Conserving freshwater ecosystem values in Tasmania, Australia: identification and application of freshwater conservation management priority areas.

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Abstract

The Conservation of Freshwater Ecosystem Values (CFEV) Project is a Tasmanian Government initiative that has developed a Comprehensive, Adequate and Representative (CAR) system to act as a strategic framework for the management and conservation of freshwater-dependent ecosystem values in Tasmania. At the core of the CFEV framework is a statewide audit of Tasmania's freshwater values for rivers, waterbodies, wetlands, saltmarshes, estuaries, karst and other groundwater dependent ecosystems. The audit aimed to characterise all types of freshwater ecosystems by undertaking a comprehensive classification and condition assessment based on the assessment criteria of Naturalness, Representativeness and Distinctiveness (NRD). The results of this audit have been used to determine a conservation value and subsequently a conservation management priority ranking for each freshwater ecosystem. A database developed as part of this process will provide environmental-based information to ensure managers are better informed when making decisions regarding the management, development and conservation of the State's freshwater resources. Further refinement of the CFEV data is currently being carried out through ground-truthing and improvements to the database access. A brief outline of the CFEV framework and its use in the conservation and protection of Tasmania's unique and diverse freshwater ecosystems will be presented.

Introduction

Historically, at a national level, conservation of biodiversity through a reserve system has been largely focussed on terrestrial and marine conservation programs. Most states have areas protected under these programs. In Tasmania, a system for establishing Marine Protected Areas (MMIC 2001) and forest reserves under the Regional Forest Agreement (RFA) (Commonwealth of Australia & State of Tasmania 1997) have been in place for some time. While some aspects of the freshwater environment have been protected incidentally within terrestrial reserves, no similar national systematic assessment process is in place for freshwater ecosystems. The Australian Government Department of the Environment and Heritage (DEH) has however, initiated some discussions and progress towards developing a national framework for the identification and protection of rivers of high conservation value (Kingsford *et al.* 2005).

The Conservation of Freshwater Ecosystems Values (CFEV) Project has been developed in recognition of the Tasmanian Government's commitment to ensuring the long-term ecological viability of the State's freshwater-dependent ecosystems. The Project was initiated by the Department of Primary Industries and Water (DPIW) with the aim to design a system for identifying and evaluating the conservation value and management priorities to underpin water resource management, conservation and development in Tasmania.

The CFEV Project is the first of its kind in developing a comprehensive, adequate and representative (CAR) analysis of freshwater ecological values at a statewide scale. This enables freshwater ecosystems to be considered alongside the terrestrial and marine systems in the context of property and water management planning throughout the State.

The Project adopted the values of *Naturalness, Representativeness* and *Distinctiveness* (NRD) as the broad assessment criteria to support the implementation of these CAR principles. *Naturalness* (N) is defined as an assessment of change from pre-European, or 'natural' reference condition. *Representativeness* (R) was assessed by undertaking a biophysical classification of each ecosystem based on pre-European natural features (e.g. fish, riparian vegetation, hydrology etc.). It is defined as the degree to which each ecosystem is representative of the class to which it has been assigned. The *Distinctiveness* (D) component of the conservation value assessment is expressed in two ways – whether the ecosystem unit contains rare classes of ecological components (a rare biophysical class) and/or 'special values' (i.e. conservation values other than those selected for representativeness). These special values include, for example, rare and threatened species and communities, important geomorphological features, sites of high species diversity and sites of ecological significance such as migratory bird sites.

The primary basis for the CFEV framework was the identification of freshwater-dependent ecosystems through an audit of all the freshwater values based on the best available data. The results of the audit were used to rank conservation value for each ecosystem and identify freshwater areas of conservation management priority. An overview of the assessment framework for the CFEV Project is shown in Figure 1. The CFEV assessment was applied to all mapped rivers, lakes, wetlands, estuaries, saltmarshes and karst across all land tenure types.

This paper outlines the assessment framework used by the CFEV Project and how the information created from this assessment is used to inform water managers.

