Evidence based environmental management:

What can medicine and public health tell us?

Presented by:
Ioan Fazey and Janet Salisbury
24 June 2002

National Institute for the Environment, Australian National University

ISBN 0-646-42024-0
Title: Evidence Based Environmental Management: What Can Medicine and Public Health Tell Us?
Author/Contributor: Fazzy, Iaon; Salisbury, Janet
Date of Publication:.01 Nov 2002 Price:
Format:.WEB Size:.297x210 No. of Pages: 29
Publisher: Australian National University - National Institute for Environment

Produced by Biotext Pty Ltd, Canberra

File: EBEM summary-06(Oct02)

Contents

Presenters

Mr Ioan Fazey

Postgraduate student at the Centre for Resource and Environmental Studies, ANU. Thesis involves the use of the systematic review process to evaluate theoretical tools in conservation biology. Ioan has considerable experience working in biological conservation in the UK and abroad, in both an advisory and practical capacity. His work has led to a strong interest in the interface between theoretical contributions to, and practical 'on the ground' management, in biological conservation.

Dr Janet Salisbury

Director, Biotext (a science information consultancy based in Canberra). Formerly in cancer research (1973–1989) but since 1990 has researched, written and edited numerous reports, proceedings guidelines and other publications on topics relating to health, agriculture and environmental science. Involvement with the NHMRC Health Advisory Committee over many years has led to a sound understanding of the methods and processes involved in evidence-based medicine. This and work in other areas has led to intense interest in the evidence basis for science-based policy decisions and in the tools available for assessing and ranking scientific evidence.

Participants

Ioan Fazey	Centre for Resource and Environmental Studies (CRES)
Janet Salisbury	Biotext
Natalie Stuckings	Coordinator, NIE, ANU
Bob Douglas	National Centre for Epidemiology and Public Health, ANU (also a member of the Cochrane Collaboration respiratory diseases group)
John Maindonald	Centre for Bio-information Science, ANU
Jurgen Bauhus	School of Resources, Environment and Society (SRES), ANU
Anne Kern	Ecological Consultant, Dubbo, NSW
Jean Chesson	Bureau of Rural Sciences (BRS)
Simon Barry	BRS
David Dumaresq	School of Resources, Environment and Society, ANU
Barry Newell	Faculty of Engineering and Information Technology (FEIT), ANU
Joern Fischer	CRES
Denis Saunders	CSIRO Sustainable Ecosystems
Joe Walker	CSIRO Land and Water

Program

09.30 Welcome

09.45 Janet Salisbury: The evidence-based approach in medicine

10.05 Ioan Fazey: Evidence-based environmental management?

10.30 General discussion

10.45 Coffee

*Session 1: What are the similarities in the evidence that is available between medicine/public health and environmental management?

Part A: Collecting and using the evidence. Brief group discussion

Part B: Comparing the levels of evidence that are available and measuring the outcomes. 3 break-out groups and reporting back

12.45 Lunch

*Session 2: Identifying situations where the approach will be most useful

Part A: Identifying the situations where the approach might be useful. 3 break-out groups and reporting back

Part B: What do we need to set up such a process? (Time permitting) Brief presentation and discussion

15.00 Coffee

15.30 General discussion and summary

*** Suggested discussion group topics only (to be finalised on the day in consultation with participants)**

Introduction and aims

Ioan Fazey
Centre for Resource and Environmental Studies
Australian National University

Ioan welcomed participants and explained that the central theme of the workshop was that environmental managers could learn much from the approach to systematically reviewing and critically appraising scientific literature that has been developed in medicine and public health over the last 30 years. This method, referred to as 'evidence-based medicine' (EBM), has turned clinical medicine around from being based largely on ad hoc literature reviews, trial and error and expert opinion, to being firmly based on the best quality evidence available internationally.

The idea that the model of EBM can be applied to environmental management has now originated in at least three 'nodes' where people either work or are linked in some way across scientific disciplines. Janet Salisbury made this connection when her consultancy work in science information took her between writing about clinical and public health issues for the NHMRC, on the one hand, and about environmental science and resource management issues on the other. She noticed that whereas in the medical and health areas there is a systematic approach to gathering, ranking and critically appraising evidence (eg for the efficacy of a clinical procedure or lifestyle change), there is no such rigorous approach to evidence about environmental interventions. Instead, many mitigation and management decisions, even expensive ones, are taken with relative ignorance as to whether they are likely to be successful.

John Maindonald, a statistician who has worked both in the agriculture/environmental areas and in epidemiology and biostatistics, made the same connections while working at the Statistical Consulting Unit at the ANU. Meanwhile, Pullin and Knight (2001) — a cross-disciplinary collaboration between an environmental scientist and a health practitioner in the UK — published a paper in *Conservation Biology* that also suggested taking a similar approach in conservation biology to that used in evidence-based medicine.

Ioan and Janet first discussed the idea of evidence-based environmental management in mid-2001. In December 2001, Janet spoke about EBM and its possible applicability to environmental management at an informal meeting of the CRES ecological discussion group. It was agreed that whilst there were a number of issues that need to be addressed, the concept of evidence-based environmental management has considerable potential.

