ECOLOGICAL RISK ASSESSMENT FOR AUSTRALIA'S TROPICAL RIVERS

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ABSTRACT

The objective of the Tropical Rivers Inventory and Assessment Project (TRIAP) ecological risk assessment sub-project is to develop a framework applicable to key focus catchments and significant locations that meet stakeholder needs. A broad overview of the major pressures on tropical Australia's aquatic ecosystems will be provided through this sub-project, in addition to more detailed risk assessments for the following focus catchments: the Daly River (Northern Territory); the Flinders River (Queensland); and the Fitzroy River (Western Australia).

A conceptual risk assessment model of the Daly River Catchment that identifies the key ecological assets and threats was developed following consultation with government stakeholders and an extensive review of existing reports and management plans. This conceptual model is a key planning tool and focuses on the interactions between susceptible assets and key threats. The conceptual model provides the basis for undertaking a "first-pass" semi quantitative risk assessment of multiple threats to multiple assets, and at different spatial scales within a GIS framework. This approach allows the production of relative risk maps for catchments across the Northern Rivers Region down to sub-catchments at the focus catchment scale.

1. INTRODUCTION

A better understanding of aquatic ecosystems is required to achieve our vision of sustainable development of Australia's tropical rivers. There is a very limited knowledge of riverine ecosystems in northern Australia and we urgently need to study them in a systematic manner. Generally only those catchments with mining, industrial or intensive agricultural development have information available on the ecology, biology, geomorphology, hydrology and management opportunities. This information is fragmented and insufficient and hence cannot address future management needs for the bulk of the tropical north. The key knowledge gaps include: ecological processes and character; the condition of assets and nature of threats; socio-economic and cultural context; and resource management structures.

In order to address some of these knowledge gaps, the Australian Government (Land & Water Australia, and The Natural Heritage Trust 2) has funded a National Rivers Consortium project titled 'Australia's tropical rivers - an integrated data assessment and analysis', also known as the Tropical Rivers Inventory and Assessment Project (TRIAP). The project scope includes an ecological risk assessment of major pressures affecting Australia's tropical rivers through engaging multiple stakeholder groups, including local indigenous people, the private sector and government agencies.

In this paper, we use the Relative Risk Model (RRM) (Landis and Wiegers 1997) to assess, semi-quantitatively, ecological risks at the regional scale. The RRM is a robust methodology that incorporates spatial variability at a large scale to examine the interaction of multiple threats to habitats, and their effects (impacts) on assessment endpoints. The method has been shown to better focus investigative studies, data collection and the decision making process (Landis and Wiegers 1997). Landis and Wiegers (1997) define the following terms used in the RRM as follows:

- Sources- group of stressors (threats); and
- Habitats-group of receptors; where the receptors reside

The RRM has been applied successfully in numerous studies and environments including: the marine environment of a fjord in Alaska (Wiegers et al 1998); Mountain River catchment in Tasmania, Australia (Walker et al 2001); an Atlantic Rain Forest reserve in Brazil (Moraes et al 2002); the Codorus Creek Watershed, Pennsylvania (Obery and Landis 2002); a near shore marine environment, Cherry Point, USA (Hayes and Landis 2004); and threats to sensitive species from military land uses in New Mexico and Texas (Andersen et al 2004).

Relative risk estimates are determined by combining source and habitat ranks. These risks are relative and can not be used to compare against other risk regions outside the application of this model. In the process, risk characterisation results in a comparison of risk estimates among sub-regions, sources, habitats and endpoints to identify: the sub-regions where most risk occurs; the sources contributing the

most risk; the habitats where most risk occurs; and the ecological assets most at risk in the study area (Hayes and Landis 2004).

Advantages of the RRM as suggested by Landis and Wiegers (1997) include: few assumptions are required; the impacts of ranking decisions upon the final outcome can be examined by quantifying uncertainties in rankings via a sensitivity analysis; rule driven approaches can be easily incorporated into the ranking system; and the rankings are testable hypotheses. Limitations in using the RRM are that the approach uses an additive model, although the effects of some threats may be multiplicative (Andersen et al 2004), and/or interactive, and threats and habitats are ranked on their relative likelihood of occurrence, as opposed to their relative consequence of occurrence (Walker et al 2001). Points of caution include end users may rely on the ranking system without validating the projected risks (Landis and Wiegers, 1997). Additionally, the geographic extent of the habitat will influence the magnitude of the effects, particularly with different size populations (Hayes and Landis 2004), and variable distances between sources and effects will add complexity and so increase uncertainty.

