rangelands Information system is based on four key types of information

1. changes in biophysical resources (eg. Nutrients, water, plants and wildlife)
2. changes in impacts on these biophysical resources (eg. Trends in land use intensity, climate and fire history, land clearing, spread of weeds)
3. trends in social and economic factors
4. institutional responses/

http://audit.ea.gov.au/ANRA/rangelands/docs/

The following products from the Australian Rangelands Information System Operational Manual were seen as potentially useful as catchment scale indicators in ephemeral river catchments.

14.1. Landsat satellite data for vegetation cover

Background

The method involves the use of Landsat MSS and TM data to indicate change in the capacity of landscapes to conserve resources (landscape dysfunction). The method involves using landscape-cover change analysis, changes in the trend of a cover index (such as perennial species vs. bare ground) or changes in the variability of cover over time (such as perennial species vs. annual species). Examples of landscape dysfunction may be the inability of landscapes to respond to rainfall and can be measured as the difference between potential and actual cover responses in years with high rainfall. Grazing Gradient analysis has been demonstrated in Pickup and Chewings (1994). Successful demonstrations of the techniques can be found archived on the National Land and Water Resources Audit website www.nlwra.gov.au. The methods provide information on landscape-scale and property-scale change.

Suitability and Limitations

The specific methodology would be extremely useful for use as a floodplain and catchment "landscape" scale indicator of ecosystem health within the Lake Eyre Basin Rivers Assessment (see Brook et al., 2001). It may also provide a useful pressure indicator for the ephemeral rivers project (QHER). In both cases the gradient approach in defining indicators appears a useful way in which to deal with the highly variable spatial and temporal data in arid and semi-arid systems. Determining trends or gradients in indicator response may increase the power of potential indictors, both at the landscape and site scale, to detect change.

14.2. NOAA satellite data for perennial vegetation cover

Background

NOAA satellite data is used to derive the Normalised Difference Vegetation Index (NDVI) which provides daily estimates of green vegetation at about 1 km^2 resolution. Again the method utilises trends in vegetation change to indicate potential ecosystem health change. Seasonal trends in vegetation cover can be established, with yearly minimums suggesting perennial vegetation cover. The technique is still in development but more information can be sourced from the National Land and Water Resources Audit web site www.nlwra.gov.au

Suitability and Limitations

The technique is relevant to the regional or perhaps larger catchment scale. It may provide a useful indicator for landscape scale changes in floodplain vegetation cover in the Lake Eyre Basin Rivers Assessment. The size of catchment of rivers and streams within the Ephemeral Rivers project (QHER) may preclude the use of this technique at a catchment scale but it may still be beneficial at the regional scale.

14.3. Rainfall use Efficiency – NOAA satellite data

Background

Rainfall-use efficiency is the amount of vegetation produced from the annual rainfall on a defined area of land and is a direct measure of landscape function. The Australian Rangelands Information System manual suggests the technique is particularly useful for periods of ten years or more and for larger spatial scales where small scale variability is incorporated into a broad scale response. The measure of rainfall use efficiency (RUE_N) is derived from NOAA satellite data and using the Normalised Difference Vegetation Index (NDVI). RUE_N is calculated using the seasonal totals of NDVI which provide reliable yearly estimates of total green biomass divided by the rainfall total in the preceding 12 months. Regression analysis can be used to attach statistical significance to trends in RUE_N over time.

Suitability and Limitations

Again at the regional or larger catchment scale this may prove a useful indicator for landscape scale changes in floodplain function in the Lake Eyre Basin Rivers Assessment. The size of catchment of rivers and streams within the Ephemeral Rivers project (QHER) may preclude the use of this technique at a catchment scale but it may still be beneficial at the regional scale.

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