Overall aims

The objective of the workshop was to take the issue further and to determine what aspects need to be considered if such an approach were to be truly successful in developing an 'evidence-based environmental management' (EBEM).

The aims of the workshop were as follows:

- To increase awareness of a move towards an evidence-based approach to environmental management based on the approach used in medicine ('evidence-based medicine').

- To facilitate general discussion about this idea.

- To begin to identify the circumstances where a structured evidence-based approach might be useful for environmental management by drawing parallels with its use in medicine and public health.

The focus of the workshop was on environmental management, rather than on the basic science of ecology and landscape. In this context, environmental managers are comparable with doctors, offering 'treatments' for environmental problems in the form of interventions (eg moving species, maintaining wildlife corridors, planting trees). The challenge is to be sure that such interventions are based on evidence that shows that they work (or at least that they do more good than harm).

Evidence-based medicine: the basics

Janet Salisbury
Biotext, Canberra

In 1972, British epidemiologist Archie Cochrane drew attention to the collective ignorance of health professionals about the effects of health care (Cochrane 1972). He recognised that many treatment-related decisions were not based on reliable reviews of the available evidence but on an ad hoc selection of information from the vast scientific literature, expert opinion and trial and error. In an influential book published in 1979 (Cochrane 1979), Cochrane made the following inditement of his profession:

> '*It is surely a great criticism of our profession that we have not organised a critical summary, by speciality or subspeciality, adapted periodically, of all relevant randomised controlled trials.'*

Cochrane's ideas were gradually taken up during the 1980s, the most notable success being the first systematic reviews of randomised controlled trials (RCTs) of care during pregnancy and childbirth that were carried out by Iain Chalmers. These early reviews showed anomalies in established practice and the benefits of the approach started to become apparent. In 1992, the first 'Cochrane Centre' was established in Oxford, UK and in 1993 the 'Cochrane Collaboration' was cofounded by 77 researchers from 11 countries at a New York Academy of Sciences meeting. Today, the Cochrane Collaboration is an international organisation. It prepares and maintains systematic reviews of RCTs and publishes then in regularly updated databases with abstracts available free on the internet (www.cochrane.org).

The Cochrane Collaboration

The Cochrane Collaboration is founded on 10 principles:

- collaboration
- building on enthusiasm of individuals
- avoiding duplication
- minimising bias
- keeping up to date
- ensuring relevance
- ensuring access
- continually improving the quality of its work
- continuity
- enabling wide participation.

Central to these principles are the notions of independence and altruism — independence from commercial interests and other influences that may bias the honest appraisal of evidence, and altruism shown through the voluntary participation of members of the collaboration in order to improve medical practice.

The Cochrane Collaboration is based around about 40 international collaborative review groups worldwide, covering most important areas of health care. These groups collect and critically review all the clinical trial evidence related to their area. Other

groups of experts — the Cochrane methods groups — research methods, set protocols and run training. Cochrane centres has been established in many countries, usually funded through government grants, charitable donations and other noncommercial funding sources, and coordinate and support the work of the review groups and methods groups. The Australasian Cochrane Centre is based at the Monash Institute of Health Services Research, Melbourne and is funded by a grant from the Commonwealth Department of Health and Ageing.

Central to this approach is the systematic review. This process brings together all the available clinical trial evidence on a topic (including unpublished and negative evidence wherever possible) and includes a critical analysis of the trials and, where appropriate, a statistical determination of the effect under consideration; for example whether treatment A is better than treatment B (or no treatment).

Clinical practice guidelines

Not all health problems can be understood in terms of RCTs and for many issues, other types of evidence needs to be considered (eg comparative and observational studies such as cohort studies, case-control and case-series studies). In the mid-1990s, several organisations around the world, including the National Health and Medical Research Council in Australia, developed ranking systems for the different types of evidence, so that in systematic reviews the best evidence carried more weight than less certain evidence (see Appendix 1). This approach has been used to develop clinical practice guidelines (CPGs) in many key health areas (eg breast cancer, stroke, preterm birth, colorectal cancer).

Method

Overall, the method used in EBM by the Cochrane Collaboration and in the preparation of CPGs and other health advisory information is as follows:

- formulate a question (eg does treatment A prevent disease B in children);
- search literature and find all the available studies relevant to the question;
- assess and rank key studies against set criteria (critical appraisal);
- summarise and synthesise results; and
- communicate with practitioners in a standard framework (eg Cochrane review, clinical practice guidelines or other health advisory information).

Effective searching of the literature requires a readily accessible online database. In medicine there is such a database called Medline, which is freely available on the internet. Some means of searching for unpublished studies is also needed to overcome publication bias. In medicine there has been a major push to get all clinical trials registered in a clinical trials registry when they start.