2. METHODS

The methodology adopted in this paper is similar to that outlined in Walker et al (2001) and Obery and Landis (2002). Risk characterisation and sensitivity analysis have not been undertaken as yet. The methodology includes the following steps:

a) Determining the Ecological Assessment Endpoints (assets) based on stakeholder input;
b) Describing the Habitats to be examined;
c) Determining the Sources of Threats;
d) Creating a spreadsheet of the conceptual model for ranking purposes;
e) Identifying and creating risk areas;
f) Ranking of Threats based on a 2-point scheme (2, 4, 6);
g) Ranking of Habitats based on the proportion of a particular habitat within a risk region; and
h) Relative Risk Calculations.

2.1 Problem Formulation and Risk Analysis using the Relative Risk Model

These steps involve the collation of existing information to determine the nature of the issue or problem and the application of the RRM.

2.1.1 The Risk Region: Daly River Catchment, Northern Territory

The Daly River Catchment is located in the Top End of the Northern Territory. It encompasses approximately 52 600 km^2 and is one of the largest catchments in the Top End. The Daly River itself is one of the largest rivers in the Northern Territory (Faulks 1998) and has a perennial flow component. The major population centre within the catchment is Katherine and the dominant land use type is grazing of natural vegetation followed by traditional indigenous use.

For this analysis we defined 18 risk regions within the Daly River Catchment, as shown by Figure 1. The risk regions are as follows: 1- Daly River; 2- Hayward Creek; 3- Green Ant Creek; 4- Douglas River; 5- Stray Creek; 6- Dead Horse Creek; 7- Fergusson River; 8- Seventeen Mile Creek; 9- Katherine River; 10- King and Dry Rivers; 11- Limestone Creek; 12- Flora River; 13- Bradshaw Creek; 14- Bamboo Creek; 15- Fish River; 16- Chilling Creek; 17- Daly River Estuary; and 18- Upper Katherine River.

Sixteen of the risk regions encompass 16 sub catchment units defined by hydrological characteristics. A further two risk regions, the Daly River Estuary (17) and Upper Katherine River (18) were derived from risk regions Daly River (1) and Katherine River (9), respectively. These two risk regions were defined based on hydrological subsections of the sub catchments and were both morphologically distinct units compared with the entirety of their sub catchment.

