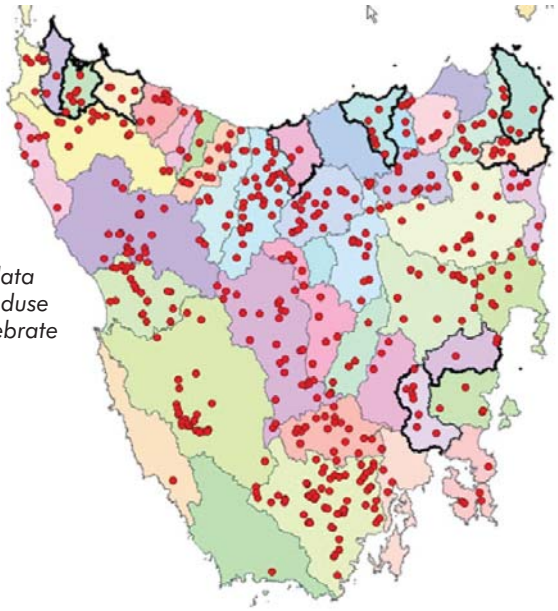
Prof Peter Davies
p.e.davies@utas.edu.au
University of Tasmania (Hobart)
Day 2, 11.25am

Land-use and nutrients as drivers of change in Tasmanian river ecosystems: correlations and mechanisms

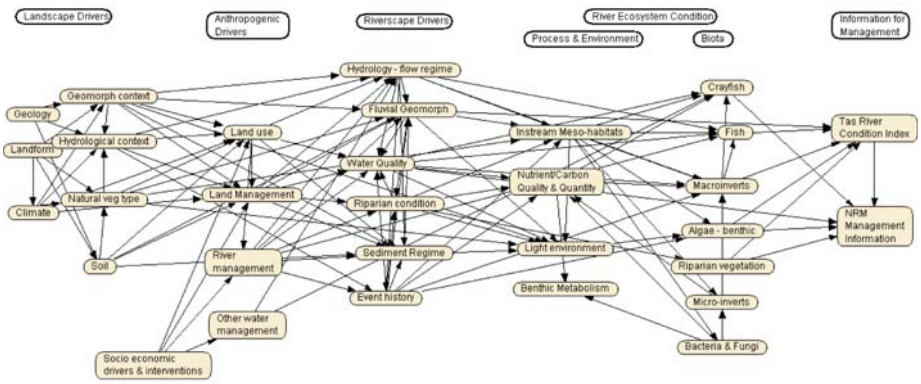
Peter Davies[1], Steve Read[2], Regina Magierowski[1,2], Nelli Horrigan[1,2]
[1] School of Zoology, University of Tasmania. [2] Forestry Tasmania.

One of the challenges of analysing the 'experiment' imposed on the landscape by historical human development is distinguishing correlation and mechanism. Most survey-based field studies suffer from multiple confounding effects coupled with unknown historical contingencies. Correlative studies that relate river ecosystem responses to land use and intermediate drivers such as water quality can attempt to control for these confounding gradients by a hierarchical approach to data analysis, using residuals from which the influence of underlying natural gradients have been partially removed. On the other hand, formal field-based gradient studies can focus on collecting data that provides multiple lines of evidence for mechanistic links between drivers and responses. When combined, these approaches provide powerful insights which can aid management decisions. We explore these issues and approaches with illustrations from data-mining and field gradient studies being conducted in Tasmanian catchments across several gradients of land-use intensity.



Sites included in the data mining analysis of landuse – stream macroinvertebrate relationships.

Initial conceptual model of links between land use and stream responses.



Take-home messages:

- Analysis of data from 780 stream sites in Tasmania as part of a national biomonitoring program revealed a strong correlation between the absence of sensitive macroinvertebrates and the area of catchments under grazing.
- This relationship was:
  a) stronger at whole-of-catchment than local scale;
  b) maintained across Tasmania's 4 hydrological regions;
  c) still valid when redundancy analysis removed the confounding effects of natural variables affecting macroinvertebrate distribution.
  d) characterised by a major threshold at 42% of catchment under grazing land-use.
- Subsequent intensive field sampling of 35 sites in northern Tasmania is identifying the mechanism(s) underlying links between land-use, nutrient loads, riparian condition, and stream algal and macroinvertebrate responses (e.g. the relative dominance of changes in stream habitat conditions and food resources as driven by physical and/or nutrient changes).

Drivers of change in Tasmanian river ecosystems: correlations and mechanisms

Peter Davies
Steve Read
Nelli Horrigan
Regina Magierowski

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Landscape Logic Approach

1. **Consultation on Problem**
   - Agricultural landuse – nutrients - river health

2. **Integration for Decision Support**
   - Bayesian Decision Networks

3. **Evidence-based**

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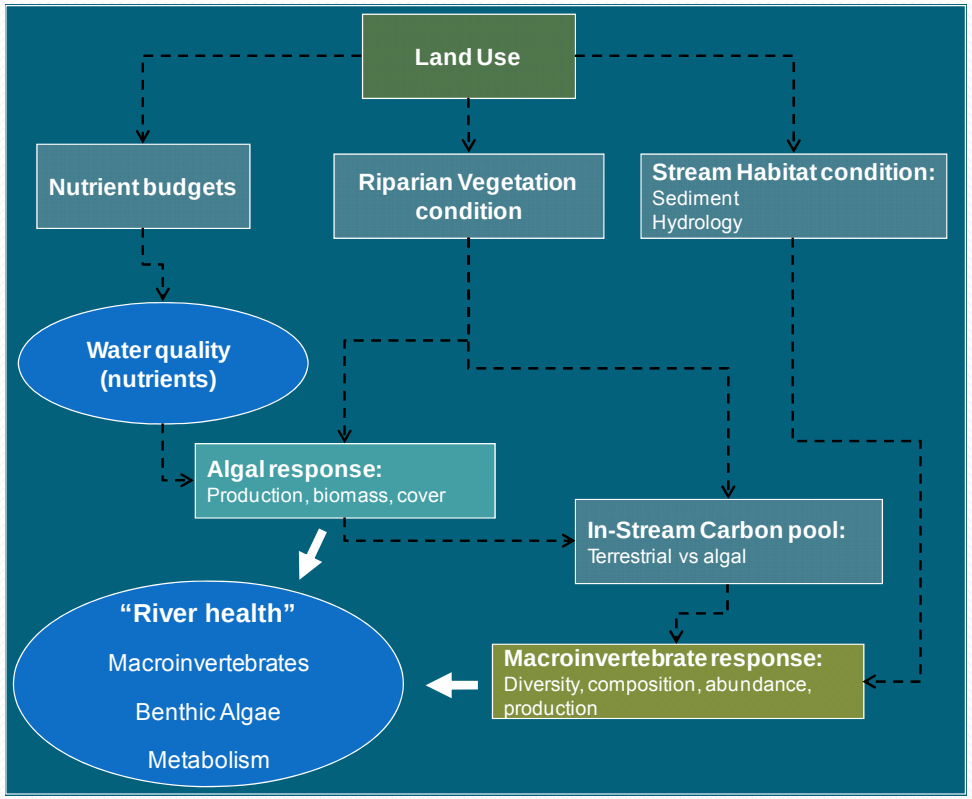
Land use ➡ Nutrients ➡ River Health