Public health issues

Issues such as whether passive smoking, living under powerlines, carrying a mobile phone or drinking water with added fluoride cause cancer, cause a lot of anxiety in the

community. Unfortunately, it is difficult to do RCTs of these exposures and the evidence available is usually from studies ranked at a lower level (see Appendix 1). Therefore, for an evidence-based approach to work for such public health issues, a more broad-based approach is needed. Like the Cochrane Collaboration, such an approach needs to be based on systematic literature review and critical appraisal. Such an approach has not been fully developed for public health issues to date. However, it is clear that in the absence of any randomised studies, more attention is needed to other aspects of the evidence (quality, size of effect, etc). Other important factors are the volume of evidence, the existence of a plausible mechanism and studies with laboratory animals that show the same effect. The 'Bradford Hill criteria' are sometimes applied (see Attachment 2) but this has not been done very well so far.

If an evidence-based approach were adopted in environmental management the same types of issues would apply because randomised trials of environmental interventions are very rare.

Advantages of EBM

- All available evidence is assessed.
- Assessment is independent and rigorous.
- Gaps in evidence are identified, promoting further targeted research.
- Researchers aim for higher levels and better quality evidence.
- Combining studies that have attempted to answer the same question improves the ability to detect modest but important effects (increased power).
- Similar effects across a variety of settings and designs show robustness and transferability of the results. If the studies are inconsistent between settings, however, the sources of variation can be examined.

Problems with EBM

- Publication bias is difficult to eliminate (negative results are not published).
- There is a wide variation in study standards and not everyone has expertise to identify flaws.
- Improved power can allow the detection of small biases as well as small effects.
- Uptake by practitioners has been slow.
- Methods are not equally well suited to all areas of human health.
- Where there are only having lower levels of evidence (eg observational studies), this may be used by vested interests as a reason for denying effect (eg smoking and cancer).

Conclusions

In summary, medical decisions today are more likely to be based on evaluation of evidence that has been systematically collated, reviewed and ranked. This approach has led to a better understanding of benefits and harms, and to improved outcomes. In

addition, researchers and practitioners have developed a common purpose and ‘language’. This has helped clinicians, consumers and policy makers to communicate better about issues and to make more appropriate decisions.

Evidence-based environmental management

Ioan Fazey
Centre for Resource and Environmental Studies
Australian National University

Introduction

Returning to the 1979 quote from Archie Cochrane, Ioan pointed out that the same could be said today of environmental management, viz:

'It is surely a great criticism of our profession that we have not organised a critical summary, by speciality or subspeciality, adapted periodically, of all relevant studies of environmental management.'

The main aims and questions for this workshop were therefore to assess the following questions:

- Can the evidence-based approach used in medicine and public health be applied to environmental management (EM)?
- What different scenarios are there in EM where this approach may be applicable and what types of evidence are available?
- What are the advantages and disadvantages of adopting this type of approach?

This is an important and timely discussion because:

- in many areas of environmental management there is sufficient information to begin a new tier of knowledge, but it is currently poorly organised;
- there is a need to review all the available evidence somehow;
- there is a lot of potential evidence that could be collected but currently is not; and
- mitigation actions are often carried out simply on the basis that they have been done before or they seem like a good idea rather than being based on actual evidence.

Comparison of evidence in medicine and public health and EM

Medical evidence is much more accessible than environmental evidence as there are more searchable databases such as Medline (published studies) and the clinical trials register (unpublished studies). It is therefore difficult to assess how much evidence there is in one field relative to the other. However, there appears to be less evidence available for EM than for medicine and public health. This may be due to less funding for environmental research, difficulties in setting up meaningful studies or other factors.

In medicine, in particular, there is a substantial proportion of evidence at the highest levels (levels I and II; see Appendix 1), whereas in EM there is very little evidence at these levels and the best evidence often comes from 'natural' experiments (eg before and after studies) rather than from randomised trials (see Figure 1).

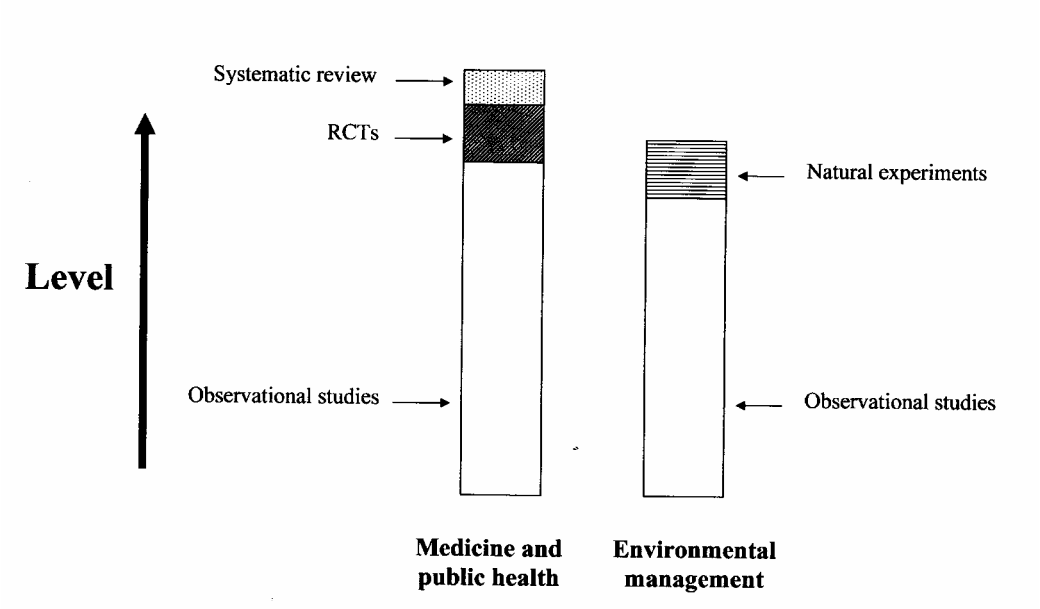

Figure 1 Comparison of the types of evidence available for medicine and public health versus environmental management (illustrative only; not based on actual proportions)