Data acquisition and development

Spatial or Geographic Information System (GIS) data layers (lines or polygons) were developed at a 1:25 000 scale for all of the ecosystem themes. Individual features (e.g. a river section as a line or wetland area as a polygon) within the data layers are referred to as spatial units within the assessment. An initial challenge for the project was to create a river drainage network and associated catchments (river section catchments) that incorporates the connectivity and flow direction of water within the system.

Spatial data layers were also produced for river catchments at three different scales: the river section catchments (the finest scale), sub-catchments and coarse scale catchments. This has resulted in a single, nested and internally consistent set of river catchments for the State. The river section catchments formed the foundation for the calculations of many of the catchment-based condition assessment variables.

For all ecosystem themes, except other Groundwater Dependent Ecosystems (GDEs), various GIS data layers were developed as input to the classification, condition and special values assessment of the freshwater ecosystems (see below).

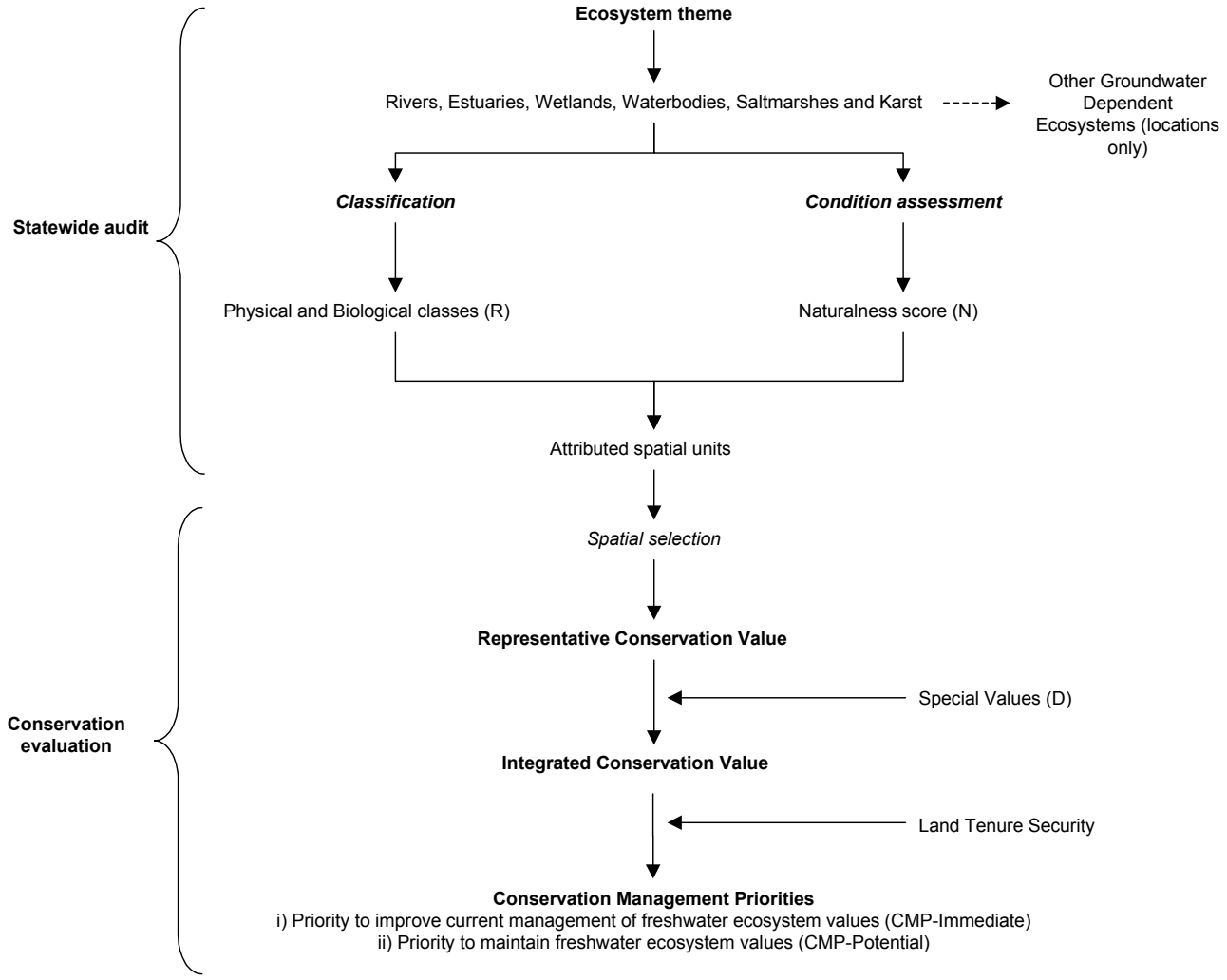

Figure 1. Flowchart showing steps in the CFEV framework (statewide audit and conservation evaluation) for assessing all freshwater dependent ecosystems.