We may have conceptual models :

but



What's the evidentiary basis?
and
What are the underlying mechanisms?

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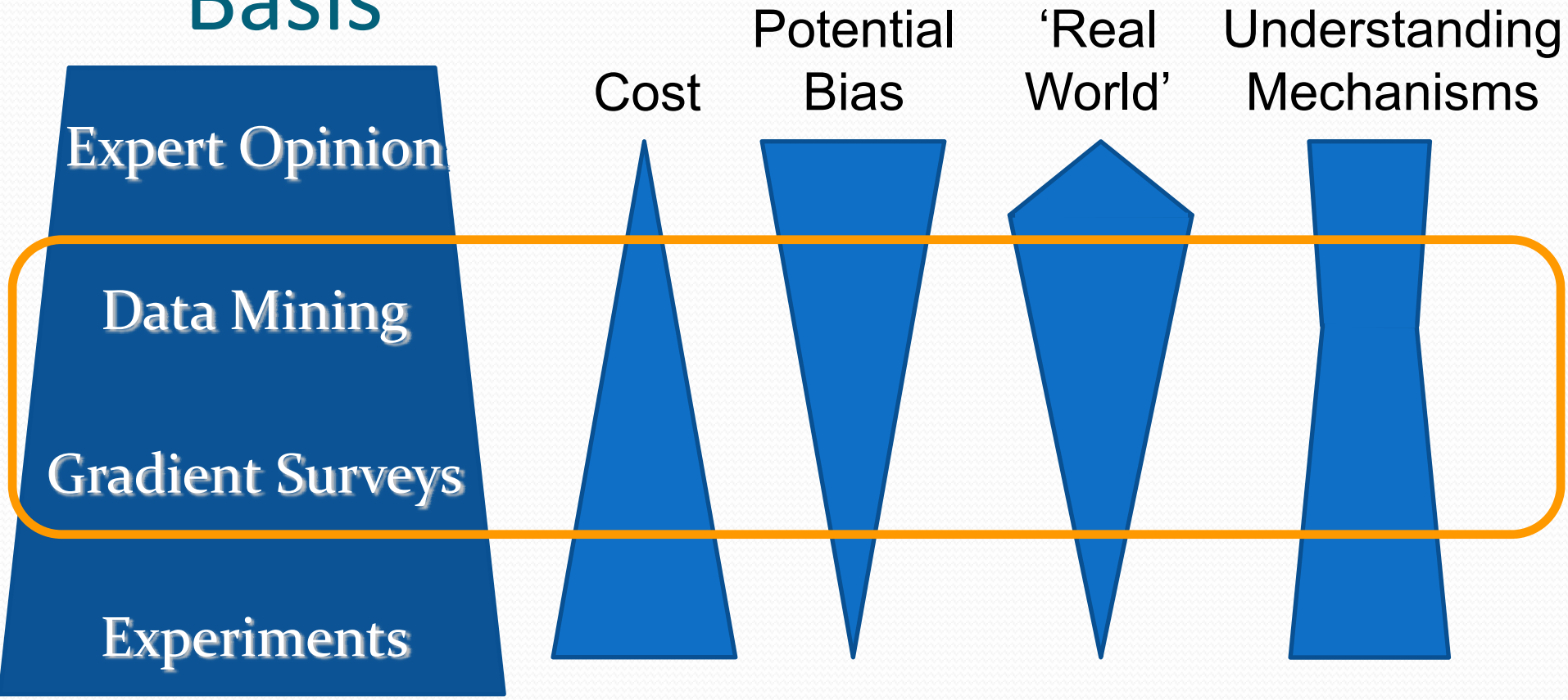
Evidentiary Basis



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Land use ➡ Nutrients ➡ River Health

Approach 1 - Data mining :

- Opportunism: ***Correlate*** existing river ecological data (macroinvertebrates) to data on land use and intermediate drivers

- Confounding: Attempt control by two-step ***redundancy analysis***:
  - fit 'natural' co-variables to taxonomic matrix
  - fit land use and other human-influenced variables to residuals