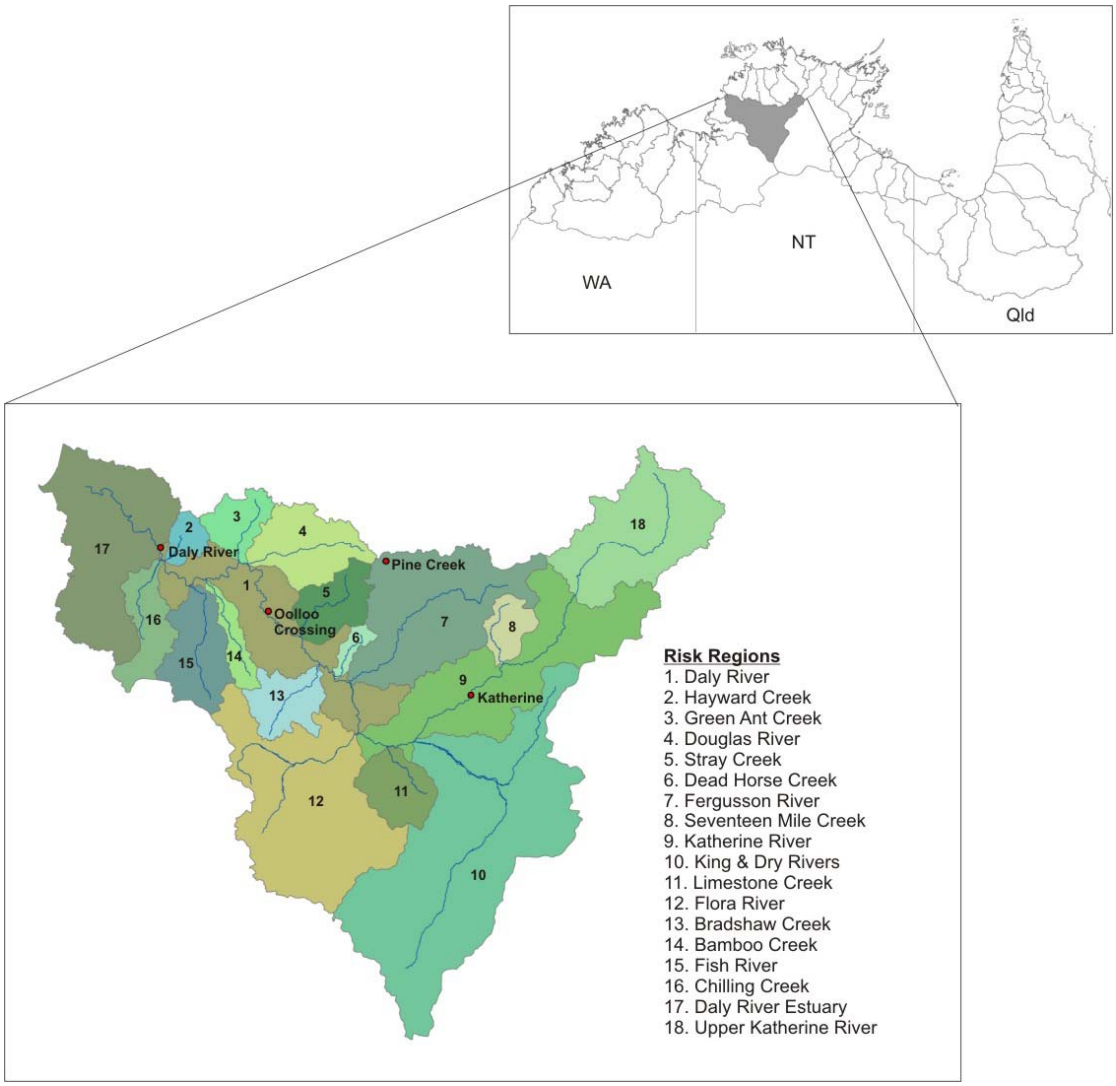

Figure 1: Daly River Catchment Risk Regions

2.1.2 Ecological Assessment Endpoints

In this project the focus is on ecological assessment endpoints although it is recognised that socio-economic assessment endpoints are of equal importance in undertaking an ERA. We chose assessment endpoints based on publically available reports and/or existing stakeholder meeting records (see http://www.nt.gov.au/nreta/naturalresources/plans/dalyregion/techreports.html). These will be further confirmed with stakeholders through communication of the first draft of the RRM.

The ecological assessment endpoints are:

- Maintenance of existing perennial flow.
- Water quality to meet or exceed a specified standard.
- Maintenance of threatened aquatic species.
- Maintenance of extent and health of riparian vegetation.
- Maintenance of biodiversity.

2.1.3 Threats

The process for identifying threats was similar to that for defining ecological assessment endpoints (use of existing reports and government stakeholder input). Of the threats identified, only a subset was used in this 'first-pass' of the RRM. The following threats were included in this application of the RRM:

- Land clearing.

- Land use (as classified by the Australian Land Use and Management Classification Version 5. Also see Bureau of Rural Sciences 2002).
- Potential sea level rise.

Land clearing data from 2005 and Land Use Mapping Project (LUMP) data were obtained in a spatial format from the Northern Territory Department of Natural Resources, Environment and the Arts. Potential sea level rise data were derived from the freely available GEODATA-TOPO 250K water bodies spatial data and a method used by Bayliss et al (1997). The areas labelled as 'subject to inundation' within this data were selected as areas (below 4 m in elevation) that could be potentially affected by a rise in sea level. (Bayliss et al 1997).

In the risk analysis, a two point scale (2, 4, 6; low, medium, high [respectively]) was implemented to categorise the percentage cover of a particular threat within each risk region. The two point scale values were assigned using Jenk's Optimisation, which is a suitable method for clustering numerical data (Obery and Landis 2002).

2.1.4 Habitats

Habitats were selected that are directly related to tropical rivers and that have spatial data that are readily accessible. The three habitats selected were:

- Waterways- spatial dataset utilised is the GEODATA-TOPO 250K drainage theme.
- Riparian vegetation- spatial dataset utilised is the Melaleuca Survey of the Northern Territory (1993).
- Wetlands- spatial dataset utilised is the GEODATA-TOPO 250K drainage theme.