Individual data layers were developed using one or more of the following methods:

1. Using selected categories/values from already existing layers;
2. Using point data collected through other existing programs and using mapping rules and/or statistical modelling to attribute values to the entire set of spatial units for the Tasmania; and
3. By modifying or updating existing data layers to suit the CFEV objectives.

The data layers generated using these methods generally consisted of polygon or point data that were intersected with the relevant ecosystem base layers to attribute the data. Some data however, were attributed directly to the ecosystem spatial units using GIS rules.

The CFEV assessment was conducted on all mapped spatial units for each of the ecosystem themes, except for GDEs where only known locations were recorded. This was primarily due to a

lack of available data. Table 1 presents the total number and length or area of ecosystem spatial units that were assessed.

Table 1. Total number and length (km) or area (ha) of each ecosystem theme assessed using the CFEV framework.

Ecosystem theme	Total number of spatial units	Total length (km) or area (ha) of spatial units
Rivers	350 524	152 941
Estuaries	113	110 666
Lakes/waterbodies	1346	137 042
Wetlands	20 597	206 790
Saltmarshes	336	5745
Karst	334	410 395
Other Groundwater Dependent Ecosystems	115 (points only)	n.a.

Statewide audit

The foundation for the CFEV assessment was the completion of a comprehensive audit of freshwater values across the State. The statewide audit sought to identify the characteristics and condition of all freshwater ecosystems in Tasmania, referred to as the classification and condition assessment.

The classification and condition assessments were conducted using a range of physical and biological variables for each freshwater ecosystem theme. The process involved consultation with key scientific experts to assist with the selection of relevant components and their descriptor variables, development of classifications, analyses, data sets, models and rule sets, and review of outputs.

Classification

With the exception of the GDEs, data was sourced for physical and biological classifications of each ecosystem theme, with the aim of providing an essentially pre-European settlement classification for a range of ecological components. A wide range of components were selected, usually including faunal (vertebrate and invertebrate), floral (aquatic and riparian) biological communities, hydrological, geomorphic and/or geophysical characteristics. Table 2 presents a list of the inputs for the river classification, as an example. The data sets were required to:

- represent natural reference condition as closely as possible (e.g. reconstructed ‘pre-European settlement’ vegetation, ‘best available site’ macroinvertebrate assemblage composition etc.);

- cover a variety of key biological and physical ecosystem components (structure and process) at appropriate scales e.g. range of faunal trophic levels, vegetation, hydrology, geomorphology, tidal regime, wave energy etc.
- have statewide coverage, or be able to be mapped over the state by the use of mapping rules or models applied to existing data;
- be of sufficient quality, detail and 'resolution' (in terms of assemblage composition or functional descriptions); and
- be readily available or derived, either from existing data sets or layers or from readily available sources.

Table 2. Ecological components used as inputs to the river classification.

Components		**Data type**
Physical	Fluvial geomorphology	Mosaics and river types
	Hydrology	Hydrological regions
Biological	Vegetation context at the riparian scale	Tree assemblages
	Native fish	Native fish assemblages
	Benthic macroinvertebrates	Benthic macroinvertebrate assemblages
	Crayfish	*Astacopsis* spp. distribution regions
	Macrophytes	Macrophyte assemblages

Condition assessment

Condition was defined as the degree of change from the 'natural' or pre-European state. No consistent condition assessments were available for any ecosystem theme at State level. Key indicators of biophysical condition were identified for each ecosystem theme. GIS data sets were developed for each condition variable. The data sets were required to:

- represent current (ca. 2005) condition as closely as possible;
- cover a variety of key biological and physical ecosystem components (structure and process) at appropriate scales;
- include data on condition within and adjacent to the spatial unit, as well as the influence of the catchment.
- have statewide coverage (at an acceptable level of detail), or be able to be mapped over the state by the use of mapping rules or models applied to existing data;
- be readily available or derived, either from existing data sets or layers or from readily available sources;

- be able to be integrated by using 'expert rules', with appropriate interactions and environmental contexts.

