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 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 classification and condition assessment based on assessment criteria of Naturalness, Representativeness and Distinctiveness (NRD). The results of the audit were used to determine a conservation value and a conservation management priority ranking for every freshwater ecosystem mapped at 1:25 000 scale. A database developed as part of this process provides environmental-based information to ensure managers are consistently informed when making decisions regarding the management, development and conservation of the State's freshwater resources. Refinement of the CFEV data is currently being carried out through ground-truthing and enhanced database access. A brief outline of the CFEV framework and its use in the conservation of Tasmania's unique and diverse freshwater ecosystems is presented.

Keywords

Freshwater conservation, CAR reserve-design principles, management framework

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, systems for establishing Marine Protected Areas (MMIC, 2001) and forest reserves under the Regional Forest Agreement (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 similarly consistent, systematic conservation assessment and management process is in place for freshwater ecosystems. The Australian Government's Department of the Environment and Water Resources has however, initiated some discussions and progress towards developing a national framework for the identification and protection of rivers of high conservation value (see Kingsford *et al.*, 2005).

The Conservation of Freshwater Ecosystems Values (CFEV) Project has been developed by the Department of Primary Industries and Water (DPIW) in recognition of the Tasmanian Government's commitment to ensuring the long-term ecological viability of the State's freshwater-dependent ecosystems. Its main aim was to design a statewide system for identification and evaluation of freshwater-dependent ecosystem 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-dependent ecological values at a statewide scale, enabling freshwater ecosystems to be considered alongside terrestrial and marine systems in property and water management planning in Tasmania.

The Project adopted the values of *Naturalness, Representativeness* and *Distinctiveness* (NRD) as the broad assessment criteria. *Naturalness* (N) is the 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 settlement natural features (e.g. fish, 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 is expressed in two ways – whether the ecosystem unit contains a rare biophysical class and/or 'special values' (e.g. threatened species, important geomorphic features and migratory bird sites).

The primary basis for the CFEV framework was 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 priority areas for conservation management. An overview of the CFEV assessment framework is shown in Figure 1. The assessment was applied to all mapped rivers, lakes, wetlands, estuaries, saltmarshes and karst.