The risk analysis for habitats was conducted as outlined above.

2.1.5 Conceptual model and relative risk calculations

Risk hypotheses are illustrated in a conceptual model for the specified threats and habitats as shown in Figure 2. This conceptual model forms the basis for undertaking risk calculations within the RRM as outlined by Walker et al (2001). The risk hypotheses are evident through the links between threats, habitats and assessment endpoints. The interactions are defined by the exposure and effects pathways.

Risk was calculated as follows (after Walker et al (2001)):

- Sum of threats in risk region = $\sum$ threats
- Sum of potential threat exposure in risk region = $\sum$ (threat * habitat) only where there is potential exposure
- Total risk to ecological assessment endpoint = $\sum$ (threat * habitat) only where there is potential exposure AND where the threat has the potential to impact the ecological assessment endpoint.
- Total risk to ecological assessment endpoint in risk region = $\sum$ (total risk to ecological assessment endpoint).

3. RESULTS

Table 1 summarises the ecological assessment endpoint and total risk ranks for risk regions within the Daly River catchment. The ecological assessment endpoints at greatest ecological risk from the specified threats are both water quality and maintenance of aquatic threatened species. Their risk scores were the same as the threat interactions were the same within the conceptual risk model. Conversely, the ecological assessment at the least ecological risk is maintenance of perennial flow. The risk region with the greatest potential impact on these ecological assessment endpoints is Risk Region 1- Daly River sub catchment.

Figure 3 presents the overall risk classification calculated using Jenk's Optimisation for each risk region within the catchment. The risk model indicates the risk region with the highest risk to specified endpoints is Risk Region-Daly River, and the risk region with lowest risk is Risk Region 2-Hayward Creek.

Future work will concentrate on refining the conceptual model and implementation of the risk calculations, including the incorporation of the additional threats (eg. invesive species) and introducing

sensitivity analysis. The RRM will also be applied at a northern Australian scale, across all 51 tropical rivers catchments.