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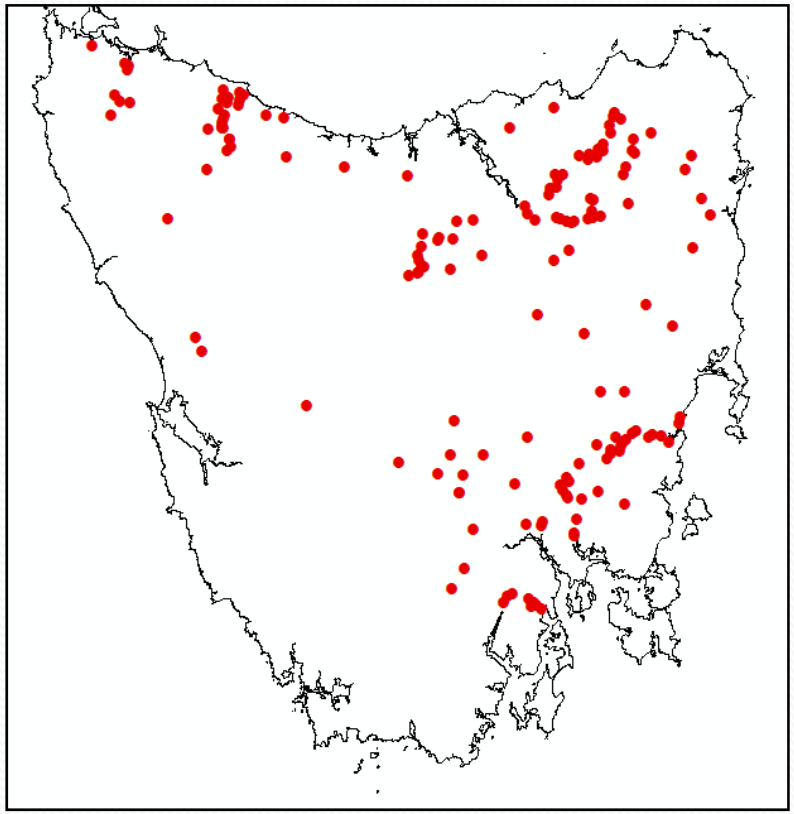
Data Mining :
Biota & Habitat Data: *AUSRIVAS*

- Sampled 1999 - 2006
- 781 sampling events
- 165 sites
- Streams 4-30m wide, 3-6 order



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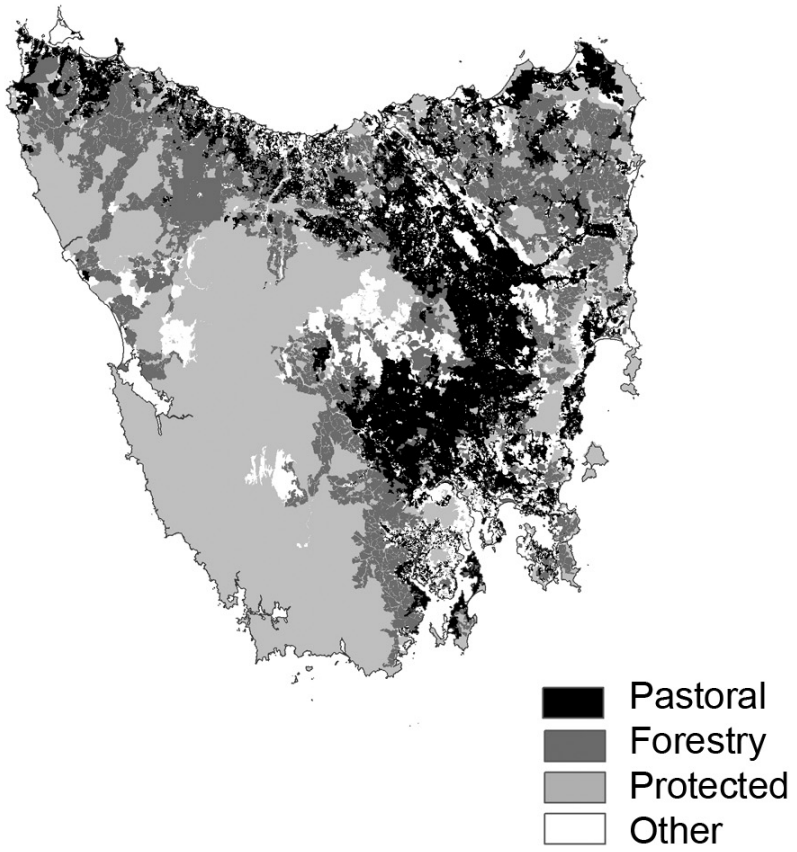
Data Mining : Land Use Data: *BRS*

- Protected (Minimal Use)
- Forestry Production & Plantation
- Cropping
- Grazing:
  - Of Natural Vegetation
  - Of Modified Pastures
  - Irrigated Pastures
  - Combined (= Grazing All + Remnant Native Vegetation)



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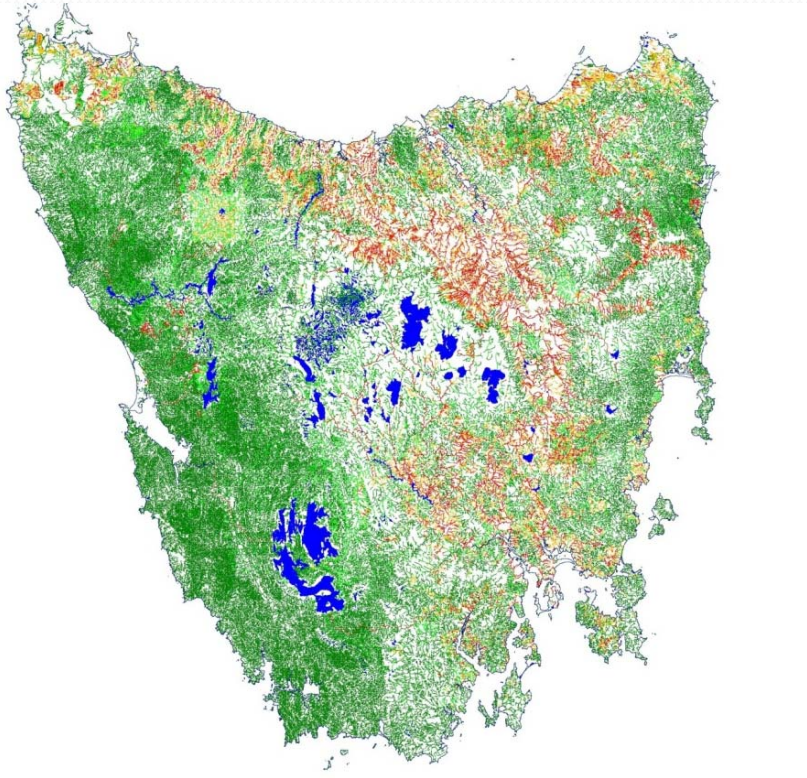
Data Mining : Catchment & Stream Features: CFEV