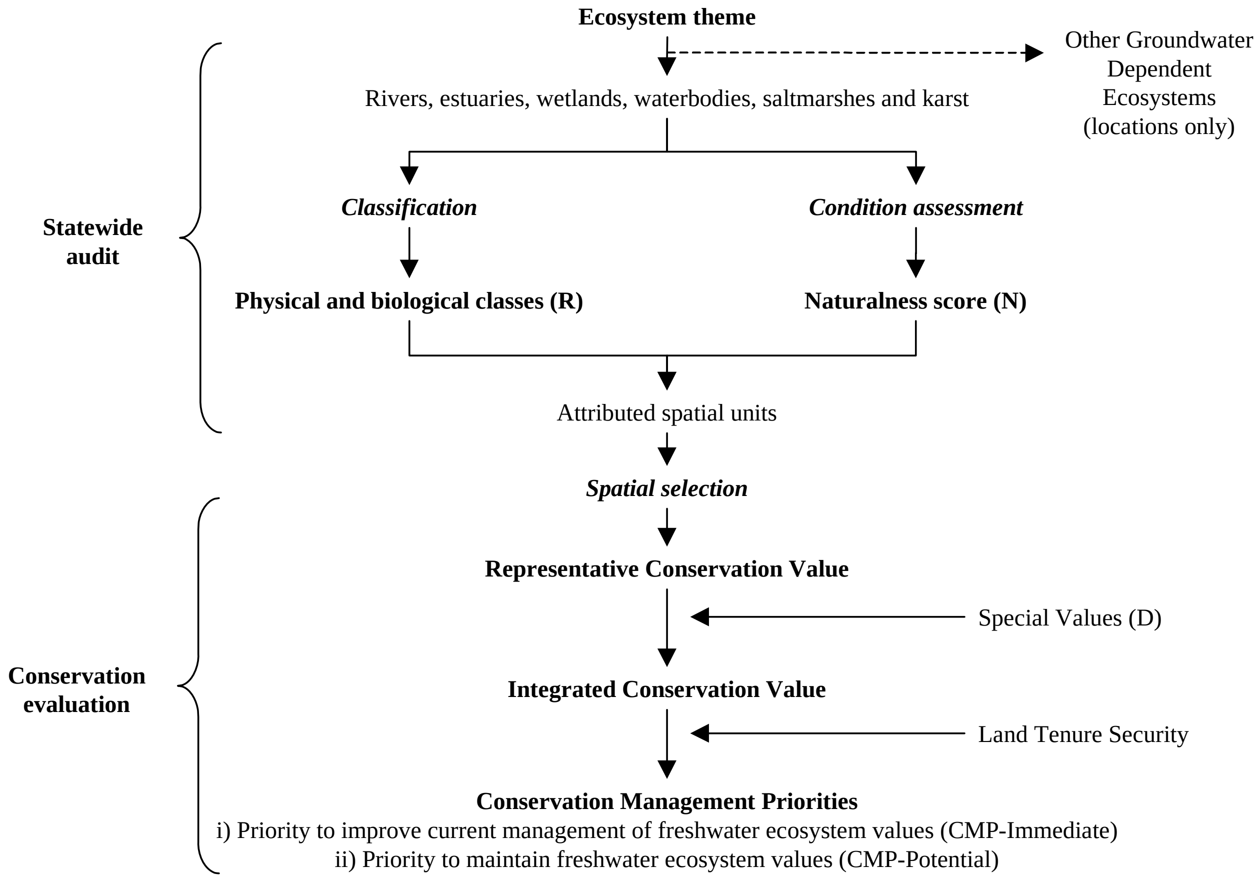

Figure 1. Flow-chart showing steps in the CFEV framework (statewide audit and conservation evaluation) for assessing all freshwater dependent ecosystems.

This paper summarises the CFEV assessment and how the data outputs are used to inform water managers.

Data acquisition and development

Geographic Information System (GIS) data layers (lines or polygons) (1:25 000) were developed for all ecosystem themes. Individual features (e.g. a river section as a line or wetland as a polygon) are referred to as spatial units. A challenge for the project was to create a consistent river network and associated catchments (river section catchments) that incorporates the connectivity and flow direction of water within the system. The river section catchments formed the basis for calculations of many of the catchment-based condition 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. Input 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 mapped set of spatial units for Tasmania; and
3. By modifying or updating existing data layers to suit the CFEV objectives.

The CFEV assessment was conducted on all mapped spatial units for each of the ecosystem themes, except GDEs, where only known locations were recorded due to a lack of available data. Table 1 presents the total number and length or area of ecosystem spatial units 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 GDEs	115 (points only)	n.a.

Statewide audit

A comprehensive audit of freshwater values across the State was conducted to identify the natural characteristics (classification) and current condition of freshwater ecosystems in Tasmania. The process involved consultation with a range of 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
Data were sourced for each ecosystem theme (except GDEs) to provide a pre-European settlement classification for a range of physical and biological components. Table 2 presents a list of the inputs for the river classification, as an example. The data sets were required to:

- cover a variety of key biological and physical ecosystem components at appropriate scales;
- have statewide coverage, or be applied across the state using rules or modelling of 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.

Condition assessment
Condition was defined as the degree of change from the ‘natural’ or pre-European state. No statewide, consistent condition assessments were available for any ecosystem theme. Key indicators of biophysical condition were identified for each ecosystem theme. GIS data sets were then 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 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, or be able to be mapped over the state using 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;

Table 2. Ecological components used as inputs to the river classification, based on re-constructed pre-European reference data sets.

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

Important drivers of condition included catchment and riparian vegetation clearing, point source pollution (e.g. acid drainage, mine sedimentation), the presence of large dams, exotic fish, weeds, 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.