If the actual proportion of studies at the different levels is considered, a fairly large proportion of the available medical evidence is at the higher levels, whereas the vast majority of EM evidence is observational. As has already been mentioned for EBM, when only lower levels of evidence are available, other aspects ('dimensions') of the evidence become more important (eg quality, volume of data, size of effect; see Appendix 1). When defining questions, designing experiments and analysing results, EM researchers may therefore need to consider these other aspects of the evidence within a defined protocol.

Overall, whatever the obstacles, the evidence for EM has to be reviewed somehow and the advantage of an approach such as that adopted in medicine is that it provides a framework for the collection of better evidence as well as for the assessment of existing evidence.

Scenarios in environmental management

Ioan described four scenarios of environmental management. The scenarios illustrate the broad range of types of evidence that is available for EM and the types of problems that are addressed.

Scenario 1: Mitigation measures

Mitigation measures (interventions) are measures applied by environmental managers to manage the environmental impact of developments or natural events. For example:

- building wildlife tunnels under roads (eg for frogs);
- translocation of species away from a development (eg moving newts from one pond to another); and
- planting trees (eg to reduce salinity).

Such interventions, which are often applied in crisis situations, can be compared to medical treatments such as a drug treatment for high blood pressure or a surgical procedure for colon cancer. However, in most of cases, decisions to proceed with environmental interventions are based on anecdote, convention or trial and error rather than on evidence. Also, follow up studies of effectiveness are rarely done (or published).

For example, great crested newts are heavily protected under legislation in the UK. Therefore, environmental managers are required to implement management plans to 'protect' then. Because the scientific literature contains mainly low-level observational and anecdotal evidence about what works and how well, most managers use either conventional (but untested) methods or anecdotal evidence to support their actions. Because of the legislation, however, interventions involving newts are fairly common, providing frequent opportunities for collection and publication of higher level evidence (eg studies of the intervention at one site and a comparable (control) site with no intervention).

For such an intervention, it is relatively easy to identify the question to be answered (does the intervention work?) and the required outcomes (survival of the species concerned, or improvement in landscape problems such as salinity). EBEM is best suited to such cases where more experimental type approaches, such as natural experiments, are possible.

Scenario 2: Effect of development and landscape change on a single species

This scenario refers to the environmental impact of a proposed development or landscape change on a single species. A proposed development may be a road scheme, urban development or managed landscape change.

The considerations in this case may be similar to those for assessing disease aetiology (causation) and risk factors for human health (eg effect of diet on the risk of heart disease, or the risks associated with occupational exposure to chemicals). However, there is rarely good evidence available for the impact of a development on plant or animal species and this is further hindered by the need to understand the whole of the species population, the complexity of its interaction with the landscape and so on. Considering the large number of developments that occur, however, it should be possible to collect better evidence than is currently the case (eg by comparing the development area with a matched area with no development). In this case it may be relatively easy to define a question but harder to measure outcomes than for the mitigation measures (interventions) discussed in Scenario 1.

Scenario 3: Managing multiple species or communities

Both the effectiveness of mitigation measures (Scenario 1) and environmental impacts (Scenario 2) become much more complex when considered at the multiple species or community level. Examples are managing wetlands or the use of fire (mitigation measures), or understanding the effects of logging on a forest community (environmental impact). In these cases, it is even harder to identify and focus the questions to be asked and to measure outcomes. Experimental studies become more difficult, and may not always be the best way of understanding the underlying processes. This makes it much more difficult to review the evidence in a systematic way.

Scenario 4: Ecosystem management

Environmental management sometimes involves whole ecosystems over a large area. For example:

- management of dry land salinity in a regional context;
- management of the Murray-Darling Basin; and
- national park management.

In these cases, similar considerations apply to those outlined in Scenario 3. However, considerable evidence is already being collected, for example the Sustainable Rivers Audit of the Murray-Darling river system (which uses independent auditors, measures the health of rivers over time, uses a reporting framework with comparable information and disseminates its findings publicly). A more general framework of EBEM therefore needs to build on such existing databases of evidence.

Potential advantages and disadvantages of EBEM

Advantages

- Provides reviewing process of evidence.
- Facilitates increased data collection, monitoring, access to data.
- Helps us understand what we don't know.
- Provides institutional and practical working framework.
- Breaks some of the entrenched 'experientially' based approaches.
- Facilitates international collaboration and understanding across systems.

Disadvantages

- Will not work in all scenarios.
- Systematic review process is only as good as the evidence itself.
- Difficult to compare lower levels of evidence and review them.
- Difficult to measure some environmental management outcomes.
- Sets expectation that there is a 'right' answer.
- May create a funding bias towards more robust studies.