Conservation of Freshwater Ecosystem Values (CFEV) GIS database:

- Riparian Vegetation Condition
- Water abstraction – annual diversions
- Hydrological regionalisation
- Catchment area
- Stream slope, order, annual runoff



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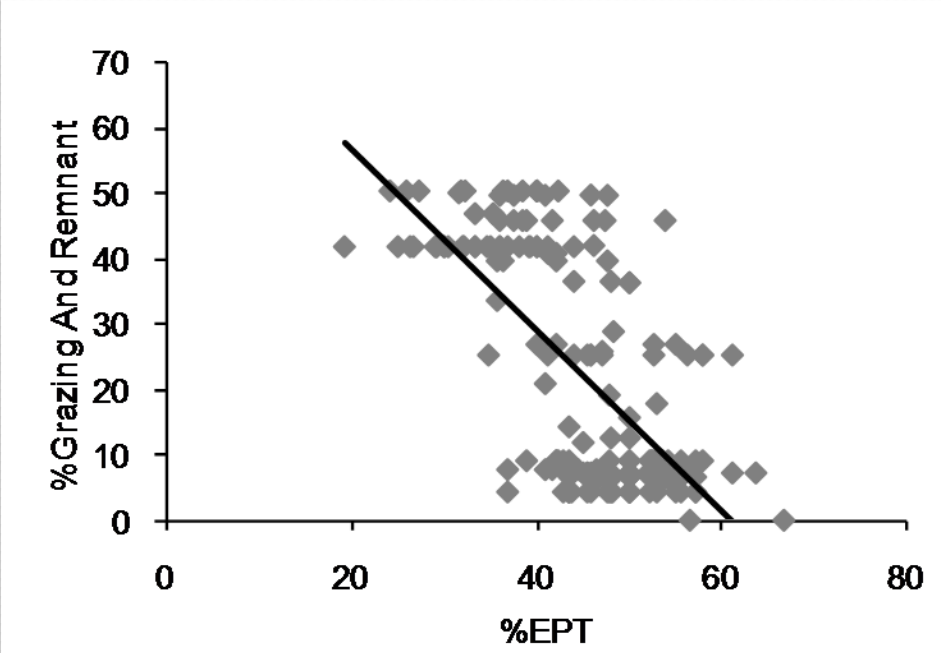
Results 1 Landuse

Macroinvertebrate composition = F[% grazing land]

- 45% of variance explained
- Same relationship:
  - for residuals after influence of natural drivers removed
  - across range of contexts e.g. hydrological region
- Limited influence of riparian veg condition



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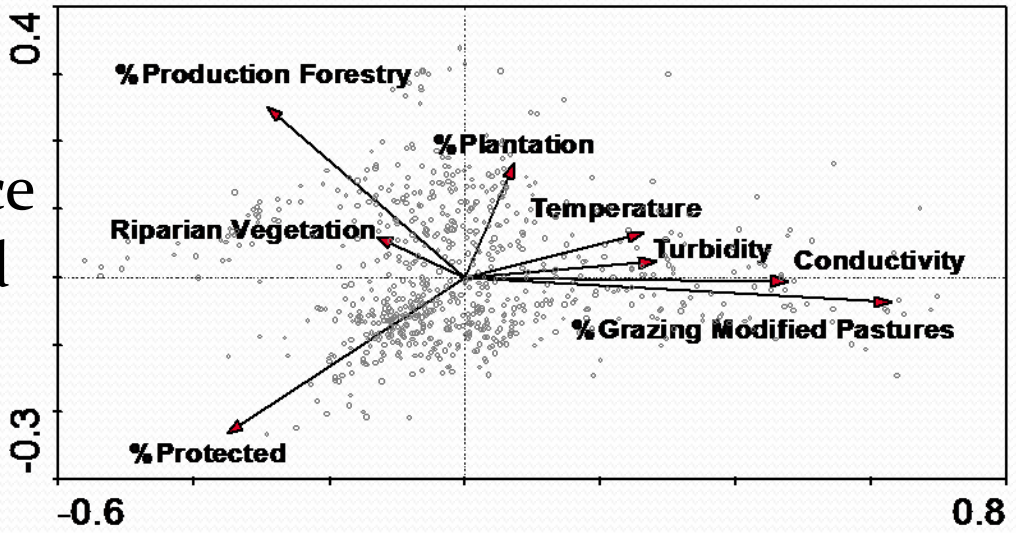
Results 2 Confounded?

Macroinvertebrate composition = F[% grazing land]

- 45% of variance explained
- Same relationship:
  - for residuals after influence of natural drivers removed
  - across range of contexts e.g. hydrological region
- Limited influence of riparian veg condition



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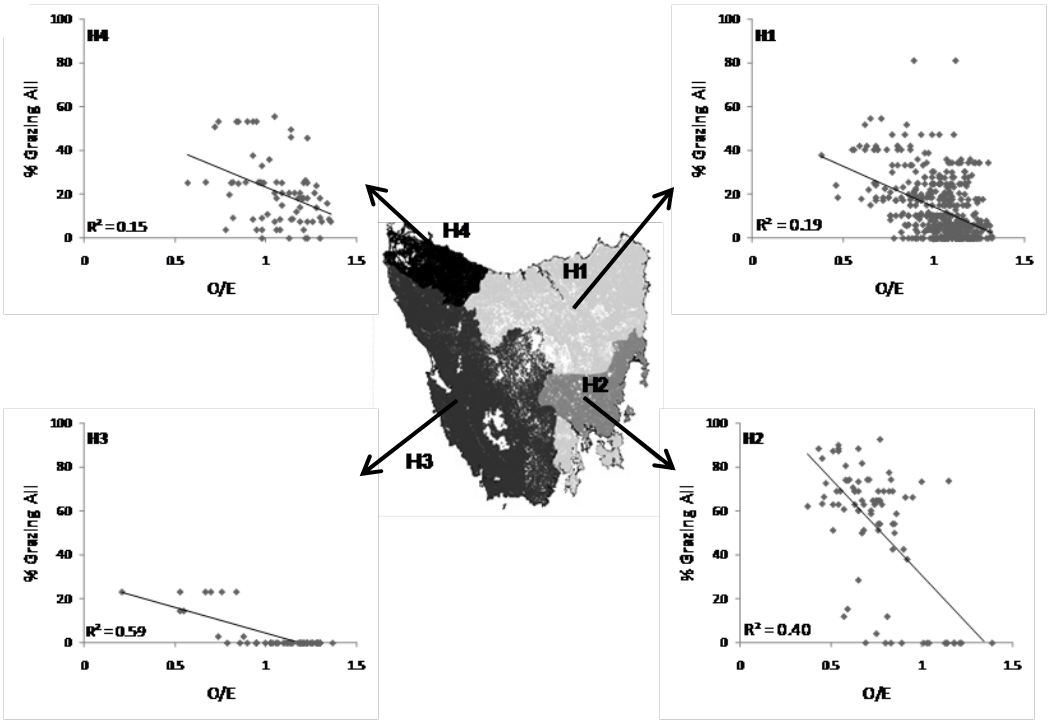
Results 3 Generality

