

Australia's National River Health Program Causal Criteria for determining ecological responses to management intervention

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Part 1 The 4 R's of Biomonitoring



Water Background in Australia

- Pressure to protection ecological values bioassessment
- Development began 1993 as a research tool
- NRHP and <u>Aus</u>tralian <u>River Assessment System</u> (AusRivAS) development based on RIVPACS
- National program managed by DEWH, applied by state/territory agencies
- Comparable results & widely available many users
- Predict the aquatic macroinvertebrate fauna expected to occur at a site in the absence of environmental stress
- Currently supports three analyses and reporting;
 - Macroinvertebrate Predictive Modelling Software;
 - Physical and Chemical Reporting Software; and
 - Mapping and Reference Site Screening Module.

eWater AUSRIVAS - <u>Aus</u>tralian <u>River</u> Assessment <u>System</u>



- Nationally standardized system
- Some regionalization for climatic ranges but standard outputs
- Easy to use and interpret outputs
- Central management and access
 control



AUSRIVAS- components

METHODS

- Standardized methods for site selection, habitats, season, taxonomy, sampling, data analysis, QA/QC, training & accreditation
- Developed as a happy alliance (mostly) between states, feds & researchers

SOFTWARE

- Internet based and managed with access to models password controlled
- Central management and control over access

MODELS

- 50 covering all of Australia small derived data sets final steps in analysis with client data
- Developed by, or in conjunction with, responsible state/territory agencies

National River Health Program





Field Methods





Lab Methods











Quality assurance/Quality Control

- Standardized methods with sampling and processing manuals ensure consistent sampling
- QA/QC methods for field & lab
- Training & accreditation also linked to contracts
- Centralized management with regional ownership



AUSRIVAS- advantages

- Standard method with nationally comparable methods and results
- Updates to software and models available immediately
- Utilitarian platform to run complex analyses
- Web site with troubleshooting and advice
- Wide range of registered users
- Manuals with video clips included
- Can be updated with new developments



"Selling AUSRIVAS"

- AUSRIVAS formally adopted as a national indicator for State of the Environment Reporting at Federal and State levels in 1997-8
- AUSRIVAS being incorporated into new National Water Quality Guidelines in 1998/9
- AUSRIVAS being progressively adopted into state licensing and catchment management legislation



Lessons learned

- National coordination with regional ownership
- Standardized methods field, lab, taxonomy
- Comparable outputs
- QA/QC necessary
- Training & accreditation
- Updating process & capacity



Part 2 Determining Cause & Effect

River managers need to determine what caused the damage



Decision-makers need evidence that proposed management intervention will cause environmental benefits





Obstacles to determining causation in rivers

 A paucity of data at the site of interest
 Natural variability undermines the capacity to reach a conclusion about a causal relationship

- There is no replication because of large scales
- Experiments are not always possible



New challenges for decision-makers

Expert opinion alone no longer acceptable



"I think you should be more explicit here in step two"



What decision makers and scientists need -

- An explicit way of organising and presenting causal evidence
- Logical, simple and transparent framework
- A consistent or standardised set of rules that can be automated
- A repeatable framework
- A framework that leads to a robust and informed conclusion
- Transparent, evidence based decision making



Historical examples of logicbased causal inferences

Postulates of Jakob Henle and Robert Koch (1870's)

- Smoking causes lung cancer (US Department of Health, Education & Welfare 1964)
- Formalisation of the use of correlative evidence (Hill 1965)



Multiple Lines and Levels of evidence (MLLE)

What is MLLE?

Logical way of organizing evidence to make a causal inference

What is a line of evidence?

An ecosystem attribute that is investigated in relation to a stressor e.g. tadpole abundance, macroinvertebrate species richness, macrophyte biomass, number of fish lesions

What is a level of evidence?

A level of evidence is the value of one of a number of criteria used to determine the case for inferring that a given human activity causes a given ecological change





Making a causal inference using our MLLE approach





Number of LOEs from local data



Developing our MLLE approach

We can find no practical, generalizable examples of MLLE using the literature and local data in an explicit and objective way for environmental assessment

Our approach:

Provides an explicit framework

Comparability and relevant to the environmental question

Weighting of inferential power of a study based on: study design, no. control & no of impact locations

Environmentally relevant subset of Hill's causal criteria

Developed software package to aid study evaluation



The causal criteria

| Causal criterion | Description |
|---|---|
| Plausibility | Mechanism that could explain the relationship |
| Response | Evidence of the response following the agent |
| Dose response relationship with agent | Evidence of a dose response relationship between the agent & response |
| Consistency of association | Expected response ALWAYS occurs in the presence of the agent |





Transparent approach

- Clear documentation & justification for each step
- Sources of evidence stated
- Transparency in evidence used
- Transparency in weighting of evidence
- Transparency in combining evidence
- Repeatable verdict