Conclusions

Although some EM scenarios are more suited to an evidence-based approach than others, all have some components that could benefit from a more rigorous approach to

the collection and assessment of evidence. Overall, two main areas can be identified where EBEM might be very helpful:

- To provide a framework for collecting better evidence (ie to increase the quality and quantity of evidence collected).
- To develop methods for systematically reviewing existing evidence.

However, a number of big questions remain about whether it is really possible to formulate questions that can be answered using an EBEM approach and, if so, whether it will ever be possible to collect and collate data into a form that can be systematically reviewed.

Discussion

Overall concept of EBEM (whole-group discussion)

After the two main presentations, there was a group discussion on the overall concept of EBEM. Some of the main points raised were as follows:

- Environmental evidence is already being reviewed and that there are many examples of reviews, databases etc.
- For environmental decisions, the role of science and evidence can be minor; very good evidence is often ignored by decision makers.
- It is difficult to find good reviews of evidence for issues such as dryland salinity (although it was pointed out that several such reviews do exist and are available on the internet).
- Environmental issues are much more complex than medical issues and the approach of gathering evidence from different areas may not be applicable.
- It may be better to tailor or target to needs of the particular area.
- Current approaches to evidence can work; when there is evidence (eg from an audit or collation of data), the landholders take notice.
- Whereas there is a relatively straightforward set of outcomes in medicine and public health, the outcomes for EM are harder to define and may be different for different groups (eg farmers, landcare groups, government).

Ioan Fazey replied that although there have been reviews there has not been an overall approach and many mitigation programs have been carried out without any review of the evidence for whether the proposed intervention actually works or not.

Bob Douglas commented that very similar discussions occurred at the start of the EBM movement. However, the Cochrane Collaboration has drastically changed the way medicine is practiced. 10 years ago there was lots of evidence but people were not doing proper systematic reviews. The Cochrane Collaboration today is a true international collaboration. There is still work to be done to improve the interface between evidence and practice, but the evidence base at least is in good shape. The existence of publicly accessible, consistently prepared, quality controlled reviews facilitates information transfer between researchers, government decision makers, practitioners and consumers.

Are there similarities in the evidence that is available between medicine/public health and EM?

Ioan Fazey introduced the first planned break-out discussion session and noted two main issues to be explored:

- possible outcomes of environmental management (1 group); and
- the types of evidence that are available for environmental management interventions and the implications of assessing evidence at the lower levels (2 groups)

However, the whole group indicated that they needed more time to consider the overall implications of the model presented and its applicability to EM.

The group therefore split into three smaller groups to discuss this issue.

Reports from groups:

Group 1 (Ioan Fazey)

The evidence that currently exists in EM isn't good enough.

A strong feature of the Cochrane Collaboration is the rigorous methods that underlie the systematic review process. Reviewers submit protocols to the editorial review board. If it is considered to be a good question/subject, then a protocol is written and the review is carried out.

Because of the complexity of EM, it is difficult to sort out what evidence is needed. Simple questions are not as simple as they first sound. Whilst it was agreed that this is also often the case in medicine, many of environmental management problems are not always as easily reduced to specific issues. The group agreed that we need to review evidence better than we are currently doing in order to determine what we know and what we don't know, and to identify gaps in knowledge and promote better studies to fill those gaps.

The issue is best described as evidence-based EM rather than 'environmental science' because it relates to the evidence behind management interventions rather than underlying principles.

Group 2 (Jean Chesson)

The group agreed that a collaborative system would be useful. Some environmental research organisations are already reviewing research (eg Intercol) but it would probably be best to set up as a new body.

Problems with getting going are that we currently lack an agenda and agreement on what would be considered to be good and bad outcomes. Also, because of complexity of systems (including adaptive responses), specific questions are difficult to identify.

Some questions may lend themselves better to international collaboration than others, which may only be of local relevance.

There may be a problem that the lack of very high level evidence would be cited by some people as a reason for no action (cf the issues of smoking and pubic health).

Group 3 (Joe Walker)

This group thought the idea was a good one in a broad sense and that it complements existing approaches in EM (such as adaptive management). However, there is a need to define a shared objective before we can move forward.

There also needs to be clear outcomes, implementation rules and compliance rules.

We need to consider:

- how evidence is currently collected and disseminated (turning knowledge into practice);
- what databases currently exist to provide details of evidence (eg such as the National Land and Water Audit, AUSLIG, NRIC, Waterwatch, regional environmental advisory committees, State monitoring programs);
- the role of scientific evidence in EM (science may only provide a small input into a multicriteria decision-making area);
- the types of questions to be asked/answered, the scale and the information framework; and
- existing international protocols for monitoring/evidence gathering (eg Montreal protocol for forests, USEPA data quality guidelines); similar protocols also exist within Australia, especially within the many EPAs.

Resolution of these issues are important in order to involve many people who are actually working in this area already, and to develop a framework that may take a different direction to the medical model that has been put forward.

General discussion

Environmental management

Evidence is currently collected and assessed but decisions are usually based on political considerations and not on scientific ones.