Macroinvertebrate composition = F[% grazing land]

- 45% of variance explair
- Same relationship:
  - for residuals after natural drivers
    - across range of contexts e.g. hydrological region
- Limited influence of riparian veg condition



Results 4 Riparian Influence

Macroinvertebrate composition ≠ F[Riparian Condition]

- 45% of variance explained
- Same relationship:
  - for residuals after influence of natural drivers removed
  - across range of contexts e.g. hydrological region
- Limited influence of riparian veg condition

% variance explained

Riparian Vegetation Condition Score	O/E	%EPT	Total Richness	EPT richness
Site	6	4	3	7
Reach	5	3	3	7
Catchment	5	3	3	7

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Results 5 - Thresholds

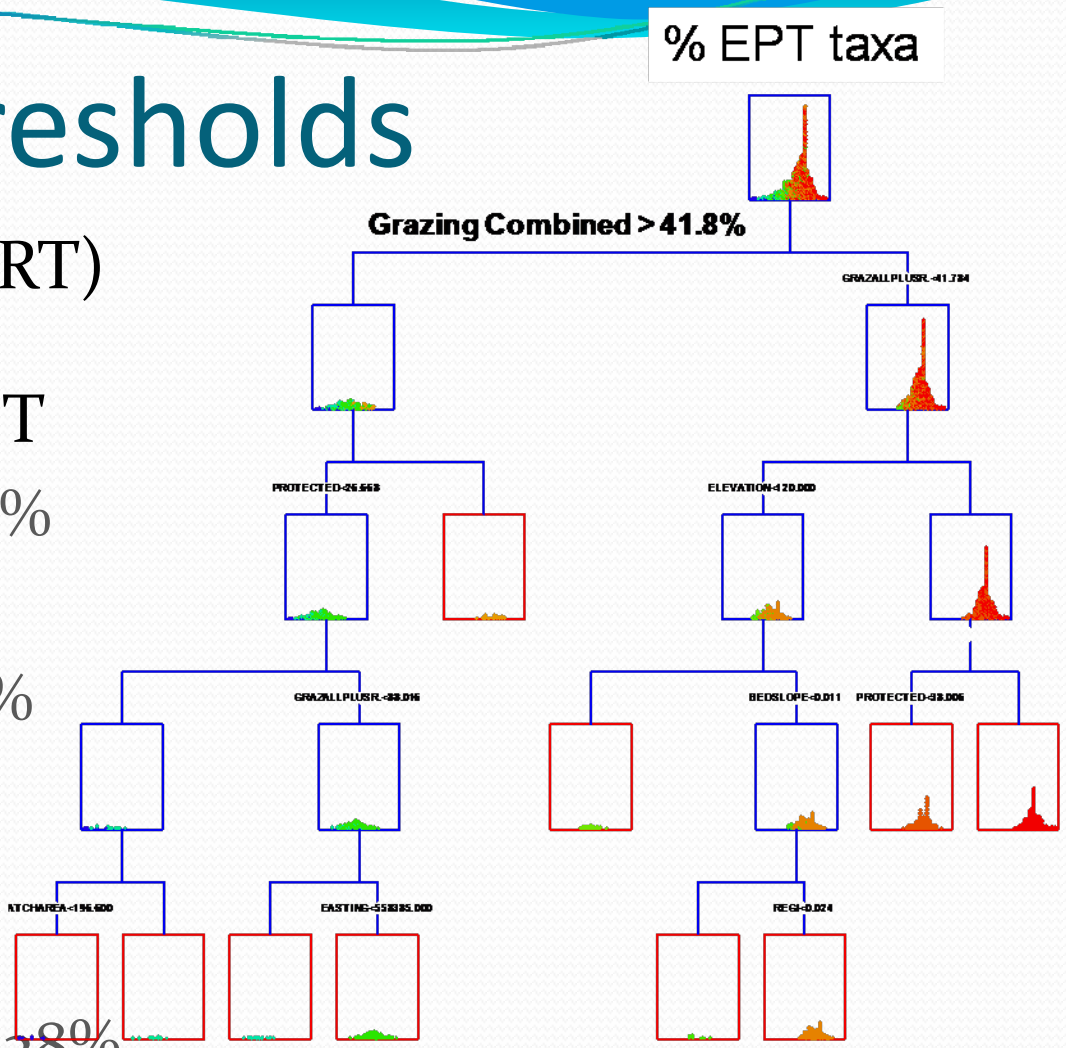
Regression tree analysis (CART)

> 42% grazing: Low-Mod EPT

- Mod EPT: Protection > 27%
- Low EPT: Grazing < 88%
- V Low EPT: Grazing > 88%

< 42% grazing: High EPT

- V High EPT: Protection > 38%.