Important drivers of condition included exotic fish, weeds, riparian vegetation clearing, point source pollution (e.g. acid drainage, mine sedimentation), the presence of large dams, disease, lake level manipulation, changes in flow regime and water availability, roading, lake level manipulation, urbanisation, land fill etc. Figure 2 shows the inputs to the rivers condition assessment, as an example.

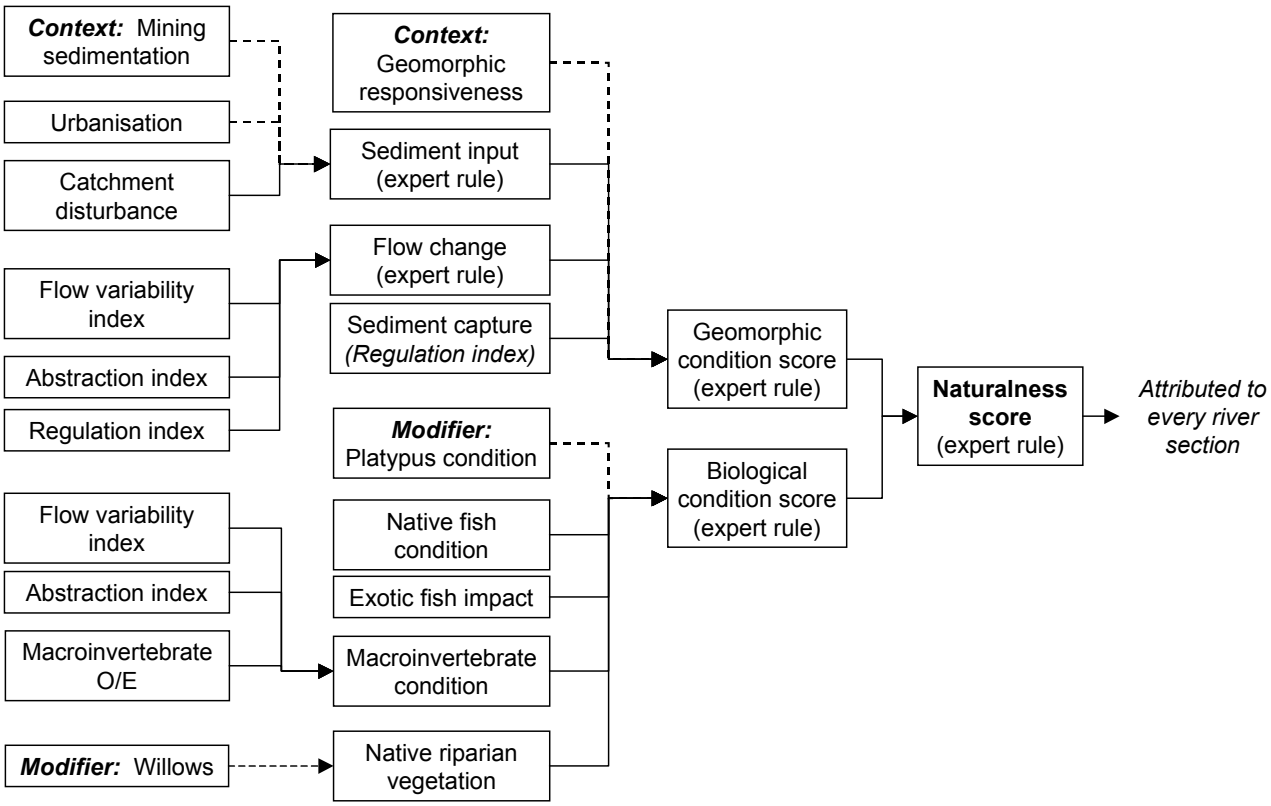

Figure 2. Flow chart showing the inputs to the river condition assessment.