Even where there is evidence, there are huge difficulties in getting the science to environmental managers.

It is difficult to define an overall shared objective for environmental management (eg objectives relating to agricultural productivity may be counter to those for preserving biodiversity) and this makes it difficult to frame questions and identify outcomes.

Medicine and public health

An advantage of an organised system of collecting and assessing evidence is that people have shared objectives and evidence is presented in a 'common voice'. This separates the scientific basis for decisions from the decision making itself and, although political judgements are still needed (eg for allocating resources), it is more difficult for purely political considerations to to be maintained.

Although there are still difficulties in getting uptake of evidence by practitioners, at least there is now much common ground for presentation of issues to decision makers, practitioners and consumers.

Many of the same concerns were expressed in the early days of the Cochrane Collaboration, as are now being expressed for EM. However, two important factors that have led to the success of the CC are its independence from any commercial interests and the involvement of a large number of academics internationally who have pooled resources to ensure the best coverage of evidence (published and unpublished) on particular topics.

Is it possible to set up a collaboration for reviewing environmental evidence?

The morning discussion focused on the overall issues of whether EBEM would be applicable or not, and although participants agreed that the discussion was very useful, no firm conclusion was reached. It was therefore decided not to have further break out groups in the afternoon, as indicated in the program, but to attempt to summarise the morning's discussions and reach some conclusion about whether an approach similar to the Cochrane Collaboration could be applied to environmental management.

With this in mind, Ioan Fazey asked Bob Douglas to summarise the discussion so far, drawing on his experience during the setting up of the Cochrane Collaboration.

Lessons from the Cochrane Collaboration

Bob Douglas
National Centre for Epidemiology and Public Health, ANU
(also a member of the Cochrane Collaboration Respiratory Diseases Group)

The Cochrane Collaboration is about how scientific evidence can be made accessible to practitioners. It is clear that for environmental science, as for medicine, there are different types of evidence. In medicine, a hierarchy has been developed to assess evidence against common criteria. The criteria used may be different for EM but, overall, a similar approach should provide a very useful basis for decision making.

To be effective the collaboration needs to be global, with the results disseminated internationally. The Cochrane Collaboration has become much more effective since the advent of the internet.

Initially, the Cochrane Collaboration got going because of the intense commitment of a few people. In particular Ian Chalmers developed the pregnancy and childbirth

database of systematic reviews and showed that the method worked. However, he was very unpopular to begin with, particularly amongst the professional organisations who were afraid that they may lose power. However, as the approach and the methods took off, the professional organisations came completely around and are now great supporters of the Cochrane Collaboration. Ian Chalmers has subsequently been knighted for his efforts!

One of the important principles of the Cochrane Collaboration that can be transferred to environmental management is the altruism of the researchers involved. For their part, the scientists involved in the collaboration are extremely excited about being involved in such useful and vigorous debates.

To get a collaboration started in EM, environmental scientists will have to agree on certain principles and goals, including a system of how evidence is judged. This will not happen without a considerable driving force. This may come from an individual or group of individuals, possibly from exploration of a particular issue (as occurred with the pregnancy and childbirth database in medicine).

Principles

Ioan Fazey asked participants if they felt that any of the 10 Cochrane Collaboration principles were not appropriate for EM or if any additional principles were needed.

10 principles of the Cochrane Collaboration:

- collaboration
- building on enthusiasm of individuals
- avoiding duplication
- minimising bias
- keeping up to date
- ensuring relevance
- ensuring access
- continually improving the quality of its work
- continuity.

Clarification was requested about the meaning of ‘avoid duplication’. Bob Douglas explained that this referred to the efforts made within the collaboration to ensure that effort was not duplicated by different groups or individuals. For example, if back issues of a journal were being hand searched for any randomised controlled trials not already indexed on Medline (internet database of the medical literature), then all such articles would be retrieved so that a similar search would not be required again in the future by the different specialty group.

Although no additional principles were suggested by participants, concern was expressed that the diversity of environmental situations would create problems (eg farm management versus nature conservation or landscape management) and that knowledge is often spread over different disciplines. Traditional management systems may also have better outcomes than contemporary science-based ones, indicating that the evidence hierarchy required may be very different to that for medicine.

Bob Douglas replied that similar problems had been found in medicine, including traditional medical practices, and have been solved by having about 60 subspecialty groups that are problem oriented. These groups are also arranged within 'fields' to ensure that broad domains are being covered (eg child health, ageing).

An important feature of the medical and public health literature is that there is a freely available searchable database of the medical literature (Medline), which can now accessed on the internet by anyone. Medline is maintained by the National Library of Medicine in the US. When it first went online in 1976, searches had to be paid for, but over the last 15 years it has become freely available, including access to many article abstracts. The CC has established a very close link with Medline so that articles are indexed in a way that is most useful for Cochrane systematic reviews (eg by study type).

Participants confirmed that such a freely available and comprehensive database is not available for environmental issues and would be difficult to set up because of diversity of issues and disciplines involved.

Conclusions

The overall conclusions of the workshop were as follows:

- an evidence-based framework similar to that developed in medicine and public health over the last 20 years could be useful for environmental management; and

- an international collaboration of environmental scientists based on similar principles to the CC might provide a useful vehicle for such an approach.