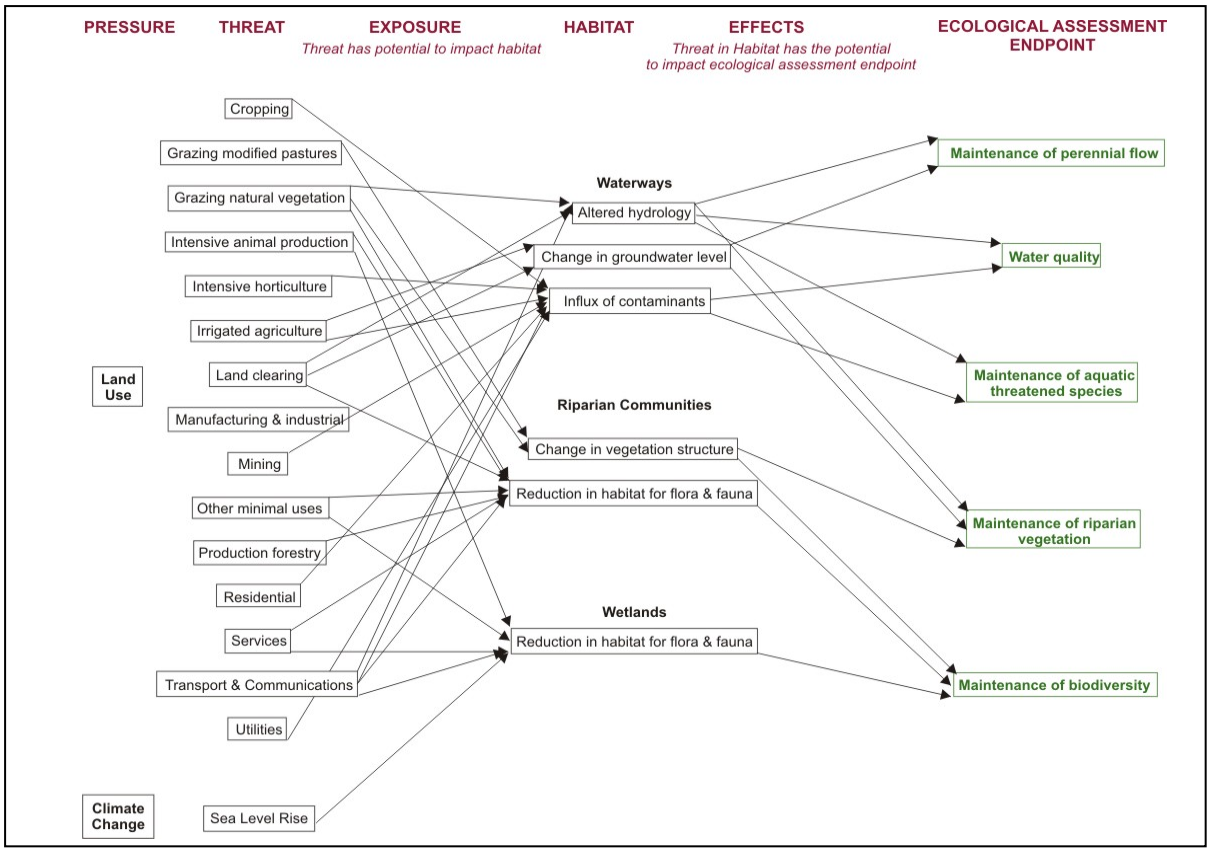

Figure 2: Conceptual model describing ecological risk at the catchment scale

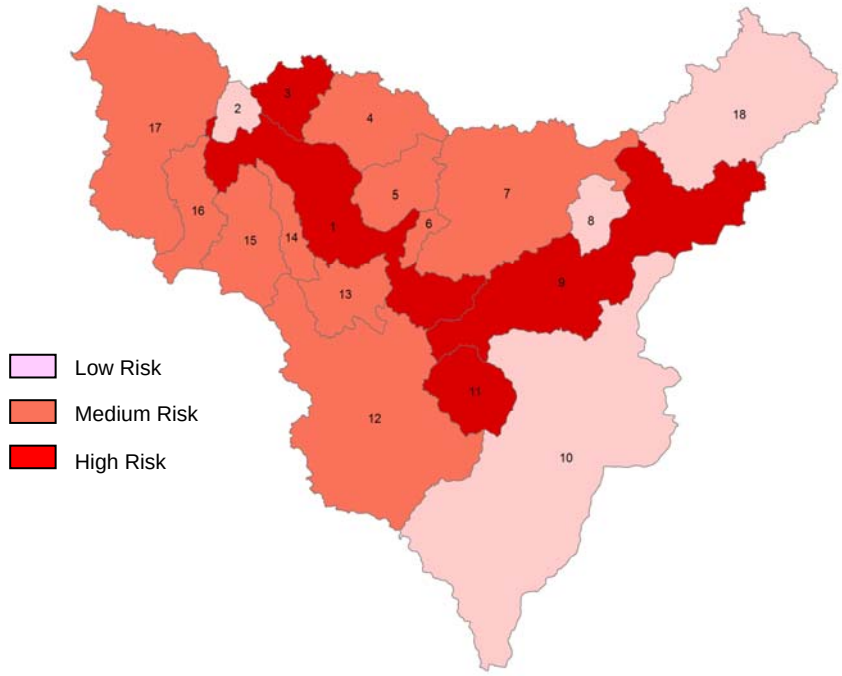

Figure 3: Relative risk classification for the 18 Risk Regions identified for the Daly River Catchment

Assessment Endpoints:	Maintenance of perennial flow	Water quality	Maintenance of aquatic threatened species	Maintenance of riparian vegetation	Maintenance of biodiversity	Total Risk by Region
Risk Region						
1	120	240	240	152	160	**912**
2	28	52	52	44	72	**248**
3	96	136	136	144	240	**752**
4	80	152	152	112	184	**680**
5	80	128	128	96	84	**516**
6	96	192	192	108	80	**668**
7	56	144	144	80	124	**548**
8	20	44	44	44	148	**300**
9	88	216	216	112	196	**828**
10	24	48	48	36	80	**236**
11	132	216	216	148	92	**804**
12	96	180	180	112	88	**656**
13	84	168	168	96	72	**588**
14	72	144	144	96	108	**564**
15	72	144	144	84	64	**508**
16	72	144	144	112	152	**624**
17	64	120	120	112	276	**692**
18	40	88	88	56	92	**364**
Total Risk for Assessment Endpoint	**1320**	**2556**	**2556**	**1744**	**2312**	**10488**

Table 1: Ecological assessment endpoint risk ranks for the 18 risk regions within the Daly River catchment.

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