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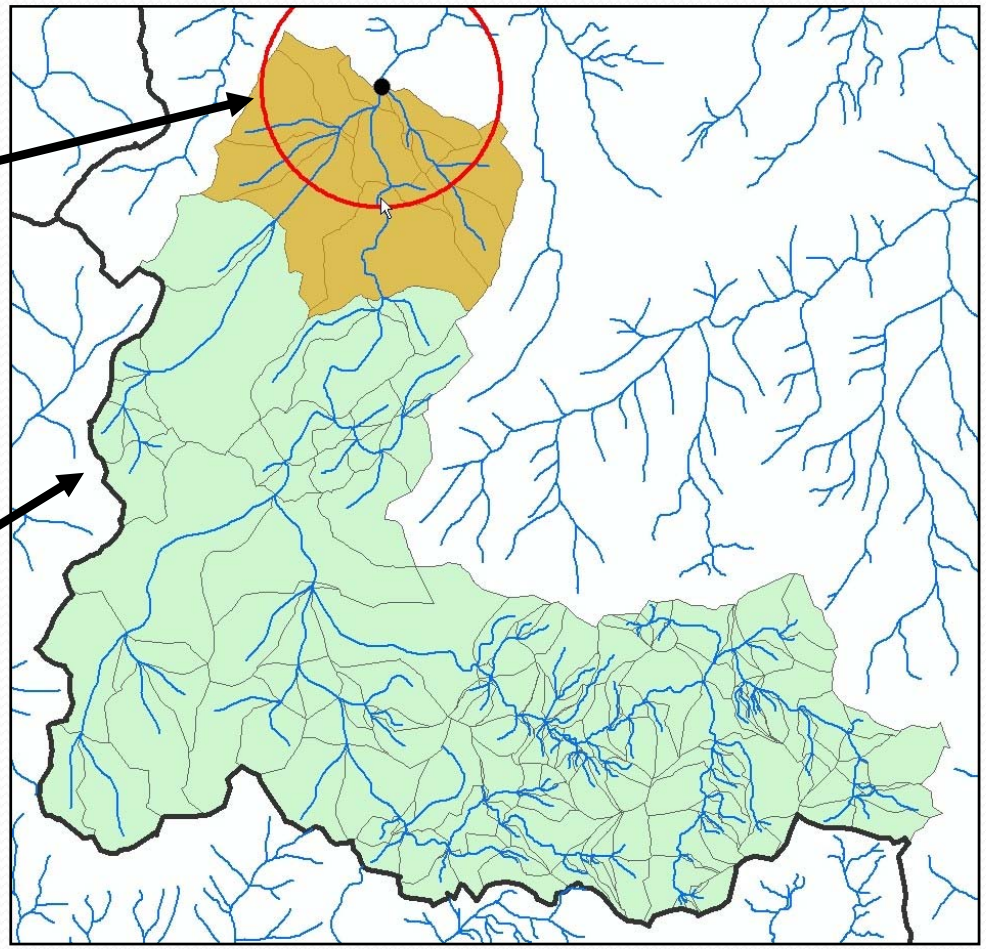
Scale: Local vs whole-catchment

Local catchment

vs

Entire sub-catchment



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Results 6: Scale

Sub-catchment influence >> local influence

on macroinvertebrate measures:

Grazing :

	% variance	
	EPT	OE
Catchment	35	14
Local	5	1

Protected :

	% variance	
	EPT	OE
Catchment	37	25
Local	12	3

Land use ⇨ Nutrients ⇨ River Health

Approach 2 - Gradient surveys :

- Historical 'experiment': ***Correlate*** existing measures of ecosystem state & function to the landuse, nutrient regime & local drivers.

- Explore mechanisms: Measure & model mechanistic links between drivers and response.

  Best OZ example: *Bunn, Davies, Fellows et al*

  SE Qld Regional Water Quality Management Strategy.

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Gradient study

1. Select sites across :
    1. Range of land use and management
    2. Nutrient loads
    3. Multiple catchments
2. Measure ecological structure and processes
   (e.g. bugs, algae, P/R, nutrient limitation)
4. Relate responses to drivers:
   Correlation, multivariate analyses, linear modelling
5. Evaluate mechanisms and thresholds