However, due to the complexities of environmental science and other political issues, careful consideration would be needed of the goals of such a collaboration, the scale and information framework involved, and existing evidence and how it is currently used (including international protocols).

A way forward would be to attempt some case studies in selected areas of EM that may be considered to be particularly suitable for an EBEM approach and to continue to assess how evidence is currently used in EM. Further discussions of these issues later in the year would be useful.

Andrew Pullin has organised a workshop in the UK at the International Conservation Biology Meeting. He will also be coming to Australia in November 2002 and hopes to meet with nature conservation managers to discuss how environmental decisions are made (ie what evidence, if any, is currently used to direct decisions in nature conservation).

Appendix 1
Evidence-based medicine: assessment of evidence

Levels of evidence used for assessment of medical evidence

Level	Study design
I	Systematic review of all relevant randomised controlled trials (eg Cochrane review)
II	At least one properly-designed randomised controlled trial
III-1	Well-designed pseudorandomised controlled trials (eg alternate allocation)
III-2	Comparative studies with controls (not randomised), cohort studies, case-control studies or similar
III-3	Comparative studies with historical control, two or more single arm studies (no control group), or similar
IV	Case series studies
[V]	Expert opinion (no longer included by NHMRC)

'Dimensions' of evidence

Level	The study design used, as an indicator of the degree to which bias has been eliminated
Quality	The methods used by investigators to minimise bias within a study design
Size of effect	The distance of the study estimate from the 'null' value
Statistical precision (*P*-value)	The degree of certainty about the existence of a true effect
Relevance	The usefulness of the evidence in clinical practice, particularly the appropriateness of the outcome measures used

Quality criteria for assessment of medical evidence at higher and lower levels of evidence

STUDY TYPE	QUALITY CRITERIA
Higher levels	
Systematic review	Was an adequate search strategy used? Were the inclusion criteria appropriate and applied in an unbiased way? Was a quality assessment of included studies undertaken? Were the characteristics and results of the individual studies appropriately summarised? Were the methods for pooling the data appropriate? Were sources of heterogeneity explored?
Randomised controlled trial	Was the study double blinded? Was allocation to treatment groups concealed from those responsible for recruiting the subjects? Were all randomised participants included in the analysis?
Lower levels	
Cohort study	How were subjects selected for the intervention? How were subjects selected for the comparison or control group? Does the study adequately control for demographic characteristics, clinical features and other potential confounding variables in the design or analysis? Was the measurement of outcomes unbiased (ie blinded to treatment group and comparable across groups)? Was follow-up long enough for outcomes to occur? Was follow-up complete and were there exclusions from the analysis?
Case-control study	How were cases defined and selected? How were controls defined and selected? Does the study adequately control for demographic characteristics and important potential confounders in the design or analysis? Was measurement of exposure to the factor of interest (eg the new intervention) adequate and kept blinded to case/control status? Were all selected subjects included in the analysis?

Source: Based on NHMRC 2000, How to Use the Evidence: Assessment and Application of Scientific Evidence.

Appendix 2
Assessment of association and causation (low-level evidence) in public health issues

At the lower levels of evidence (observational studies, particularly without controls), the other dimensions of quality become even more critical, for example:

- how well the study was conducted (was bias taken into account, were there confounding factors?)
- size of the effect
- volume of evidence (are there lots of studies that show the same effect?)

A set of criteria sometimes referred to but rarely used in any rigorous way is the **'Bradford Hill criteria'**, which were framed by Austin Bradford Hill (Professor of Medical Statistics, University of London) in 1965, for assessing association and causation for environmentally induced disease (public health):

Strength	This is the term he used for the size of the effect — if the effect is very large then the association is likely to be correct even if the studies are low level (eg smoking and cancer).
Consistency	Is the same effect seen in different studies?
Specificity	Is the effect specific for a particular set of parameters and not for others?
Temporality	Is the causative agent always present before the effect occurs (ie does the 'cart comes before the horse'?)
Biological gradient	Is there is a relationship between dose and response?
Plausibility	Is there a plausible mechanism for the effect? (although this factor may not be reliable on its own, combined with the other criteria, a known mechanism for the effect seen adds considerable weight to the assessment). In many human health examples, mechanisms are tested in laboratory studies (eg on rats and mice).
Coherence	Does the effect comply with the known facts about the natural history and biology of the condition? (related to plausibility)
Experiment	Have there been any experimental or semiexperimental evidence about this issue? (eg if persons stop smoking does incidence of lung cancer decline)
Analogy	In some cases it may be reasonable to draw an analogy with another similar situation, particularly if the analogous situation had very disastrous consequences.

Source: Bradford-Hill A 1965. The environment and disease: association and causation? *Proceedings of the Royal Society of Medicine,* Section of Occupational Medicine.

Appendix 3
Environmental management — some possible types of studies

(Modified from: John Maindonald (2001), *The Design of Research Studies — A Statistical Perspective*, Statistical Consulting Unit, Graduate School, ANU, page 27)

The simplest kind of randomised experiment has a treatment and a control group, with a randomisation device used to make the assignment to treatment or control. Natural events can create the conditions of a randomised experiment. For example, in a local area of a city, buildings are constructed according to several different designs. Some survive an earthquake, while some do not. The only consistent difference between buildings that survive and those that do is in design.