Steps 1 & 2 – Question/activity & location

| M MLLE | | | |
|---|---|--|---|
| File Settings | | | |
| STEP 1 (a) : Human | Activity STEP 1 (b) : MLLE Question | | |
| Did a change in er to 2004 result in a | vironmental flow releases (reduction in base-flow) to the Cotter Riv deterioration of the aquatic ecosystem in the short term (< 2 years)? | ver below Bendora Dam from July 2003 ? | |
| STEP 2 : The location | | | |
| STEP 3 : Conceptual model | | | |
| STEP 4 : Lines of evidence In Step 1a an | d 1b document th <u>e nature of the human activity</u> | y and | |
| STEP 5 : Literature review draft your ML the MLLE fram | | | × |
| STEP 6 : Revise model box, then click will have many question but b | File Settings ask 1b: Draft your the "save" button yopportunities dur e aware that a ver | STEP 2 : Characteristics of the investigation location Cotter River is an upland river (700-900m) in SE Australia with high aseasonal rainfall (1000mm), and a steep vegetated catchment. The river has a steep gradient and substrate is predominantly cobble. It has a constrained channel with a good | - |
| STEP 7 : Weight the evidence MLLE approact STEP 8 : The verdict | STEP 1 : The human activity | deal of bedrock outcropping. The impounded part of the catchment is a national park and has native vegetation. Below the water supply impoundments land-uses are softwood forestry and native vegetation. Human access to the impounded part of the catchment is restricted and so the principal potential impact is river regulation. | |
| | STEP 3 : Conceptual model | | |
| | STEP 4 : Lines of evidence | | |
| | STEP 5 : Literature review | Document the characteristics of the investigation location. In what context will the MLLE question be asked? | |
| | STEP 6 : Revise model | Instructions Task 2: Describe the investigation location in the above text box, then click the "save" button and move to Step 3. | |
| | STEP 8 : The verdict | More information: | |

3 Conceptual models





eWater 4 & 5 LoE & literature review

| S MLLE | | | |
|---|---|--|--|
| File Settings | | | |
| STEP 4 : Lines of Evid | | | |
| STEP 1 : The human activity | | | |
| STEP 2 : The location | | | |
| Add Line of Eviden | Select the line | of Evidence you want to remove and click ine of Evidence' button | |
| STEP 4 : Lines of evidence | Add Line of Evidence Rem | nove Line of Evidence | |
| STEP 5 : Literature review Decide on the | relevant lines of File Settings | | <u> </u> |
| investigation, t | ask 4: Documen hen click the "Ac stion; it needs to | P 5 (a) : Search Strategy STEP 5 (b) : Citation detai | ils STEP 5 (c) : Lines of evidence |
| STEP 7 : Weight the evidence "quantifiable" | | | erature search and review. udies judged to be relevant to the investigation |
| STEP 8 : The verdict previous steps | should have pro | structions Task 5a. Document your LLE question, then click "Save all" and ore information: | literature search strategy for your current di move to the Step 5b tab. |
| | STEP 3 : Conceptual model | | <u>×</u> |
| | | eywords nter keywords (one per line) | Databases Enter databases (one per line) |
| | R | educed flow ow + macroinvertebrates low flow effects | Web of Science Current contents CSS |
| | STEP 6 : Revise model | Comments | |
| | | nter any comments about your search | Clear All |
| | STEP 7 : Weight the evidence | | Undo All |
| | STEP 8 : The verdict | | Save All |

5 – search strategy, citations, LoEs, check, LoE & agent, weighting, relevance

| MLLE | | | × |
|------------------------------|--|---|---|
| File Settings | | | |
| | | Citation details STEP 5 (c) : Lines of evidence | 1 |
| STEP 1 : The human activity | Study weight ID | e of evidence and agent STEP 5c (ii) : Weighting STEP 5c (iii) : Relevance Establish the relevance of the study | |
| STEP 2 : The location | Comparable* | Y Is the study comparable or relevant to the investigation? | |
| | 1 | Detail why the study is or is not comparable. | |
| STEP 3 : Conceptual model | Explain Comparability* | Comparable stressor (reduced flow because water diverted for water supplies) and if macroinvertebrate communities are considered (not the specific taxa) it is reasonable to assume that they would both be represented by taxa that have | |
| STEP 4 : Lines of evidence | | Did the study undertake statistical analysis providing significant p-values? | |
| STEP 5 : Literature review | Save P-value reported and significant?* | Y If there is no p-value reported, were the effects obvious, e.g. mass extinctions? | |
| | Comparable Pa | | |
| STEP 6 : Revise model | Undo App Agen | Select the agent and stressor t [^] Reduction in low flow or base flow ▼ | |
| STEP 7 : Weight the evidence | Cancel App LOE | Tracroinvertebrates | |
| | * Required Field | | |
| STEP 8 : The verdict | ^ Required Field if enabled | I of 12 >>> | |