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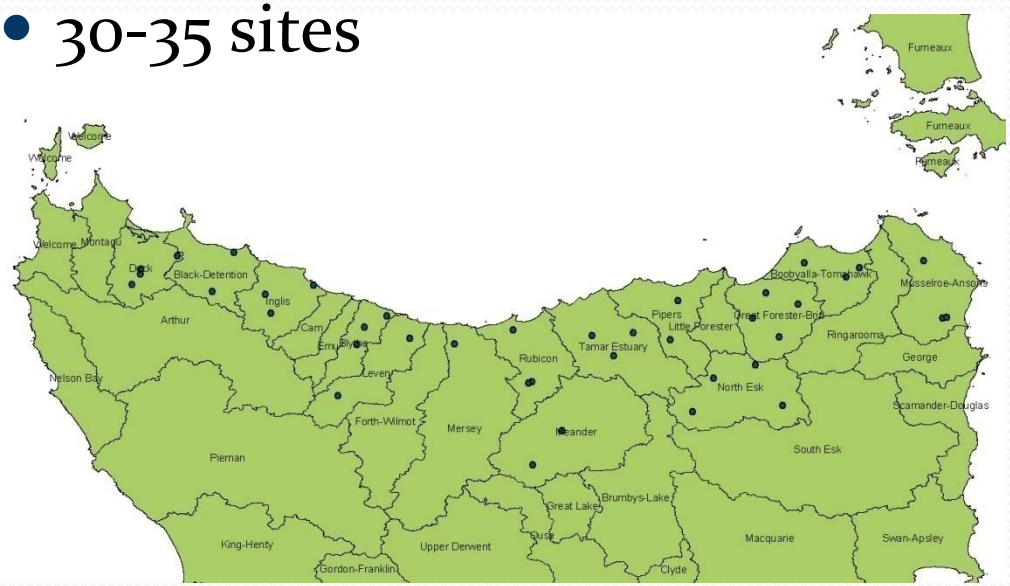
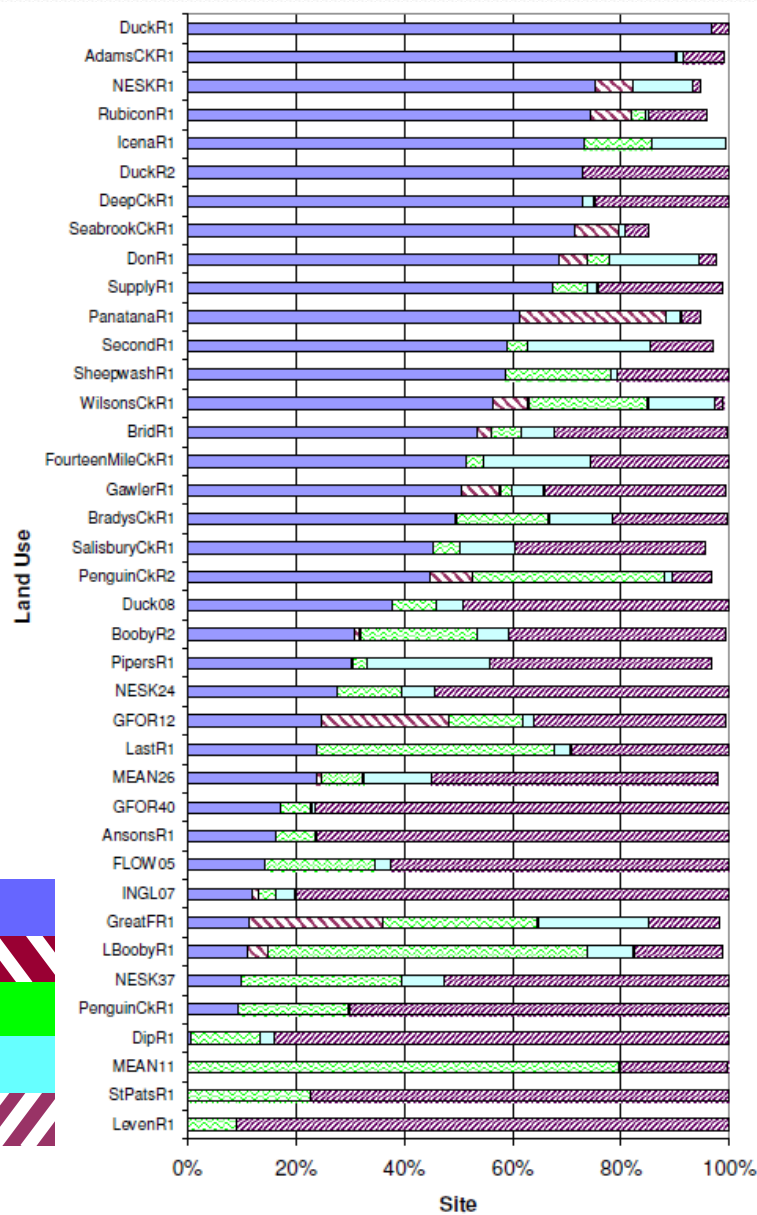
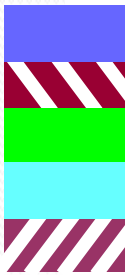
Agricultural gradient

- 30-35 sites





Grazing
Cropping
Minimal Use
Remnant veg
Forestry



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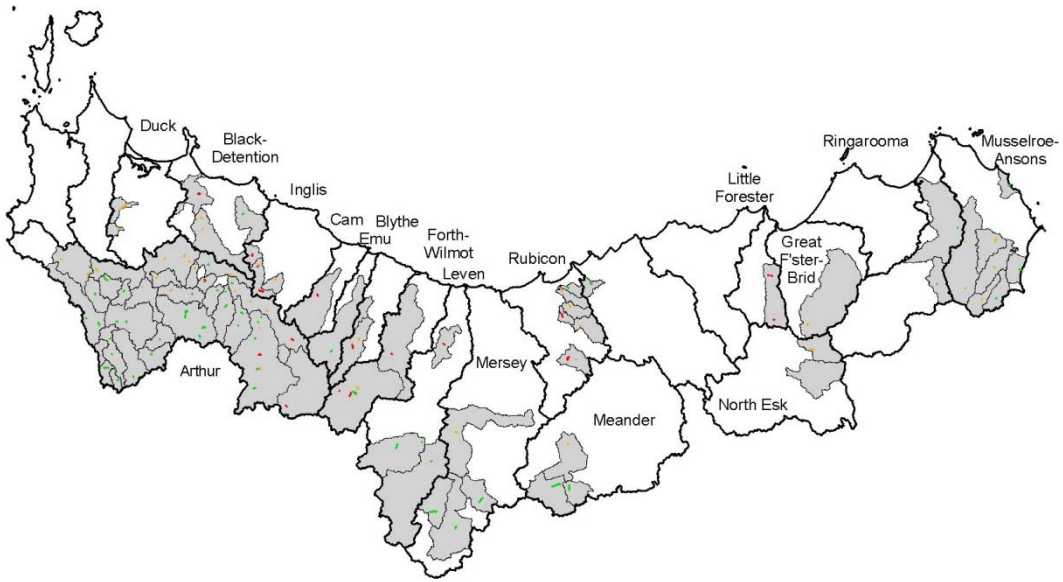
Forestry gradient (CRC for Forestry, FPA)

- 30-35 sites

Propns of catchment under:

- Plantation
- Clearfell, Burn & Sow
- Partial logging



Age of operations :

- Plantation (establishment)
- CBS (logging)
- Partial logging (logging)