Expert rules ('fuzzy logic' (Negnevitsky 2003)) were used to integrate the input variables to produce sub-indices and then subsequently, derive a condition (Naturalness, or 'N') score. Rules were developed through workshops with local experts, using relevant data where available. Expert rules also took into account the context associated with individual class types.

Conservation evaluation

Data developed as part of the statewide audit, particularity the biophysical classes and the N-score, were used as input to a spatial selection algorithm which, for each ecosystem theme, ranked the spatial units based on conservation value. The algorithm iteratively selected all spatial units, based on the rarity (i.e. total statewide extent) of each biophysical class, ensuring that each class had been selected at least once (including the 'best example') before proceeding to a second or

subsequent selection. A length/area weighted naturalness function (if all else equal, choose the most natural) was also written into the algorithm. In the case of rivers, analysis of conservation values in neighbouring sections was also conducted by the algorithm to identify suitable groupings of river sections ('clusters') for management prioritisation.

Conservation value

Conservation value was assessed in two steps – Representative Conservation Value (RCV) and Integrated Conservation Value (ICV). RCV is a measure of relative importance (A, B or C class) of spatial units based on their representation of biological and physical classes and condition. It takes the output from the spatial selection algorithm and selects representative samples of each biophysical class in the best condition within the top ('A') class. ICV is the conservation value (very high, high, medium or lower) of freshwater ecosystems using a combination of RCV and their status with regard to Special Values (SV).

Special Values are unique and distinctive values present within an ecosystem other than those that are representative of the ecosystem type. These include rare and threatened flora and fauna species, threatened and priority flora and fauna communities, and also priority geomorphic and limnological features. The SV assessment scores spatial units according to the numbers of special values associated with a given ecosystem and their conservation status.

Conservation Management Priority

A Conservation Management Priority (CMP) (very high, high, medium or lower) was identified for each spatial unit within each of the ecosystem themes on the basis of conservation value (either RCV or ICV), current condition (N-score) and current level of management protection (security associated with land tenure). Land Tenure Security (LTS) is used as a surrogate for the degree to which land tenures may be considered to provide secure protection for freshwater ecosystem values. These three inputs were used in a rule set developed by experts to identify management priorities for freshwater ecosystems. Two outputs were generated:

1. CMP immediate - Priority to improve current management of freshwater ecosystem values (i.e. the priority for immediate action (this rating relates to the need for management to protect conservation values under current management conditions and land tenure status)) and

2. CMP potential - Priority to maintain freshwater ecosystem values (which need consideration if new or further development is proposed).

Implementation and use

A key output of the CFEV Project is a geodatabase which stores all the assessment data and acts as a planning and information tool to support the inclusion of freshwater values within existing planning and regulatory instruments. Data can be viewed and interrogated at various spatial scales and levels of detail.

The CFEV database is currently being used by DPIW's water managers in the assessment of water development proposals and water management planning to ensure high conservation value ecosystems are appropriately considered. Outputs from the database show areas of very high and/or high conservation value or CMP that could be impacted by the proposals or water management changes and outline the values and status of these freshwater-dependent ecosystems according to the CFEV assessment. This information can assist water managers to develop environmental objectives for water management planning catchments, identify assessment components to target for further investigation or make recommendations on dam proposals.

The CFEV database will also be an extremely useful freshwater conservation planning and assessment resource for other water resource decision-making bodies, such as other Government agencies, the three Natural Resource Management (NRM) Regional Committees, local government, and also the general Tasmanian public. Web-based access to the CFEV database is being developed over the next six months. This will improve the integration of the CFEV database as a decision-making tool.

Further work is required before the CFEV outputs can be used in a policy or legislative context with respect to identifying and implementing a freshwater reserve system. However, the development of the CFEV framework and resultant database provides Tasmania with a sound basis to link directly into such a system and may also help guide the establishment of a national framework for freshwater protected areas.

Future work

In addition to improving access to the CFEV database, the CFEV Project is currently implementing a project to validate the results in the field through ground-truthing. The aim of the project is to further refine the database and to increase confidence in the CFEV data for land and water managers. Ongoing review of the CFEV framework and maintenance of the CFEV database will be carried out by DPIW as new data becomes available.

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