6 & 7 Revise model, weight evidence

| MLLE | | | | | | |
|------------------------------|--|--|--|---|---------------------------|----------|
| File Settings | | | | | | |
| | Revise Model | | | | | |
| | | ine conceptual model | | | | |
| STEP 1 : The human activity | Did the literature revie | ew identify additional lines | of evidence? | | | |
| | Do you need to revise? | Instructions | | | | |
| STEP 2 : The location | Instructions for Task 6. Has | You dont need to review the now go to step 7 | e conceptual model, and can | | | |
| STEP 3 : Conceptual model | identified other lines of evidence or plausible | | | | | |
| | C Yes | | | | | |
| STEP 4 : Lines of evidence | | | | | | |
| | Comments | MLLE | | | | |
| STEP 5 : Literature review | 1 | Settings | | | | <u> </u> |
| | | | | | | |
| STEP 6 : Revise model | | INTRODUCTION | STEP 7 (a) : Weightings STEP 7 (b) : Catalogue and weight the ev | idence | | 1 |
| STEP 7 : Weight the evidence | | STEP 1 : The human activity | Catalogue of weigh | ited evidence | | |
| | | | App Agent | App Line of evidence | Biological Response | |
| STEP 8 : The verdict | | STEP 2 : The location | Reduction in low flow or base flow | macroinvertebrates | High | Low |
| | | | Reduction in low flow or base flow | diatoms | Low | Low |
| | | STEP 3 : Conceptual model | Reduction in the frequency of flood events of a particular size | | Low | Low |
| | | STEP 3 : Conceptual model | Reduction in the frequency of flood events of a particular size | diatoms | Low | Low |
| | | STEP 4 : Lines of evidence | | | | |
| | | STEP 5 : Literature review | | | | |
| | | STEP 6 : Revise model | Catalogue and V | Weight the Evidence | | • |
| | | | | | rom the Application Stree | 1022 |
| | | STEP 7 : Weight the evidence | Clear Output Table Select one or m tab, and click '0 | nore Application Stressors fi Catalogue and Weight the I | Evidence' to show outco | omes. |
| | 6 | STEP 8 : The verdict | Export Outputs | Catalogue and Weight th | e Evidence | |
| | | | La de la della d | | | |



8 The verdict

| ngs | | |
|----------------------|--|---|
| | STEP 8 (a) : Accept or reject the hypothesis STEP 8 (b) : Compile Multiple Lines and Levels of Evic | lence Report |
| : The human activity | What is the verdict? | |
| : The location | Accept or reject the hypothesis? | |
| | Instructions for Step 8 Data from the literature review and local data have h | een assembled into |
| : Conceptual model | Instructions for Step 8. Data from the literature review, and local data, have b multiple lines and levels of evidence catalogue. the 'Preview Report" button to rev evidence support your hypothesis? Use the results to accept or reject the hypothe conclusion in the text box below, then click on the 'save' button. to Step 8b and M your Multiple Lines and Levels of Evidence Report. | iew the results.the sis. Document your |
| : Lines of evidence | multiple lines and levels of evidence catalogue. the 'Preview Report" button to rev evidence support your hypothesis? Use the results to accept or reject the hypothe conclusion in the text box below, then click on the 'save' button. to Step 8b and M | iew the results.the sis. Document your |
| | multiple lines and levels of evidence catalogue. the 'Preview Report" button to reverse evidence support your hypothesis? Use the results to accept or reject the hypothesic conclusion in the text box below, then click on the 'save' button. to Step 8b and M your Multiple Lines and Levels of Evidence Report. | iew the results.the sis. Document your |
| : Lines of evidence | multiple lines and levels of evidence catalogue. the 'Preview Report" button to reverse evidence support your hypothesis? Use the results to accept or reject the hypothesic conclusion in the text box below, then click on the 'save' button. to Step 8b and M your Multiple Lines and Levels of Evidence Report. | iew the results.the sis. Document your LLE will now compile |
| : Lines of evidence | multiple lines and levels of evidence catalogue. the 'Preview Report" button to reverse vidence support your hypothesis? Use the results to accept or reject the hypothesic conclusion in the text box below, then click on the 'save' button. to Step 8b and M your Multiple Lines and Levels of Evidence Report. Preview Report Click 'Preview Report' to review the resluts Conclusion Preview Report to review the resluts Evidence supported the hypothesis that a change in environmental flow releases to the | iew the results.the sis. Document your LLE will now compile |
| : Lines of evidence | multiple lines and levels of evidence catalogue. the 'Preview Report" button to reverse vidence support your hypothesis? Use the results to accept or reject the hypothe conclusion in the text box below, then click on the 'save' button. to Step 8b and M your Multiple Lines and Levels of Evidence Report. Preview Report Click 'Preview Report' to review the resluts Conclusion | iew the results.the sis. Document your LLE will now compile iew Report |



Outputs

- All steps documented
 - Question
 - Location
 - Model
 - Thorough literature search in a framework
 - Quality of studies weighted
 - Combination of evidence
- Verdict transparent



Outcomes

- An objective method to include the literature in assessments
- Strong local data less need for added evidence from the literature
- Weak local data more need for added evidence from the literature