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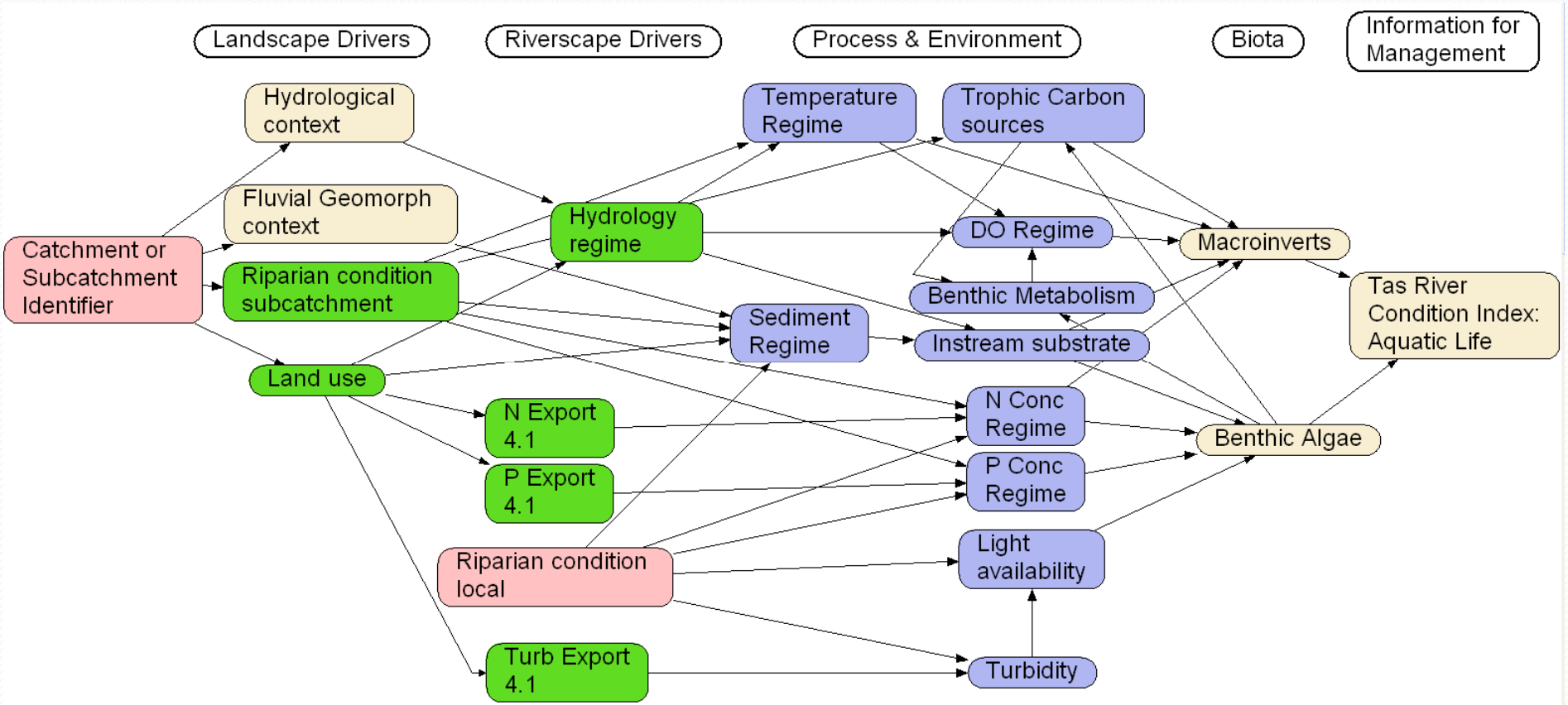
Integration: Bayesian Belief Network



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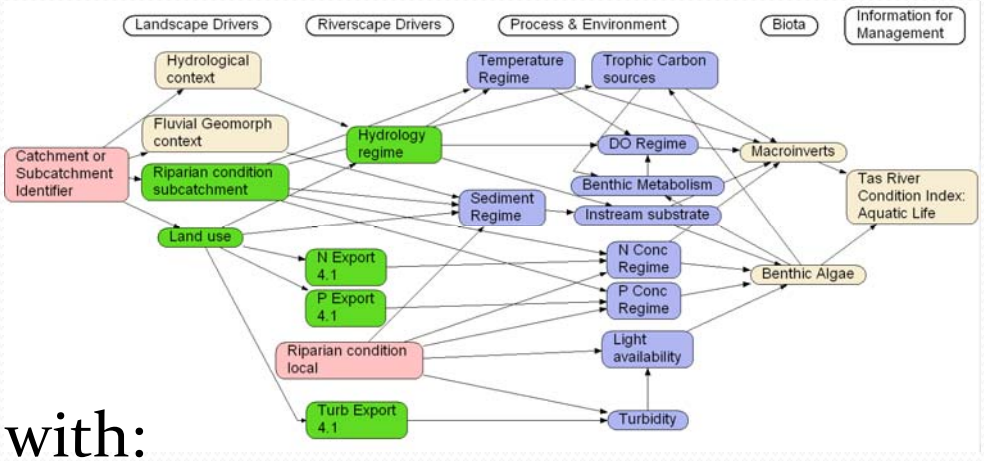
Bayesian Belief Network



Parameterise with:

- data from field gradients, GIS and models
- relationships from review of other studies & LL projects, expert opinion

Test on real world scenarios

Document level of uncertainty

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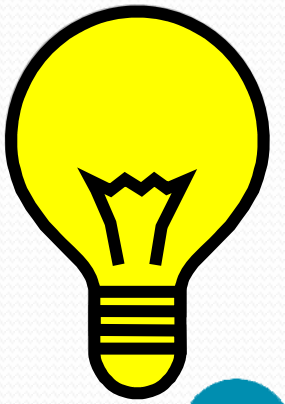
Let's monitor 'river health' !

1. Get some numbers on Bugs, Fish, Algae etc
2. Compare them to 'reference'
3. Add 'em all up and divide by 5
4. Get a score!
5. What now?



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Outcomes

- How and why river health ‘scores’ relate to land use and nutrients
- Questions re-drivers e.g.

  “When do nutrients drive river ecological health measures?”
- Scenario outputs from BBN’s to decision support
- Ecologically based regional nutrient water quality standards (ANZECC step III)

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LINKING LAND AND WATER MANAGEMENT TO RESOURCE CONDITION TARGETS

Australian Government

Department of the Environment and Water Resources

A partnership between North Central, North East & Goulburn Broken CMAs, NRM North, South & Cradle Coast, University of Tasmania, Australian National University, RMIT University, the Tasmanian Department of Primary Industries & Water, CSIRO, Forestry Tasmania and the Victorian Department of Sustainability & Environment.