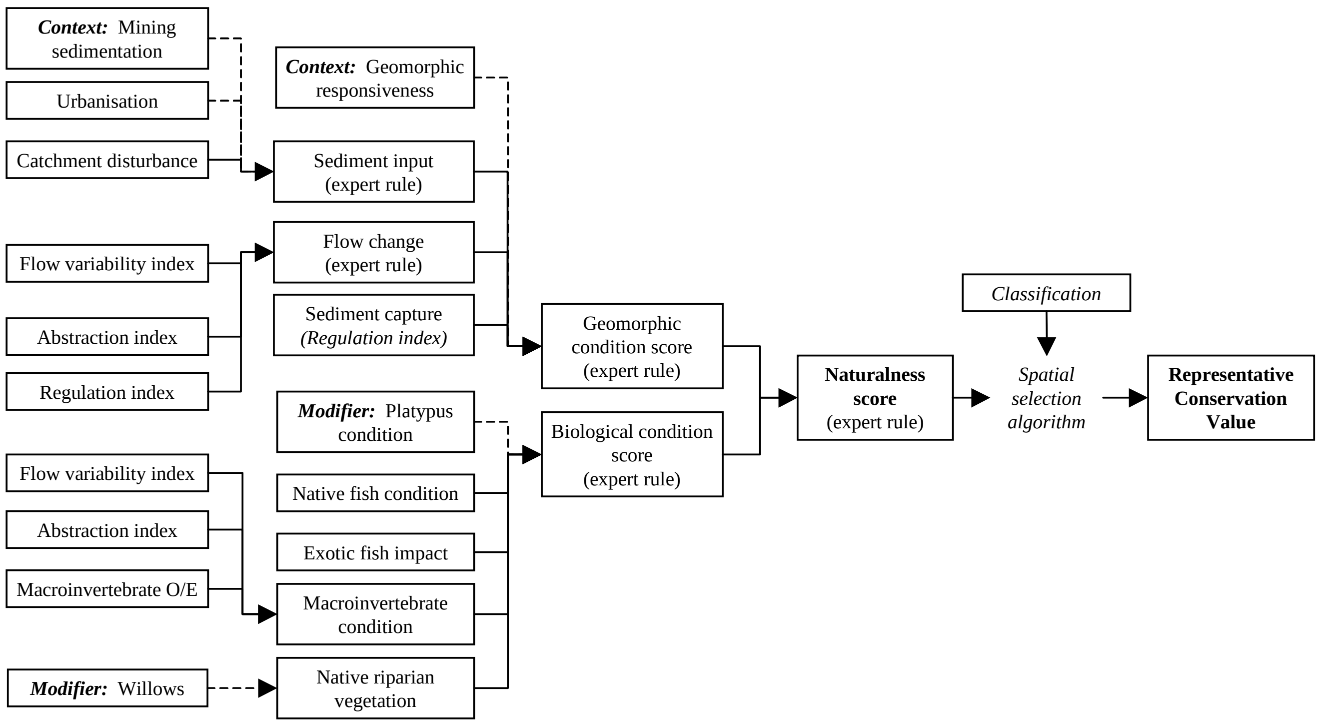

Figure 2. Flow-chart showing the inputs to the river condition assessment.

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 ecosystem class types.

Conservation evaluation

Data developed as part of the statewide audit, particularly the biophysical classes and the N-score, were used as inputs 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, its condition and (for rivers, wetlands and saltmarshes) its size. The algorithm ensured that each class had been selected at least once (including the 'best example') before proceeding to a second and subsequent selections. 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.

Special values are unique and distinctive values present within an ecosystem other than those that are representative of the ecosystem type. A substantial body of work was required to produce consistent and comprehensive spatial data sets for special values for each ecosystem themes, with review from experts, and criteria for data acceptance and ejection.

The types of special values included in the CFEV assessment were:

- threatened flora and fauna species;
- threatened flora (forest) communities;
- priority flora and fauna species;
- priority flora (non-forest) and fauna communities;
- priority geomorphic and limnological features;
- sites of fauna species richness;
- phylogenetically distinct fauna species;
- palaeolimnological and palaeobotanical sites; and
- important bird sites.

The ICV assessment ranks spatial units according to the number and importance of special values associated with a given ecosystem and their conservation status (RCV).

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 using rules sets with inputs 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 is used as a surrogate for the degree to which land tenures may be considered to provide secure protection for freshwater ecosystem values. 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 of the 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 resource for other water resource decision-making bodies, such as other Government agencies, the three Natural Resource Management regional committees, local government, and also the Tasmanian public. Web-based access to the database is currently being developed. 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 for 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 validating the results through ground-truthing. Ongoing review of the CFEV framework and maintenance of the CFEV database will be carried out by DPIW as new data becomes available. A technical report is also being prepared that will accompany the database and detail the methodology of the assessment framework, data limitations and results.

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References

Commonwealth of Australia and State of Tasmania (1997). *Tasmanian Regional Forest Agreement*. Canberra: The Commonwealth of Australia & the State of Tasmania.

Kingsford, R. T., Dunn, H., Love, D., Nevill, J., Stein, J., & Tait, J. (2005). *Protecting Australia's rivers, wetlands and estuaries of high conservation value*. Canberra: Department of the Environment and Heritage.

MMIC (Marine and Marine Industries Council)(2001). *Tasmanian Marine Protected Areas Strategy*. Marine and Marine Industries Council, Crown in Right of the State of Tasmania, Hobart.

Negnevitsky, M. (2003). *Artificial Intelligence. A Guide to Intelligent Systems.* Essex, England: Pearson Education.