In the earthquake example, it is after the earthquake (a natural intervention) that the different treatments are identified. In some instances it will be clear what aspects of building design or land features have favoured survival. In other cases, it may not be so clear. Is it the design of the foundations or of the superstructure that is crucial? Is the local geology an issue? There is rarely the same clarity of connection between effect and cause as in an experiment. Similar issues arise in studying the effects of a natural event or an accident on a wildlife habitat. Also, rather than a natural intervention, there may be a government intervention — perhaps a change in management regime.

Possible types of studies that investigate effects of an intervention on a wildlife habitat

'Level'	Study
1.	Study experimentally induced changes, with different management regimes assigned (at random) to different sites. (cf Randomised controlled trials = level II)
2.	Study experimentally induced changes, with different management regimes applied (by managerial choice) to different sites. (cf Cohort studies: Level III-2)
3.	Compare sites subject to natural changes (eg flooding) or accidents (eg oil spills), with comparable (control) sites where they has been no intervention. (cf Case-control study: level III-2)
4.	Before/after studies of effects of management or natural changes (eg flooding) or accidents (eg oil spills). (cf Case-series study /pre- and post-test : level IV)
5.	Gather observational data from a number of sites, spanning a range of management regimes. Use the data to determine conditions that lead to favourable outcomes. (cf Case-series study, post-test only: level IV)

Possible types of studies for monitoring and evaluation of a rehabilitation project

Modified from Rutherfurd et al (2000), *A Rehabilitation Manual for Australian Streams*, Vol 1, pp 164-73 (Also reproduced in LWRRDC's Riparian Land Management Newsletter, edition 17, 2000)

Evaluation level	Study	Observation	Level of confidence
1.	Replicated sampling, replicated controls, sampling before and after rehabilitation	'The increase in the number of platypus in the treated reach was greater than any increase at either control reach'	Very high
2	Unreplicated, controlled, sampling before and after rehabilitation	'The number of platypus increased after rehabilitation in the treated reach, but not in the control reach'	High
3.	Unreplicated, uncontrolled, sampling before and after rehabilitation; OR Unreplicated, controlled, sampling after rehabilitation	'There were more platypus after the work than before'; OR 'After rehabilitation there were more platypus in the control reach than in the treated reach'	Moderate
4.	Unreplicated, uncontrolled, sampling after rehabilitation	'There was a gradual increase in the number of platypus in the two years after the work'	Low
5.	Unreplicated, uncontrolled, anecdotal observation after rehabilitation	'I saw lots of platypus after we had done the work'	Very low

References and further reading

Bradford-Hill A 1965. The environment and disease: association and causation? *Proceedings of the Royal Society of Medicine*, Section of Occupational Medicine.

Cochrane Collaboration (http://www.cochrane.org)
(for reviews, follow prompts to The Cochrane Database of Systematic Reviews)

Cochrane AL (1972). Effectiveness and Efficiency. Random Reflections on Health Services, Nuffield Provincial Hospital Trust, London (reprinted in 1989 in association with the British Medical Journal).

Cochrane AL (1979). 1931–1971: A critical review, with particular reference to the medical profession. In: Medicines for the Year 2000, Office of Health Economics, London.

Heneghan, C and Badenoch, D (Centre for Evidence-Based Medicine, Oxford, UK) *Evidence-Based Medicine Toolkit*, BMJ Books, 2002. ISBN 0 7292 1601 7

Irwig J, Irwig L and Sweet M. *Smart Health Choices: How to Make Informed Health Decisions*, Allen and Unwin, 1999.

Maindonald J, *The Design of Research Studies — A Statistical Perspective*, Statistical Consulting Uni7t, Graduate School, ANU, 2001

Maindonald J. *The Statistics of Evidence-Based Medicine.* Statistical Consulting Unit, Graduate School, ANU, 2001

NHMRC (2000, 2001) Handbook Series on Preparing Clinical Practice Guidelines ('toolkit' series) (http://www.health.gov.au/nhmrc/publications/series.htm):

How to Review the Evidence: Systematic Identification and Review of the Scientific Literature

How to Use the Evidence: Assessment and Application of Scientific Evidence

How to Put the Evidence into Practice: Implementation and Dissemination Strategies

How to Present the Evidence for Consumers: Preparation of Consumer Publications

How to Compare the Costs and Benefits: Evaluation of the Economic Evidence

Pullin AS and Knight TM (2001). Effectiveness in conservation practice: pointers from medicine and public health. Conservation Biology. 15:50–54.

Rutherfurd I, Jerie K and Marsh N (2000). *A Rehabilitation Manual for Australian Streams*, Vol 1, pp 164-73 (Also reproduced in LWRRDC's Riparian Land Management Newsletter, edition 17, 2000).

Sackett DL, Straus S, Richardson S, Rosenberg W, Haynes RB. Evidence-Based Medicine: How to Practice and Teach EBM. 2nd Edition, London; Churchill Livingstone, 2000.